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BROAD & CAPACIOUS

A New Norm for Instructional Development in a Research Setting

By Brian P. Coppola

In Short

- As a matter of principle, broadening professional scholarly development for future faculty logically follows from the interest in broadening the concept of scholarship to include teaching and learning.
- Strategically, broadening scholarly development to include teaching and learning does not need to be invented *de novo* because we already have an impressive system in place for educating the next generation in discovery research.
- The program built in the chemistry department at the University of Michigan involves five critical components: department/administrative leadership, faculty engagement, tested models for student participation, programming run by students, and dissemination of results.
- Changing the culture for teaching and learning in an academic department has relied on building on existing faculty and student roles and providing non-prescriptive guidance, with many points of entry and possible levels of participation.

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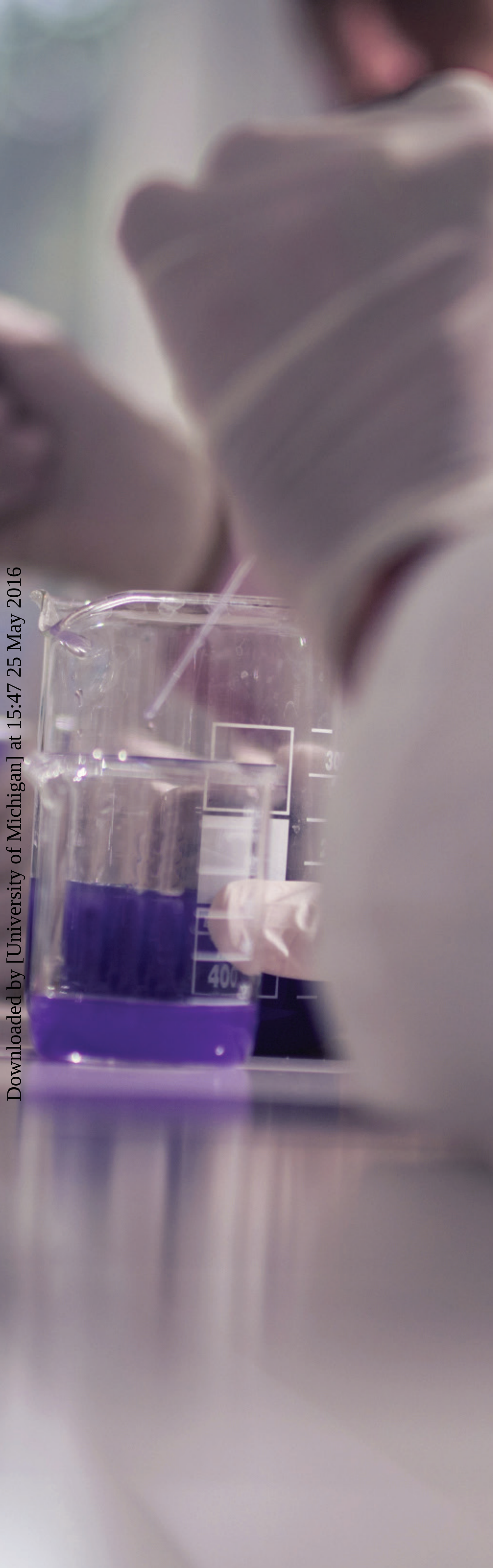

Boyer Was Right

I have always thought the single, key concept in *Scholarship Reconsidered* is captured in this sentence (Boyer, 1990; p. 16):

> We believe the time has come to move beyond the tired old 'teaching versus research' debate and give the familiar and honorable term 'scholarship' a broader, more capacious meaning, one that brings legitimacy to the full scope of academic work.

Despite the unresolved, and often tiresome, decades-long debate about what the scholarship of teaching and learning might mean, the revelation in Boyer's statement is that scholarship is something we already know and understand, if we can only adjust our vision enough to see its broader meaning. Boyer's charge: not to split and segregate academic work, "scholarship," but to reconcile false dichotomies and improve and advance the entire profession.

Without belaboring my own academic autobiography, two aspects of my career relevant to this article are (a) that I am a chemist and (b) that I entered the professoriate with a pre-existing belief about the need for and value of a broad and capacious view of educating future faculty (Huber, 2004).

Broadening Scholarship Also Requires Broadening Scholarly Development

Mainly because of a few accidental but highly formative experiences I had during graduate school (the late 1970s), I entered the professoriate with a single question driving my core interests. Seen in retrospect through Boyer's lens, the question is this: if scholarship should have a broader and more capacious meaning—based on everything we know about scholarship already—then must this not also apply to the infrastructure for scholarly development for what most faculty members will actually do in their (teaching) careers?

Said differently: the extent of professional readiness required for discovery research, resulting as it does in my discipline from 10 years of deliberate and intentional intergenerational work under the watchful gaze of – everyone! – should be, if not must be, broadened to include the full array of responsibilities and obligations for a member of a faculty on the first day of one's independent career. Seen through this lens, the traditional practice of not providing this level of professional readiness is at least irresponsible and would arguably draw accusations of malpractice in any other professional area requiring an advanced degree. If we trained physicians the way we train professors, we would never let them see a patient or use a stethoscope before they stepped into their first practice.

The emergent growth of the Preparing Future Faculty (PFF) programs and the increased attention to broadening professional readiness has been heartening. And yet, the vast majority of these programs, if not all them, are centered in administrative units and built with competency-based certificate structures and are still a far cry from the work done of, by, and for students as part of the intimate and signature educational processes that characterize their disciplinary educations. The standard PFF programs fall short of Boyer's charge because the level of engaged and informed independent work in them is nowhere near the level of one's disciplinary training for research and discovery.

The underlying rationale of PFF programs is absolutely correct: new faculty members are underprepared for the broad responsibilities and obligations of their careers. Similar calls and programs to improve the professional readiness of students in higher education have been widespread for decades. However, significant cultural and programmatic change in graduate education has been challenging, even as the need is obvious. Using my field as an example: in the vast majority of cases, being an effective chemistry faculty member requires so much more than designing and carrying out research, given that only 190 out of nearly 5000 higher education institutions in the United States have PhD programs in chemistry. And according to the American Chemical Society, 50% of PhD students are clustered at only 30 of these schools. By definition, the professional settings in which the majority of chemistry professors work differ vastly from the one in which they were educated.

As I said: I think Boyer was right. And so the key revelation from thinking of scholarship in a broader and more capacious way was the connection to professional and scholarly development: we did not need to invent or reinvent this because we already do it well for the scholarship of discovery. Instead, we realized that we needed to understand the existing features of professional and scholarly development and broaden these to include the broadening conception of scholarship.

Fortuitously, I was in a good position to think about a highly visible framework used to prepare scholars. As a chemist, and particularly as an organic chemist, I am the product of a finely grained and tiered professional development infrastructure laser-focused on research and discovery. Organic chemistry is laboratory intensive. "Running reactions" and "working them up" and "analyzing the results" requires constant face time in the lab, including working with (and living with) the other members of your research group for whom this is equally true. The intergenerational, familial structure of organic chemistry research groups is reminiscent of stories about one-room schoolhouses, where everyone has their chores, including and especially the responsibility for senior students to be teaching the junior ones at each step along the way.

The large scientific research group is an invention of the mid-twentieth century, only possible with the advent of government funding after WWII. The chemistry faculty member, who once continued to toil away with hands-on experimental work in the laboratory room that was always connected with a door to the faculty member's office, instead became a bit like the CEO of an organization. A faculty member in this co-joined office/lab became the leader of a scientific team, thinking big thoughts about the sorts of scientific projects that might be done by a group of 8–40 scientists-in-training (at different points in their own careers) on ideas that would have been impossible for an individual or a small group to pursue (Coppola, 2007, 2009).

> "The standard PFF programs fall short . . . because the level of engaged and informed independent work in them is nowhere near the level of one's disciplinary training for research and discovery.

Thanks to this infrastructure for professional and scholarly development, high school graduates can enter into about a 10-year program of intentionally designed growth and emerge from it as a scientist who can be expected to contribute, from the get-go, to advancing an independent area of investigation. And despite the huge advances in understanding that have happened in my field over the decades, the size of this 10-year box has not really changed. This is a remarkable testimony to the power of this model and what happens during that time, as generation after generation appears on the scene with fully realized capability and professional readiness – for doing science (Coppola & Roush, 2004; Caserio et al., 2004).

The rest of this article provides the elements we have created for broadening the professional development infrastructure for our students who are interested in academic careers. This program has been developed over many years, and truly represents a cultural change within an academic department. And at every turn, the most common answer to the question "how should we be doing this or that in the context of working with the future faculty on their professional development for teaching and learning?" has been a simple and reasonable one, namely, "how do we already do it for their professional development for research and discovery?"

CSIE|UM (Chemical Sciences at the Interface of Education)

CSIE|UM (Chemical Sciences at the Interface of Education) is the culmination of over twenty-five years of work by the faculty members in a single department (chemistry) at a single institution (the University of Michigan), through which we have changed our academic culture. After experiment, trial, and error, starting in 2014 we installed, with unanimous consent by the faculty, a professional development infrastructure that combined the traditional elements found in the existing research program: opportunities for faculty members to mentor teams of students on relevant projects, backed with financial, administrative, and programmatic support to enable the work. Building on a long departmental tradition of excellence in chemistry education, we launched CSIE|UM (pronounced "cesium," a volatile element).

Students in our department interested in academic careers, starting from the undergraduate level and extending to the postdoctoral level, can broaden their professional preparation to include education (preparation for teaching, instructional design, and education research). Simultaneously, following the powerful model of the research group in chemistry, CSIE|UM provides faculty members in our department—just in the same way it does for their research ideas—with a sustaining mechanism to develop and realize their ideas about instructional development and educational assessment.

I would be remiss if I did not emphasize that CSIE|UM has not been a simple, overnight fix. It represents the results of a generation of persistent efforts by a department committed to excellence in chemistry education, including supporting the faculty line I occupy. I have had the privilege and opportunity of seeing CSIE|UM emerge as a core component of my own scholarly work. As I wrote in the essay I submitted as part of my promotion and tenure documents in 1996:

> My proposition is that progress in science education is analogous to progress in all other forms of intellectual inquiry. It is also hindered by exactly the same factors. However, a formal infrastructure that guides the training of the future professoriate for their teaching careers does not exist. This is the acute problem I have begun to address at the post-secondary level… If you examine, all at once, the pieces that I have been constructing, you will see the outline of an infrastructure that could allow individuals the opportunity to develop an "instructional agenda" during their formal education. It is far from complete…

Above all else, I acknowledge the broad and capacious view of faculty work entertained, supported, and sometimes tolerated by my colleagues at the University of Michigan over a long period of discussion, experiment, and trial and error leading to the creation of CSIE|UM.

CSIE|UM has four components (http:// sites.lsa.umich.edu/csie-um):

1. Departmental administrative leadership

Prior to 2014, all of the individual pieces described here existed, and some of my faculty colleagues and their students, often with me as a collaborator, pursued educational development activities. Installing CSIE|UM as a departmental program has resulted in a combination of legitimacy, permission, and identity for work in education alongside exactly the same existing attributes for discovery research.

The department committed a dedicated budget line to CSIE|UM along with creating a new administrative position that I now occupy, called Associate Chair for Educational Development & Practice. Strategically, this approach took the features of my existing scholarly program and turned them into a compensated administrative duty with a discretionary budget and the authority to further develop the ideas, just as in the discovery research area.

Currently, my portfolio (as this Associate Chair) includes CSIE|UM; CALC|UM, a companion program for the professional development of students who are interested in non-academic positions in industry, government laboratories, and other private sector options; organizational leadership for some newly launched, standalone Masters degree programs; and point of contact between the faculty and the university for creating international agreements, as interest in global research collaborations has been growing rapidly.

> **"Students in our department interested in academic careers, starting from the undergraduate level and extending to the postdoctoral level, can broaden their professional preparation to include education (preparation for teaching, instructional design, and education research).**

2. Faculty engagement

Every semester, I solicit (from the department) descriptions of course and/or program projects to which faculty members wish to attract student collaborators, that is, to build a "teaching group" around their big ideas in education that is modeled on their deep, prior understanding of building a "research group" around the big ideas in research. From a department with 38 FTE (34 tenure track and 4 non-tenure track), there were 17 project solicitations posted at the CSIE|UM website for the Fall 2015 term, and 22 for the Winter 2016 term. The following examples are representative of how my faculty colleagues, all of whom are running active, funded, and world-class discovery research programs, have engaged instructional development because of CSIE|UM.

Professor Anne J. McNeil, a polymer and materials chemist, has led a number of projects. As an assistant professor, she and one of her graduate students, Cheryl Moy, developed and tested assignments for integrating Wikipedia editing into our introductory graduate courses (Moy, Locke, Coppola, & McNeil, 2010). Currently, as a part of her work in recognition of her achievement as an HHMI Professor, she and her team are creating and implementing a research-based undergraduate laboratory program into the 2000-student first-term, first-year organic chemistry program. They aim to produce a suite of 12 4-week modules, tested on a large scale, which can be selected by colleagues to create customized, project-based laboratory courses.

Professor McNeil notes that "having worked with students on curricular projects both before and after CSIE|UM, I have noticed that the students feel like their work is more legitimate now. They have a community of peers who are also taking part in educational activities, they can share ideas, give presentations, and go to conferences. Doing this work is no longer seen as a fringe behavior, but part of a larger group."

Professor Eitan Geva, whose expertise is in theoretical and computational chemistry, and his team of graduate student collaborators, have created a novel program called "compute to learn" (C2L; http://www.umich.edu/~gevalab). Selected students in three of our undergraduate physical chemistry classes learn a mathematical programming language and create student-generated instructional materials, available to the rest of the students, and more broadly through a public demonstration site. Geva has not only distributed his instructional development activities through his team of graduate students, but also brought in the undergraduates who are taking these courses as creators of useful instructional materials.

According to Professor Geva, "training students to be science educators and advocators as opposed to lab technicians has never been more important. In this context, creating forums for rethinking creatively about what makes for effective teaching and participating in the development and implementation of novel pedagogical approaches is key."

Not all projects are large and comprehensive, nor do they need to be. Professor Kristina Håkansson, whose specialization is mass spectrometry, routinely teaches in the introductory course in analytical chemistry. She and her graduate student collaborators developed a single new laboratory experiment in which undergraduate students can design their own physical, macroscopic model for studying the fluid flow issues that arise in the state-of-the-art scientific area called microfluidics. She and her group are currently exploring how to carry this out using 3D printing technology.

3. Tested models for student participation

We have neither been interested in nor supportive of thinking of education as a stand-alone area apart from one's core work and understanding of the discipline from which a truly discipline-centered approach to teaching and learning emerges. We are interested in the next generation of mainstream chemistry faculty members, who represent Boyer's ideal and who start their careers with an integrated, multidisciplinary understanding of chemistry and education. A resolution to the research-versus-teaching conundrum – how to do demanding work when time is finite – is by better educating the future faculty so that they are smarter with the time they have. Improving efficiency answers the ubiquitous plea from faculty members on how to do more with education, and forming "teaching groups" redefines the responsibilities for how this work gets done.

In the following ways, we have created diverse scholarly development opportunities for the different levels of students for whose training and education we are responsible.

Dual-mentorship research and teaching post-doctoral associates:

Since 2002, we have hosted over 50 individuals who had been, first and foremost, recruited into one of our research groups. These individuals also serve as instructors with one full course assignment per year, typically in one of the department's highly mentored, multi-section introductory courses, although this is not a requirement. This group has been extremely successful in obtaining faculty positions, and this experience is reported to be critical. As active members of research groups, all of these students were still engaged in the daily work of science, learning valued task and time management skills at the same time they gained first-hand teaching experience (Coppola, Banaszak Holl, & Karbstein, 2007).

Many of these individuals are tenured or are currently in tenure track positions, and all of them report the distinctive advantage of going into their interviews with the practical skills and knowledge gained through these positions. For example, Professor Nancy Goroff, now a full professor and senior administrator at Stony Brook University, was one of the first postdocs in the predecessor of this program. In reflecting on her experiences with us, she made what is still one of the most informative comments about moving into her independent academic career, "I started teaching with complete confidence and with a strong understanding of what I wanted to accomplish in the classroom. I have been able to do a better job with less effort because of what I learned in my postdoc. As I watch our newest faculty member prepare to teach his first class, I am glad that I had the chance to figure out how I wanted to teach before I was trying to balance teaching with getting my research established." Our dual mentorship postdocs have the option of joining one of the ongoing education projects as a part of their activities.

We have also used the post-doctoral program as a way to actively avoid hiring a cadre of short-term, non-tenure instructors to meet our teaching demands. We use the budget that would otherwise go for this purpose to support the lion's share of the postdoc's salary during the term in which they teach, and they are expected to be learning how to divide

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their time between research and teaching. Based on our enrollments, usual teaching demands, and the steady state of regular faculty who are not teaching for various reasons (leave, administrative duty, sabbatical, etc.), we have a minimum guarantee of eight CSIE|UM postdoc positions per year covering the teaching in eight courses in one of the two regular terms. To date, we have usually been hiring 9–14 of these individuals per year.

Graduate students:

We originally started integrating graduate students into teaching projects between 1998–2011, when we were using funding from the US Department of Education's GAANN (Graduate Assistantships in Areas of National Need) program. Part of that program's guidelines included an interest in encouraging our best domestic graduate students into academic careers.

We have institutionalized this graduate support by creating hybrid graduate assistantships we call FFGSI (Future Faculty Graduate Student Instructor) position. These positions are simply part of the regular pool of GSI positions we receive to cover our needs for undergraduate discussion and laboratory instructors in which 50% of the 20-hour contract is devoted to normal GSI duties while the other 50% is available for collaborating on faculty-led CSIE|UM projects.

The graduate students, most of whom were going to be GSIs anyhow, review the proposed faculty projects that are posted at the CSIE|UM website and contact those faculty members for more information about what the project might entail. The graduate students then apply to be an FFGSI, including a brief description of their role on the project, along with short statements from the project leader and the student's research advisor, who both need to support the student's participation. Readers interested in the details of the financial model can contact the author directly for that information. The key aspect of the College's approval for these hybrid GSI positions was the credibility we had because the positions were one part of a comprehensive program with clear precedents and support mechanisms, and not a standalone effort.

Other options available to our PhD students provide credit and support parallel to what they regularly have available in their research training. They may use education classes, typically in the School of Education or the Department of Psychology, where our colleagues have been welcoming of bringing post-secondary education perspectives into their courses, to satisfy their PhD cognate requirements. I also collaborated with the School of Education to create a new MS degree in post-secondary science education that can be earned along with the PhD in chemistry. The only proviso is that the MS degree cannot be awarded until and unless the PhD is earned, to prevent the MS path from being an escape route for students who might leave the PhD program. Since 2003, some of our doctoral students have elected to include chapters on their education work as a part of their dissertations—*not in lieu of any research chapters, but in addition to them.*

As with the post-doctoral positions described above, CSIE|UM has been a powerful tool for bringing excellent graduate students into the department, providing the department with a unique and competitive recruiting advantage. My younger colleagues, in particular, have used their support and interest in the CSIE|UM framework to help attract students into their research groups.

Undergraduates:

As we know from undergraduate research, students can be a powerful and positive addition to any team. Undergraduates have participated in various parts of the teaching program for many years, as both instructors and as participants on CSIE|UM project teams. They can enroll in the independent study course mentioned in the previous section or, if the work is budgeted, they can be paid, just as we do with undergraduate research participants.

3. Programming initiated, organized and implemented by students

Learning how to plan and run seminar programs, workshops, and symposia is another legitimate activity for future faculty development, therefore our preference is not to do these things for the students, but rather make these activities a part of what students can get involved in doing for themselves. Under my supervision as CSIE|UM director, an organizing committee of 10–12 graduate students and post-docs meets regularly to create, plan, organize and implement events of general educational interest for the department. This creates opportunities for students to develop critical organizational management, leadership, and interpersonal skills that they would not otherwise get during their research training. These are critical skills, and, as Director, I have set this up as an active mentoring relationship with the

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committee members, where we talk about steps and strategies, and where they share drafts of messages and discuss options.

Recent programming has included seminars and panels addressing topics such as (a) working with underprepared students, (b) preparing for interviews, with mock interviews featuring faculty members representing different institutional types, (c) teaching with technology, (d) balancing teaching and research in faculty careers, and (e) research-based laboratory design. In June 2015, the entire organizing committee functioned so well together that they proposed, completely planned, and carried out the first CSIE|UM regional symposium. At this symposium, the CSIE UM students hosted a group of 90 participants, 25 of whom were from outside the University. The topic for the day was the use of authentic research experiences in undergraduate laboratory instruction, which was featured in a morning plenary discussion, in a noontime poster set over lunch, a set of four concurrent hands-on sessions led by CSIE|UM project participants in this topical area, and an end of the day seminar by an external speaker.

We are currently pursuing plans to create off-site, 2–4 month teaching internships at host institutions, including international settings. We are also developing the idea of coupling CSIE|UM activities with our research-based MS chemistry programs. We hope to recruit and train individuals who might be particularly attractive hires in educational settings with high populations of underserved students.

4. Going public: dissemination, collaboration, and hiring

Regardless of the variation in how the scholarship of teaching and learning has been contextualized, Shulman's highly popularized notion of "going public" with one's work as community property, subjecting it to peer review and critique (Shulman, 1993), is a key ideal. As with discovery research, students and their faculty mentors have many different venues where their work is presented and evaluated, and so CSIE|UM activities must be necessarily so, too.

In addition to the roughly 50 individuals who have been in the dual mentorship postdoctoral program, about 65 graduate students have been involved with instructional development projects, and four have earned the MS in Education. Over 300 undergraduate students have been involved in CSIE|UM as discussion or laboratory instructors; a particularly strong group of over a hundred of them have been the primary instructors for honors organic and physical chemistry. Student collaborators have co-authored papers and given conference presentations about their education work in addition to the graduate students who have represented it in their written dissertations (Matz, Krajcik, Rothman, & Banaszak Holl, 2012; Danowitz & Taylor, 2011).

> "We have . . . launched the pilot offering of a parallel professional development program for the rest of our students, in particular who will be seeking jobs in the industrial, government, and other private and public sector venues.

Graduate schools and employers have given our students preference because CSIE|UM results in the sort of well-rounded faculty members they want to hire. Professor Alan Kiste (Cal Poly – San Luis Obispo) claims that "CSIE|UM is going viral; I am not alone in replicating parts of the program that work at my institution, and now my own students are having the same success that I did. CSIE|UM participants develop expertise in combining chemistry and education; their work draws from contemporary ideas about teaching and learning, feeding back to the general educational expertise of the department." Jason Pontrello (Brandeis University), who as an undergraduate helped develop the Structured Study Group program in organic chemistry during 1994–1999, has build impressively upon this work in the area of chemical biology (Boltax, Armanious, Kosinski-Collins, & Pontrello, 2015; Coppola, Daniels, & Pontrello, 2001; Pontrello, 2015).

CSIE|UM has had a critical and positive effect on the culture of our department. The success of our students is tied to faculty engagement, as in research. Members of the department have been successful attracting external funding for education initiatives, and we have created a discipline-centered and evidence-based mechanism for continuous improvement in our educational mission (Coppola & Krajcik, 2013, 2014).

Moving Forward

I have no hesitation in saying that CSIE|UM is a part of who we are (identity) and what we do (mission) as an academic department. We have also received some recognition for this work.

Our department received the College's 2015 Award for Education and a 2016 Provost's Teaching Innovation Prize. In her award citation for the former, the Associate Dean remarked "While Chemistry received this award only six years ago, it is clear that the department has not rested on its laurels, but continued to renew and extend its commitment to a deep-seated culture of educational excellence and innovation. There are many examples of this pattern: CSIE|UM ...provides a remarkable forum for innovation in undergraduate courses; the department's participation… and recognition through [both internal and external grant programs]; and the department has worked to provide greater customization and a better fit between student interests and available educational opportunities..."

CSIE|UM is a proof of concept. Professor Art Ellis (currently Provost, City University of Hong Kong), a long-time friend of our department, in reflecting on a presentation about CSIE|UM, expressed that our most impressive accomplishment was to have "built this into the DNA of the department" by making it a part of the mission and identity of the chemistry program. CSIE|UM was also shortlisted in the 2015 "Reimagine Education" award competition (http://www.reimagine-education.com) in its Nurturing Employability category.

This year (2015–16), the department has taken this proof of concept one step further, and we have, in September 2015, launched the pilot offering of a parallel professional development program for the rest of our students, in particular who will be seeking jobs in the industrial, government, and other private and public sector venues. In this program (*Chemistry Aligned with Life and Career at the University of Michigan;* CALC|UM, pronounced "calcium"), we have opened our doors to companies and organizations to help educate and inform our students about better understanding and preparing for the post-university careers. We are also adapting the hybrid GSI model so that graduate students in chemistry can potentially collaborate with faculty members and programs of direct relevance to diversifying their skills and integrating their expertise with other areas such as law, business, public health, public policy, and entrepreneurism.

Yet, as noted previously, CSIE|UM is also just one department in one institution, and so, despite Alan Kiste's optimism about its viral nature, it is impossible to say whether we have done something that is inherently reproducible or intrinsically irreproducible. From a scholarship perspective,

The CSIE/UM Alumni Speak:

I was challenged on several interviews why I chose to teach and not be in the lab. I defended the scholarship that one needs at the helm of the classroom. It has truly made the transition easier and enjoyable.

Professor William Pomerantz
(University of Minnesota)

I was never under water with the course I taught as a CSIE|UM postdoc, but I was exposed to all the intricacies of a course, from designing effective assessments to addressing academic dishonesty situations. Months later, I believe this experience catapulted my application through the interview process at a primarily undergraduate institution.

Professor M. Taylor Haynes
(California Polytechnic University – San Luis Obispo)

To maximize their potential, students need an environment where they are challenged and stimulated, but also feel comfortable taking intellectual risks, one in which an error is not viewed as a failure but rather as an essential part of the learning process. I seek to show my students unconditional support along their personal and professional journey, and in this way channel what I learned at Michigan to inspire the next generation of young scientists.

Professor Keary M. Engle
(The Scripps Research Institute)

My participation in CSIE|UM in no way slowed or diminished my progress toward my PhD, but in fact helped me to better manage time and remain very focused on completing my work, much the way faculty members must balance teaching, research and service. The skills, experience and confidence I gained were critical differentiators when I began interviewing for faculty positions.

Professor Megan Frost
(Michigan Technological University)

Now that we lead research groups at Vanderbilt and mentor postdocs, grad students, and undergraduates, we especially appreciate how impressive it was that participation in the program was keyed in on drawing out the innate strengths of undergraduate students, generating a strong sense of ownership on our behalf, and involving everyone in sustaining organizational activity and engagement while continuously recognizing progress and milestones.

Professor Rebecca Ihrie (Vanderbilt University)
Professor Jonathan Irish (Vanderbilt University)

Several students in my laboratory were also involved in this program and our advisor was constantly asking us questions about our experiences. These conversations and discussions have had a profound impact on the manner in which is handle situations that arise in my current department. I see multiple perspectives that I would not have developed or been aware of without the opportunities.

Professor Melissa M. Reynolds
(Colorado State University)

on the other hand, perhaps this conundrum is exactly true, all the time: a discovery is made, or an invention is created; the work is made public and the people who worked on it go out into the world with the expertise of their experience, and they test and tinker in their new context. The scholarly community decides about its community property, after all, and whether they can (or want) to live with a discovery or an invention based upon whether or not it serves their purposes, and matches their own identity and/or mission. Within my local community, the department of chemistry at the University of Michigan, the answer to these questions has been resoundingly "yes."

Acknowledgments

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Resources

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