

Some Thoughts on the Benefits of Long-term NSF Support:

What I Would Have Said if I Had Time to Say it

Wm. David Burns

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Transforming Undergraduate Education in STEM: Building a Community to Transform Undergraduate STEM Education was the title of the 2013 TUES Principal Investigators Conference, organized by the National Science Foundation and the American Association for the Advancement of Science and held from January 23-25 in Washington, DC. About 550 PIs attended.

The opening plenary session was a panel moderated by Bruce Alberts, editor-in-chief, *Science*, professor of Biochemistry and Biophysics, University Of California, San Francisco (UCSF), and president emeritus, U.S. National Academy of Sciences. According to the organizers, the panel “included six presenters from different scientific disciplines who had funding from TUES/CCLI for 10 years or more.”¹ I was honored to be among them. Panelists were requested to “dis-

cuss ‘synergies’ and research sustainability that long term funding has made possible (understanding that the funding is segmented into a series of grants), including having good evidence that your project improved undergraduate STEM education.” Panelists were also asked to discuss “lessons learned, including:

- Challenges and how you overcame those challenges;
- Unanticipated outcomes;
- What internal and external resources and support you needed to build and sustain a long-term program, other than more grant funds; and
- What keeps you going?”²

Each panelist was allocated five to seven minutes to make a presentation. Those who know me most likely would believe that it is more likely that that famed Biblical camel will pass through the eye of the needle before I could speak for just five minutes, or even seven, on one question, let alone a half dozen. But you would be wrong. As it turns out, I was the only speaker who stayed under the time limit (a fact noted and remarked upon by those who knew me who were in attendance).

¹ The other panelists were: Nathan Klingbeil, Senior Associate Dean and Professor Mechanical & Materials Engineering, Wright State University; Cathy Manduca, Director Science Education Resource Center - Carleton College; Pratibha Varma Nelson, Professor of Chemistry and Executive Director, Center for Teaching and Learning, Indiana University Purdue University Indianapolis; William Oakes, Associate Professor, School of Engineering Education and Director, Engineering Projects in Community Service (EPICS), Purdue University; and, Katherine Perkins, Associate Professor of Physics, Director of PhET Interactive Simulations Project and Science Education Initiative, University of Colorado Boulder.

² These goals are taken from a January 9, 2013 e-mail from Yolanda George of AAAS.

I had been intrigued by the questions, however, and though I knew that I could not even begin to answer them in the allotted time, I prepared some notes and remarks. As many of the questions were of the same general character as those I posed to myself and answered in the two-part series, “But You Needed Me-Reflections on the Premises, Purposes, Lessons Learned, and Ethos of SENCER,”³ readers who know those pieces will find some of this to be familiar. I offer what follows as a version of what I would have said had time and circumstances permitted me to do so.

I thank Myles Boylan and Don Millard of the NSF for inviting me to participate. My prepared remarks follow.

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First, congratulations to all of you who are here.

I wish you great success with your work. I invite you to use the resources of our National Center and SENCER in any way that would help you achieve your goals.

Given how tough it is these days to earn the opportunity to be in this room, my congratulations are heartfelt.

In thinking about my own situation, I have recalled the consolation I once offered a terrific student who had been rejected by Harvard’s Kennedy School.

“Admission,” I told him, “was an accident on the road to rejection.”

Much as I think SENCER’s work is praiseworthy, I remind myself that we exist because we too are an accident on the road to rejection, so to speak.

Thus, I expect I represent you as well when I say I am truly grateful to the US Congress, to the President, to the NSF—and especially to all who pay taxes that make the NSF’s work possible—for the chance to do what we do.

Long-term NSF commitment to a mission that embraces advances in scientific knowledge as well as advances in the public’s knowledge of science provides the framing context for the work we have to do for our nation. (We owe a debt of gratitude to Bruce Alberts for championing not just science education but this latter goal as well, a goal that goes far beyond the replication of a scientific research elite.)

NSF’s support, guidance, and funding for SENCER have enabled us to labor in support of that mission. This

³ http://secej.net/secej/summer11/burns_part_1_yo.html

support has also made it possible for us to meet that most basic ontological challenge: **existence**, something my mother would have described as “a mere detail”!

I won’t say it is the difference between “being” and “nothingness,” but it sure comes close!

If I had to sum this up in one statement, it would be this: long-term NSF support is what has empowered a sustained, extensible, and growing **movement** for STEM education reform.

So what does SENCER do? I have made a handout available, but, in brief, in connecting STEM “learning and doing” with some of the most “complex, capacious, contested civic challenges of our time,” we deliberately

- + try to **do more than one thing at once**: specifically we work to improve STEM education and stimulate civic engagement,⁴
- + **focus on the “science for all” challenge** (an opportunity made possible, as I said, in part thanks to the leadership and legacy of Bruce Alberts),
- + empower faculty and students to **make STEM learning real, relevant, responsible and rigorous** (while fighting against the impulse to confuse rigor with failure),
- + **bring the science of learning to the learning of science**,⁵
- + **explore connections between scientific practice and democratic practice**,
- + **build an extensible and growing national “movement,”**
- + **support that movement with resources, assessment tools, rewards and connections**,
- + **contribute to the STEM education knowledge base**,⁶ and
- + **serve the public good.**

⁴ This embraces the ecological and economic notion that “you can never really do only one thing.”

⁵ This is a central SENCER tenet: actively aligning our work with what is known about “How People Learn” (cf, Bransford, Duschl, and others) at least at the level of organizing “theory” and increasingly, with our rubric and other devices at the level of implementation.

⁶ See www.sencer.net for resources (models, backgrounders, assessment tools, etc) and www.secej.net for our on-line, peer-reviewed publication.

Synergies Made Possible By Long-Term Support

Synergy is a good organizing notion for mapping one region of this broad territory. Long-term, continuous (though sometimes tenuous) support has enabled us to develop and sustain what I believe are the key drivers of change:

- Having a **good idea**,
- Organizing and supporting a **community of practice** dedicated to bringing the idea to life,
- Supporting that community and **strengthening relationships over time**,
- **Welcoming newcomers** not just to join but also to shape our efforts,
- **Encouraging “alumni”** to push the envelope and influence our agenda,
- **Achieving “noticeable” scale** (some 10% of US institution of higher education, so far),
- **Being strategically opportunistic**, taking advantage of new collaborative opportunities,
- Listening actively (engaging in ongoing formative assessment),
- Refreshing our approach in light of what we learn,
- Inviting participants to become new leaders,
- **Distributing leadership opportunities and responsibilities**,
- **Rewarding achievement**, and
- **Collaborating with others** who are similarly engaged.

New synergies have enabled new engagements, you could say, and added new responsibilities, as well. I will mention just a few specifically:

- **We’ve given broader distribution to work already supported by NSF:** Barbara Tewskbury’s Geology and Africa course is a good example. Originally created with NSF support before there was a SENCER, Barb graciously allowed us to use the course as “a SENCER model.” That use resulted in a broader impact for that NSF investment than had been envisioned or promised by Barb in her original application for NSF funds.
- **We’ve provided “alpha testing” for a series of projects that have been developed more fully and**

disseminated with subsequent CCLI/TUES support: We have made more than 300 “NSF-supported sub-awards” to support innovation, faculty development, and alpha testing of new ideas. Several of these have become the basis for successful new TUES I applications to NSF and other extramural support.

- **We’ve learned from the advanced thinking of others:** We have been inspired, for example, by EPICS, because engineering the way EPICS supports it is very “SENCER-y” in that it is the perfect model of a discipline that negotiates the complex intersections of human desire and the “laws” of science.
- **We’ve developing and shared a Digital Library Collection of our resources:** With the help of Kathy Manduca and Sean Fox of Science Education Resource Center (SERC) at Carleton and with Claire McInerney and the colleagues at the Rutgers School of Communication and Information, this asset has been developed, is added to regularly, and is now freely available to all.
- **We’ve launched a new SENCER-ISE II project:** Growing out of an observation that the SENCE approach applied the principles of informal science education (ISE) to formal learning, this new NSF-supported project will forge collaborations between higher education and ISEs on matters of civic consequence. This is a project that, in a small way, is designed to deal with another issue Bruce Alberts (and Jay Labov) identified when they said that, for most college’s students, the introductory course in STEM is sadly also the terminal course.
- **We’ve organized and supported new regionalization initiatives:** Our nine regional SENCER Centers for Innovation (SCI) are directly supported with NSF funds. Their success inspired us to request and receive support from the W.M. Keck Foundation for the development for seven nodal partnerships across the West. The GLISTEN project (focused on the Great Lakes) was a direct outgrowth or regional work undertaken by our Chicago-based SCI. A new grant from the EPA will enable continuity and growth in science education, student-led research and service learning in the Great Lakes region.
- **We’re cultivating ongoing collaborations with organizations with interests in common:** New

collaborations include those with the Council of Colleges of Arts and Science (CCAS), Hispanic Association of Colleges and Universities (HACU) and the White House Office on Historically Black Colleges and Universities.

As I noted, all of these collaborations and new initiatives share a basic ontological requirement: that there be a “we” that “they” or you can collaborate with! This is a matter absolutely essential I think when we consider the scale and scope of the STEM education reform challenge we face.

Research Made Possible by Long-term Sustained Support

Scale, scope and, especially duration (longitude) have enabled our partners and ourselves to:

- ♦ **develop, test and refine a national assessment resource, the SALG and SENCER-SALG.** Elaine Seymour, our original evaluator of SENCER saw in SENCER the opportunity to further develop, test and validate the SALG⁷, an instrument she had initially created in connection with an NSF-supported project in chemistry education. Now the SALG, with additional support from the NSF, has been enhanced and is being employed by a growing community of users to encourage students to reflect on their own learning and help professors improve their instructional strategies. Steve Carroll, the SALG PI, is attending this meeting and has a poster on the project,
- ♦ **engage in and produce “scholarship of teaching and learning” (SoTL).** Members of the SENCER community have been engaged in envisioning, designing, conducting and publishing research on the effectiveness of their STEM education reform interventions, through workshop training in the SoTL at Summer Institutes and regional meetings,
- ♦ **launch a peer-reviewed on-line journal to provide broader impacts for SENCER-initiated and other related work.** *Science Education and Civic Engagement—An International Journal* was originally conceptualized by SENCER co-funder, Karen Oates, as

a vehicle supporting the community of practice and specifically as a strategy to strengthen global partnerships, such as those she had established with the newly independent states of Georgia, Armenia and Azerbaijan and those begun with our AAAS-partnerships in Africa. The journal, in its sixth year, is now “published” twice annually,

- ♦ **organize our own formative assessment/research program.** Learning as we go and going on as long as we have has enable us to acquire a library of assessment and evaluation materials on each of our institutes and other national programs, to conduct periodic focus groups and survey research initiatives. The most recent of the latter was a survey of past participants in our formal education programs that yielded significant findings about the extent to which participation in SENCER had, for example, over time, resulted in respondents achieving promotion and tenure or promotion after tenure [n=~200]. These and other findings are reported in the new American Chemical Society/Oxford University Press book, *Science Education and Civic Engagement: The Next Level* (2012, hardcover: 2013),
- ♦ **disseminate and support important emerging national STEM education reform initiatives:** Because we have a large national community of participants (~2,500) who receive our bi-weekly e-newsletter, we have been well-positioned to assist in getting the word out on the new science standards, for example, or to encourage our community to read Rick Duschl et al’s *Taking Science to School*, to apply his Evidence/Explanation continuum (along with our Rubric 2.0) to their work, to participate in the Vision and Change initiative and support the nomination of PULSE scholars, and to promote the goals of the NRC’s *Thinking Evolutionarily* project, to name just a few, and
- ♦ **envision and enact an emerging partnership with College Board** related to the revisions in the AP program that will help assess the “enduring understandings” achieved by students in the SENCER STEM courses.

7 SALG stands for “student assessment of their learning gains” (see: www.salgsite.org for more details)

Challenges Faced and “Overcome”

Our work has not been without many challenges. I will mention a few and touch on strategies that seem to be helping us overcome them:

Proportionality: We are blessed with substantial resources (a new TUES III award, for example) from NSF, but the scale of needed reform is enormous. For example, our TUES III award for the next four years is about 1/10 of the annual budget for life sciences of just one member institution in the AAU with which I have some passing acquaintance. The overall TUES budget may be substantial, but it is tiny in comparison with the scale and “wealth” (not to mention the mass and “inertia” of the enterprise that is the target for “transformation”). So, like NSF, we have to use leverage in a currency that is understood on campus (small, targeted sub-awards, for example, >300 so far) and we cultivate volunteer leadership and labor.

Academic Accountancy: Integrative, collaborative, cross-disciplinary work is underdeveloped territory, especially at the level of administration. Everybody is for “interdisciplinarity,” but few have figured out how to organize, staff and pay for it. So we pay close attention to faculty members who have evolved and figured out strategies that work, such as course intersections (like the Vassar model on our website), cross-teaching (scheduling linked courses at the same time, but switching teachers back and forth), learning communities, organizing a narrative spine (as at West Point in the energy program) and other novel, clever and sometimes subversive acts. We provide connections and consultation to academic leaders who want to change these conditions.

Rewards: As some of you no doubt know first hand, adopting progressive pedagogies can be harmful to your careers. So we work to provide recognition and rewards that have CV value to our collaborators/partners (as noted, >200 have reported gaining tenure/promotion due, in part,

to their association with our work). The NSF “imprimatur” is critical to making this work on campus.

Marketing: We spend so little time, money and energy on marketing (in part because we don’t have a surfeit of any of these commodities). This limits our reach. So we rely on other networks and “mobility” to help spread the word. Our “alumni” move to new institutions and work to bring the program there. We’ve found this “word-of-mouth” endorsement to be the most effective marketing strategy, though it suffers from a degree of randomness and unpredictability.

Continuity: Our alumni come and go and we have limited capacity to stay in touch, to follow up years afterwards. We’re still working on this, but we hope our program of Leadership Fellows and the reinstated sub-award program with a cadre of mentors will enable us to maintain connections and promote continuity.

Access: There’s no question that the conditions on campus (workload, growth in contingent faculty ranks, budget cuts, travel restrictions, etc) and our new “business plan” (i.e., passing costs on to users) necessitated by changes in funding availability have affected access to our resources. So we have encouraged robust regional networking (and increased social networking, too, though hardly overdeveloped at this point), and we are creating, with NSF’s support, a modest program to assist folks who would otherwise be unable to afford to participate in our Summer Institutes, for example.

Uncertainty: While we all live with it and some of us celebrate it when we are speaking in the abstract, it has been difficult to plan long-term interventions and programs in the absence of a long-term funding platform. So we will be doing some serious planning (and so equally serious hoping and helping, if asked, in respect to the development of new mechanisms—funding programs—that will increase access to proven programs, while

assuring the expansion of opportunities for newcomers and new ideas and a fresh approach to assuring accountability).

Unanticipated Outcomes Experienced

Have we had unanticipated outcomes? Have we! In some ways, most of the really interesting things that have happened were never really envisioned by my founding partner, Karen Oates, and me, when we first pitched the SENCER idea to Myles Boylan at NSF. I will mention only five:

1. **We have helped teachers change their teaching practices, not just their courses.** We thought we would be helping faculty change courses and we did. In the process, however, faculty members have changed their ideas about teaching all students. This is a much larger and more enduring outcome than we anticipated, though one that was anticipated in a way by one of the reviewers of our initial proposal (you may be in the room: thank you).
2. **Students don't initially like change any more than faculty members do.** Many students, including especially students who have succeeded in the old pedagogies, are initially resistant to new pedagogies because these practices expose them, just as they do new teachers, to risks. So we have to work to overcome this—and one way is to focus on being transparent about learning goals.⁸
3. **Engaging community colleges is essential but it is tough.** Given the crushing faculty workloads, and the pressure on community colleges (and lots of other colleges, as well) for uniformity or at least making courses totally fungible, this has been difficult. We have had success and indeed have course models that were developed at community colleges. However, where we advocate hand-crafted courses that strengthen faculty authority and engage with real student interests or local and community-based civic problems, the trend seems to be in the direction of transferring the “factory model.” This is lamentable, to say the least, and it remains to be seen whether the MOOC movement will enable “flipped classrooms” that will make way for SENCER innovations, or if they will represent a

cyber-enabled hegemony that no textbook author has ever dreamed of!

4. **Things have been accomplished that we never imagined even in our dreams.** To end this list on a less bleak note, we have been amazed by the local, regional and even global reach that time, talent, and imagination have engendered, from students changing campus energy use practices, affecting local health regulations, enacting regional conservation practices, all the way to forming a high school for girls in Kenya. It has been a wonderful to behold what has occurred.

What internal/external resources have we used to build our program?

NSF support was itself a key motivator and influential driver of our success. The NSF “imprimatur” is a critical catalyst for change and widely respected invitation to be engaged. That “validation” (and our ability to deliver on the promises we made to NSF in the course of our applications for support) has helped us develop new internal and external resources. Chief among these, I would say, is the “intellectual capital” contributed by our members, the matching and in-kind financial support for our subgrantees institutions, the generosity of our volunteers, the energy of our campus student leaders, the wisdom of our collaborators from National Research Council and many other places, the legitimacy the members of our advisory board have conveyed upon our work, and the critical support from other sources, like The W.M. Keck Foundation, the Noyce Foundation, the Corporation for National and Community Service, the EPA, and anonymous donors.

What keeps us going?

This is a great question. You probably already know some of the answers. Here's my short list:

Eros—We reconnect folks with the original objects of their desire. It is that idea of love that seems to describe and explain the loyalty and devotion of the community and of the members of the community and their work with students.

Success—The results are pleasing to participants (and to us) even though the work is hard. A commitment to student success seems to create conditions that

⁸ See my article, “With Friends Like These” at http://serendip.brynmawr.edu/sci_cult/scienceis/burns.html

lead to that success.⁹ When you identify your success as a teacher with the accomplishments of your students, it changes the moral conditions of the classroom, itself.

Colleagues—There is no doubt that what has fueled and nourished our desire to continue with the SENCER project and to do the work and undergo the stress that accompanies depending on raising funds and support for the continuity of the work is a sense of obligation to those who have undertaken this work with us.

Flexibility and Partnership—We have been blessed with a program officer at NSF who has encouraged us to act like natural scientists and allow reality to shape our planning. I used to joke that Myles Boylan was my “probation officer” and, of course, there is a grain of truth in that remark. He is a part parole officer, surely, who keeps us to our word, but he never holds us to do something we now have reason to think will not work. Our community regards him as a wise counselor and partner in our endeavors.

Taking a Long-Term View—Gertrude Stein wrote that “before the flowers of friendship ended, friendship ended.” That’s true of a lot of grant-funded projects. The commitment goes even before the money gets spent. We have never conceived of our project as having a beginning, middle and end. Though this stance has given us a curriculum in the art of living with uncertainty, it has also enabled us to conceive of SENCER as an extensible and dynamic project—indeed, at the

9 Not all teachers agree with this, of course; consider an alternative:

The macroeconomics professor who helped shape Paul Ryan is a voluble, passionate supply-sider and self-described “hard-core libertarian” named William R. Hart, known as Rich. Listening to him, you can imagine that you are hearing what Paul Ryan would say if he were not inhibited by the demands of electoral politics. Hart is the opposite of politic — to the point of regularly, publicly denouncing Miami University for what he regards as declining academic rigor and coddling of students, all in the university’s pursuit of “money, money, money.” Hart is not a coddler. He proudly reports that of the 112 students who took his latest Principles of Macroeconomics exam, 56 failed and 27 got D’s.

See: http://www.nytimes.com/2012/11/05/opinion/keller-the-republican-id.html?pagewanted=all&_r=0

risk of repeating this hubris: a movement—that is responding to a critical need.

A Commitment to Strengthening Our Democracy—We look beyond helping to create so-called “well rounded” students, or preparing graduates for jobs and careers, as reason and motivators for study in STEM to a larger challenge: we simply will not achieve the promise of a democracy without a citizenry that possesses the intellectual skills that come from excellent instruction and engagement in the STEM disciplines and exercises their right to access the benefits that come from science and scientific research.

WD Burns

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About the Author



Wm. David Burns is the founder and principal investigator of SENCER, the NSF-supported national dissemination project. He is also executive director of the National Center for Science and Civic Engagement and professor of general studies at the Harrisburg University of Science and Technology. Prior to establishing the National Center, he served as senior policy director for the Association of American Colleges & Universities (AACU). During his nine years with AACU, he established the CDC-sponsored Program for Health and Higher Education and created the Sumner Symposia dedicated to exploring the power that students have to improve the health of colleges and communities. David is the principal author and editor of *Learning for Our Common Health* and, among other publications, the article, “Knowledge to Make Our Democracy.”