Disseminating STEM Teaching Practices: The Role of Centers for Teaching and Learning

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Abstract

Centers for Teaching and Learning (CTLs) are established to promote teaching excellence. While CTLs are effective at fostering teaching excellence in the main, they have provided little attention to addressing potentially unique needs of STEM faculty. This article proffers explanations as to why CTLs do not focus on promoting STEM pedagogies and suggests ways that CTLs can assist in the dissemination of STEM best teaching practices.

CTLs and STEM: A Local Perspective

When we were asked to write about the intersection between Centers for Teaching and Learning (CTLs) and the dissemination of STEM pedagogy, the obvious starting point was to explore STEM activities on our own campus, California State University, Sacramento. Located in Northern California, California State University, Sacramento is one of twenty-three campuses in the State university system where forty-four thousand faculty and staff serve over four hundred thousand students. The CSU, Sacramento campus has a student body of approximately twenty-eight thousand and nearly sixteen hundred full- and part-time faculty members. Located in the capital of the nation's most populous and diverse state, California State University, Sacramento focuses on excellence in teaching and learning.

Although CSU, Sacramento maintains an active CTL with regular brown bag discussion sessions, pedagogy workshops, teaching and learning presentations, class observations, departmental and college workshops, support grant development assistance, evaluations and research assistance, and internationalization of the curriculum, we do not specifically target STEM faculty or STEM courses. To gain a better understanding of teaching and learning practices in STEM courses, we contacted faculty we believed would be most familiar with and likely to employ STEM-specific teaching practices, such as those profiled in this issue.

To our surprise, we found that our STEM faculty were not using the innovative and empirically supported pedagogies such as JiTT (Just-in-Time Teaching) and POGIL (Process-Oriented Guided Inquiry Learning) discussed in this issue and elsewhere. The STEM faculty members we talked with were, for the most part, unfamiliar with the STEM-specific research and pedagogies focused on decreasing withdrawal and failure

rates and increasing student learning by improving the classroom learning environment. A response from one of our most student-centered mathematics faculty is typical of other responses:

> I am not aware of any generally accepted teaching strategies for working with STEM students (which I take it is understood to mean techniques that have been found to improve minority success rates in STEM disciplines). In mathematics, there is a generally accepted structure for improving minority success, and most of this follows from the work of Uri Treisman while he was at UC Berkeley...He developed the use of a specific style of workshop attached to calculus classes, using cooperative groups, posing longer deeper problems, using workshop facilitators who have been through this program. In math, the term "Treisman-style workshop" is widely understood... Here at Sac State, we use Treisman-style workshops for the pre-calculus and calculus classes that are associated with the AMP program [LSAMP stands for Louis Stokes Alliance for Minority Participation]. We have perhaps the most successful program to be found for minority students in calculus.

The "Treisman-style workshop" is an example of a pedagogical practice developed and applied in STEM disciplines, as well as other disciplines. What is unclear from this statement is the extent to which this workshop style is used, the consistency of its use, and any evaluation of its use. What we would like to see is a systematic and purposeful adoption of such techniques in a classroom.

Interestingly, we discovered that our STEM faculty was focusing on the matriculation needs of underrepresented students so that they might recruit and retain traditionally underserved and underrepresented STEM students. By approaching our faculty we discovered that our university has recently charged a group of STEM faculty members to work on a STEM initiative. In a preliminary report, this committee developed a "unified vision" statement for our campus. Although not driven by STEM teaching practices, the "unified vision" statement outlines the efforts that our campus is taking to recruit and retain a diverse student population. Improving the teaching and learning environment is central to recruiting and retaining students, including those from diverse populations. Yet, we were not part of this conversation. And the STEM faculty members on the initiative group were chosen not for their "inspiring teaching practices" but rather for their desire to help with outreach recruitment and retention of underrepresented minorities into their programs. It is not unusual for faculty initiatives, such as this one, to leapfrog faculty development and begin all teaching and learning discussions on student learning.

CTLs and STEM: A National Perspective

One of the most ambitious efforts to explore STEM pedagogy in colleges and universities was undertaken by the National Research Council in 2002 and summarized in their report titled, "To Improve Undergraduate Education in Science, Technology, Engineering, and Math, Colleges and Universities Should Revamp How They Evaluate Teaching." The report emphasizes the need for superior science and mathematics

instruction for undergraduates. The report calls for university leaders to expect teaching methods that are based on scientific evidence about how students learn best and to clearly articulate that expectation. The report also calls for universities or particular departments to establish and support centers for teaching and learning in order to provide faculty with ongoing professional development opportunities since most professors who teach undergraduates in these subject areas have received little formal training in instruction techniques or in assessment of student learning.

This report refers to two types of centers for teaching and learning: those with a campus-wide focus and those with a disciplinary focus. The report suggests that an obvious hub for the dissemination of STEM pedagogy be relegated to college and university centers for teaching and learning, with an emphasis on the disciplinary focus. They wrote:

> As these centers evolve [CTLs], they are supporting new pedagogies and more efficient methods of assessing teaching and learning, and are serving as focal points for efforts to advance the scholarship of teaching and learning (Boyer 1990; Glassick, Huber, and Maeroff 1997). Many of these centers are clearly tailoring their assistance to faculty to reflect differences in approaches and emphases among disciplines. Experts in these discipline-based centers are often disciplinary faculty with expertise in pedagogical content knowledge, assessment of learning, and other issues specific to their disciplines (Huber and Morreale 2002, 26).

Yet, the authors acknowledge that conversations about teaching are enriched when they extend beyond disciplinary boundaries:

> Effective teaching needs to be seen as a scholarly pursuit that takes place in collaboration with departmental colleagues, faculty in other departments in the sciences and engineering, and more broadly across disciplines (Boyer 1990; Glassick, Huber, and Maeroff 1997; Kennedy 1997). Faculty can learn much by working with colleagues both on and beyond the campus, thereby learning to better integrate the materials they present in their own courses with what is being taught in other courses (Hutchings 1996, 31).

STEM pedagogy interest groups and CTLs are driven by a common goal: improving undergraduate education through the dissemination of effective teaching practices. While one would think that this common goal would bond and draw these groups together, relationships between these two groups are loosely-coupled, if coupled at all. CTLs can be a more central voice in this national conversation about how to improve undergraduate STEM education.

The disconnection between our CTL and STEM initiatives and practices taking place on our campus is not a unique phenomenon. In our discussions with other CTL members from several institutions about how they promote STEM-specific pedagogies we found similar experiences. It seems that we are moving along two parallel tracks to promote improved teaching by faculty: university-wide and disciplinary-focused teaching and learning centers. The university-wide track is not discipline specific and consists of

actions coordinated and undertaken by CTLs. These CTLs are often funded through internal allocations, with some external funding. Often aligned with the academic mission of the university, they report to provosts or chief academic officers. They engage in professional development of faculty, as well as organizational development—helping to expand and emphasize the teaching mission of the university. The other track is STEM discipline specific. Actions are taken by STEM faculty innovators who are developing and expanding on teaching and learning pedagogies to enhance student performance. STEM innovators present these ideas in national conferences and workshops to STEM faculty, with the intention that individual faculty will return to their campuses and institute changes in the classroom. Less clear are coordinated actions on campus, that is, discipline-focused teaching and learning seems to come from the discipline with little coordinated campus activity. Further, when attention is focused on STEM teaching and learning on campuses, it seldom reaches the ears of those outside of STEM disciplines—thus, failing to become part of a campus-based conversation about teaching and learning. Clearly, greater connections between CTLs and STEM pedagogical efforts need to be actively and aggressively cultivated and nurtured. STEM needs to be part of the larger organizational conversation, and CTLs need to nurture STEM-specific efforts.

Prior to seeking to cultivate and nurture relationships between CTLs and STEM pedagogy innovators, an understanding of why there is a weak relationship between these groups should be broached. It seems likely that both interest groups have contributed to the divide. For CTLs, a common operating philosophy is that they provide a host of services and that interested faculty make themselves available to receive those services that they perceive to be most beneficial. Given that the academy places a high premium on academic freedom, including whether or not the faculty use the services of the CTL at their university, CTLs are typically limited to serving those people who voluntarily seek their services. Perhaps STEM faculty do not believe they need help or are unaware that their CTL can assist them. CTLs must be more active in availing their services and abilities to assist STEM faculty. The CTL at Sacramento State will now work with STEM faculty on their teaching pedagogy and in understanding the connections between teaching practices and retention of students of color.

STEM educators are also likely contributing to the divide. For one, some STEM faculty hold the belief that teaching practices that work in the social sciences do not work in STEM classes. This belief that research on teaching strategies does not generalize across disciplines could contribute to solitary efforts of STEM educators and interests groups to work from more narrow pools of research and literature. Second, and this idea is echoed in the National Research Council report, STEM disciplines almost always rank teaching and learning activities lower than research when making hiring, tenure and promotion decisions. The culture found on most campuses does not hold teaching nearly as high as research, and on many campuses, untenured faculty are told to focus on their research efforts first and foremost.

Connecting CTLs and STEM

The articles in this special edition share similar concerns and observations:

- we need to decrease the withdraw/dropout rate of students in STEM courses;

- STEM faculty need to alter their teaching practices to retain students;
- creative, insightful, and research based teaching practices have been tested and found to be effective in STEM classrooms; and
- dissemination of STEM research-based teaching practices must be improved.

So, what role can CTLs play in this national crisis? CTLs have ready multiple approaches for fostering and strengthening connections between CTLs and STEM faculty including a centralized administrative structure, new faculty and TA orientations, emphasis on the scholarship of teaching and learning, the promotion of faculty learning communities, and a national association to connect CTLs with each other. A discussion of each of these topic areas is provided below.

Centralized Structure. Because CTLs are often enmeshed within the structure of their college or university, they tend to have greater access to the administrators, who are typically the agents of university structural change, than individual faculty (Singer 2002). CTLs can and should use their position to promote better STEM teaching practices and assist in finding the necessary resources for STEM faculty to excel at teaching excellence.

Prior to engaging in a campaign of university change for STEM faculty, any CTL must first better understand these STEM faculty members. Are they relatively new to teaching, highly experienced, or are they quite varied in experience? We also need to understand how the different STEM disciplines approach teaching—lab structures in computer science are not the same as those in biology or mathematics. While broad similarities exist, the conceptual goals and skill sets used in labs are quite different. For example, in an introductory biology lab much may be accomplished by setting a specimen before a student with the directive, "Look carefully and report precisely what you see" in the style of Louis Agassiz. Yet this same approach would be senseless to a novice computer science student since code is abstract. The level of experience and disciplinary values of the faculty will affect choices for dissemination of STEM pedagogies.

New Faculty Orientation. At California State University, Sacramento, our CTL is fortunate to play a role in new faculty orientation. In addition to organizing panels on effective teaching, we inform new faculty of the services that we provide. All new faculty hires are guaranteed a position in the Teaching using Technology Summer Institute (TuT) that is held at the end of their first year on campus. TuT has been a very successful faculty development model where faculty focuses on effective teaching strategies while incorporating multi-media into their course content. CTLs serving in the capacity of facilitator, organizer, or member of a faculty orientation group can use their position to promote STEM pedagogy. This could be as simple as providing handouts to STEM faculty about STEM-specific pedagogies and directing them to the literature or connecting them with like-minded mentors. Such actions can have an immediate impact on the use of designated STEM teaching practices.

A common problem with faculty orientations in general is that they occur at the same time that faculty are trying to orient themselves to their new environment—signing up for health benefits, reviewing the research and teaching expectations to receive tenure,

finding where they can park, and getting their offices set-up. Once new faculty are familiar with the university, CTLs can offer STEM-specific workshops, brown bag sessions, and conferences as ways to engage new and experienced STEM faculty in discussions on ways to improve their teaching and student learning.

TA Training. Many CTLs are involved in teaching assistant (TA) training programs. Typical formats for TA training include large general training sessions organized with generic content to provide information for the widest range of TAs. Given the generic nature of the large training sessions, some STEM disciplines have taken it upon themselves to conduct their own TA training. Quite frequently, when these trainings are shifted from the university level to the discipline level, CTL participation and coordination assistance typically disappears. CTLs must work to re-engage in the training process by approaching STEM departments that offer discipline- based training programs. CTLs could be helpful by providing reading lists and workshops that are focused to the teaching of introductory STEM courses that TAs often teach.

Stanford University has already implemented a training program that connects their CTL and STEM departments. During the university-wide orientation, the CTL reaches out to eighteen STEM departments and programs through tailored training to approximately three hundred teaching assistants. This training includes research-based successful teaching strategies and generates awareness of the support and services available to TAs from the CTL. The TAs involved in this training become more aware of the role that CTLs can serve in assisting them when, or if, they become faculty members.

On a limited number of campuses, STEM graduate students are part of Preparing Future Faculty (PFF) programs. The PFF, launched in 1993 in conjunction with the Council of Graduate Schools and Association of American Colleges and Universities, is a highly effective program in over fifty universities to train future professors to be exceptional researchers and teachers. The PFF program is premised on the belief that the nurturing of successful future faculty members occurs best with extensive mentoring. To this end, students working through this program are given access to multiple mentors that assist them in improving their teaching and research skills and making them aware of the service responsibilities that they will assume when they become faculty.

The design of the PFF program is to create clusters of partners that work with individual students. While there is not a single model of creating clusters, the original program involved doctoral institutions, liberal arts and community colleges, and a master's university. Taken together, these various partners assisted the future faculty participant by providing opportunities to teach classes outside of their specialty area, attend faculty development activities, work with teaching mentors, and work with faculty committees. STEM departments are actively involved with the PFF program, including Biological and Life Sciences, Chemistry, Mathematics, and Physics.

Scholarship of Teaching and Learning (SoTL). While there are many definitions of what SoTL includes, most definitions agree that it is research on teaching methods and approaches and how these pedagogical choices impact student learning. The primary

goal of SoTL is for faculty to reflect upon their teaching methods and selection of material. In this process, they begin to ask questions about how changes in their teaching might enhance student learning.

Although some administrators and faculty members find value in conducting SoTL research, others are less supportive. Part of the problem with scholarship of teaching research is that it is teaching-based and is often less valued than more traditional disciplinary-based research. This perception has stifled scholarship of teaching research and has contributed to a reduced readership on the topic. By promoting the scholarship of teaching to faculty and convincing university administration that it is a valid and valuable form of scholarship, CTLs can spur a greater enthusiasm and respect for this research among STEM faculty. The Carnegie Foundation for the Advancement of Teaching is attempting to add credence to SoTL. Not only do they actively execute and financially support SoTL, but also they are dedicated to committing themselves to promoting effective change in education through pedagogy research.

Whether a faculty member seeks to publish or to read about STEM-specific pedagogical research, there are both general and specific outlets for SoTL research. A partial list of SoTL publication outlets and SoTL conferences for STEM faculty is provided below.

Table 1. Examples of Publication Outlets for STEM Faculty

Journals:	
Biochemistry and Molecular Biology Education	http://www.bambed.org
American Biology Teacher	http://www.nabt.org/sup/publications/
The Chemical Educator	http://chemeducator.org/
Journal for Research in Mathematics Education	http://my.nctm.org/eresources/journal_home.asp?journal_id=1
Physics Teacher	http://scitation.aip.org/tpt
Journal of College Science Teaching	http://www.nsta.org/college
Conferences:	
Learning Community Commons: Creating a Culture of Success in Math and Science	
American Association for Clinical Chemistry (AACC) Annual Meeting	
National Council for Teachers of Mathematics (NCTM) Regional Conference and Exposition	

Two years ago, our CTL became active in promoting the Scholarship of Teaching and Learning at our campus. We began slowly. In our first year we worked to simplify the process and decrease the time needed to receive university human subjects' approval to conduct research on classroom teaching practices. In our second year, we became more active. We worked with a previously untapped group of faculty interested in meeting some of the required research expectations for tenure and promotion by conducting research on specific teaching practices in their classes.

At California State University, Sacramento staff in our Center for Teaching and Learning met with eighteen different faculty in over fifty meetings and totaled more than eighty hours of individual assistance in our first year of promoting SoTL one-on-one consultation to our faculty. As a result of our commitment to the Scholarship of Teaching and Learning, several faculty have submitted their classroom-based teaching research to journals in their disciplines. Very few of our STEM faculty sought individual assistance to work on Scholarship of Teaching and Learning. Further efforts via personal contact and offering to do workshops for STEM departments could provide helpful in changing these numbers.

CTLs are often unaware of discipline-specific teaching and learning mass communication outlets and we can find no single Web site that lists STEM specific SoTL outlets. When Sacramento State added a list of SoTL-related publication outlets to our university CTL Web site, it required extensive searching on our part. If CTLs seek to further promote SoTL, especially among STEM faculty, then they need to be more active in reaching out to faculty to provide general support and to maintain active and current lists of SoTL publication outlets as well as conferences to make the information readily available to those faculty members seeking to conduct research in this arena.

Faculty Learning Communities. One of the most powerful yet complex means of dissemination employs faculty learning communities (Cox 2004). Faculty learning communities (FLCs) attract members with specific interests and commitments to the specific project selected engaging them in long-term, systematic investigation of and development of teaching methodologies. Consequently, participants emerge with well-grounded and elaborate understanding of their target of study. They also act as champions for innovations, methods and approaches to teaching that may not easily be understood or may not be immediately accepted by other STEM instructors.

The emergence of FLCs in improving the teaching of STEM faculty and disseminating successful teaching approaches is already underway. For example, Western Michigan University has adopted a program known as Science, Technology, Engineering, and Mathematics Talent Expansion Program (STEP). STEP is a FLC modeled after a program previously adopted at Texas A&M University. For the STEP program, faculty of STEM introductory courses meet weekly to coordinate their courses, read and reflect on the teaching process, and plan special student and faculty activities that are designated to reinforce and extend learning taking place in the classroom.

FLCs are an attractive option for disseminating STEM pedagogies. They are inexpensive to establish, facilitate learning transfer for students, increase faculty interest in teaching and learning, and heighten a sense of community among faculty and students involved.

Connecting CTLs with CTLs. CTLs can learn from each other, especially about ways to effectively work with STEM faculty. The most prominent and comprehensive association connecting CTLs is the Professional and Organizational Development Network in Higher Education (POD). At present, POD has approximately sixteen hundred members and includes universities, administrators, faculty, and higher

education consultants. Although a majority of members are based in North America, membership represents twenty-five countries (http://www.podnetwork.org).

POD connects CTLs through publications, a Web site and an annual conference. At present, POD provides few links to national STEM efforts and conference presentations on STEM pedagogy are infrequent. At first glance, it may seem incongruous of POD to provide so little attention to STEM efforts—though STEM is focused on student learning rather than on faculty development. However, successful STEM teaching strategies exist and could be better promoted by POD. For example, PODs Winter 2006 newsletter provides an essay on teaching excellence and provides suggestions on "Teaching with Hospitality." This general or generic content could be applied to STEM courses, but that connection is not made. Of greater use would be a portal from the POD Web site to STEM-related pedagogical tools and research.

Another way in which CTLs connect is through the newsletter "The National Teaching and Learning Forum." This newsletter is an open forum to discuss teaching issues. Discussions include teaching approaches that faculty have found to work. Although not devoted uniquely to STEM pedagogy, the newsletter could be an outlet for sharing STEM pedagogical information more broadly. For example, in a recent issue of the newsletter, the lead article focuses on whether Engineering faculty know about the problems in their classes and how to fix them when revealed.

CTLs can connect to disciplinary-based STEM PFF programs through the Center for the Integration of Research, Teaching and Learning (CITRL). This expanding network of faculty in STEM programs and those interested in higher education teaching and learning, is currently limited to eight institutions, but plans are to expand. While the CIRTL provides a good model for the dissemination of effective research-based STEM pedagogy, CTLs are not an integral part of the equation of integrating or connecting with CIRTL forums. While it would be nice if these groups were to find one another and to work collaboratively, this is not the dominant paradigm taking place on university campuses. At a minimum, CTL staff should visit this site to learn more about STEM pedagogies (www.cirtl.net). Even better, we should find ways to insert CTLs into this conversation.

Conclusion

This article offers explanations about why CTLs are not more active in the dissemination of proven STEM pedagogical strategies, and we offer ideas about how CTLs can become more active. Numerous opportunities for dissemination of STEM pedagogies exist on campuses—from simple brown bag discussions and summer teaching institutes to conferences; from listservs to complex online repositories of materials. Of course, each CTL and host institution must decide what resources they will commit to disseminating STEM pedagogies. Decisions about resource allocation should consider the goal of the CTL and STEM faculty—is it awareness, understanding or action? Once decided, the particular mix of dissemination tools can be selected and implemented.

Given the possibilities of CTLs being a major player in the dissemination of effective research- based STEM pedagogy, CTLs should become more active in interest groups such as PFF, POD and CIRTL as they work to improve pedagogy in STEM departments. The first step for CTLs wishing to become more active in STEM-based pedagogies is to know what is being done on their own campus and to be ready to offer assistance where appropriate. Potential future steps include building greater repositories of STEM research for faculty and CTLs, being more active in reaching out to STEM faculty through tailored programming, and becoming part of the larger national conversation about improving teaching and learning in STEM courses.

As the result of discovering STEM activities on our campus, we have developed a new relationship with key STEM faculty and will offer workshops for them. Other CTLs should consider engaging in information seeking to uncover what STEM activities their faculty is involved in on their campuses. It seems reasonable to posit that CTLs that can attach themselves to STEM groups already working on their campus will likely encounter less resistance and, as a result, will be able to contribute positively to the STEM efforts already in progress. The obvious juncture between STEM and CTL activities is that in partnerships with CTLs, STEM interest groups will be able to focus on faculty development that builds on learner-centered teaching strategies which will result in recruiting and retaining underrepresented students.

References

Boyer, E. 1990. *Scholarship reconsidered: Priorities of the professoriate.* New York: The Carnegie Foundation for the Advancement of Teaching.

Cox, M. D. 2004. Introduction to faculty learning communities. In *Building faculty learning communities, new directions for teaching and learning: no. 97*, eds. M. D. Cox and L. Richlin, 5-23. San Francisco: Jossey-Bass.

Glassick, C. E., M. T. Huber, and G. I. Maeroff. 1997. *Scholarship assessed: Evaluation of the professoriat.* San Francisco: Jossey-Bass.

Huber, M. T. and S. Morreale. 2002. *Disciplinary styles in the scholarship of teaching and learning: Exploring common ground.* Washington, DC: American Association for Higher Education and the Carnegie Foundation for the Advancement of Teaching.

Hutchings, P. 1996. *Making teaching community property: A menu for peer collaboration and peer review.* Washington, DC: American Association for Higher Education.

Kennedy, D. 1997. *Academic duty.* Cambridge, MA: Harvard University Press.

National Research Council Report. 2002. *To improve undergraduate education in science, technology, engineering, and math, colleges and universities should revamp how they evaluate teaching.* Washington, DC: National Academies Press.

Singer, S. 2002. Learning and teaching centers: Hubs of educational reform. In *New Directions for Higher Education*, no.119. Wiley Periodicals, Inc.

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