Award Address

The Most Beautiful Theories[1]

2006 James Flack Norris Award

by Brian P. Coppola

> *Die schönsten Theorien werden durch die verdammten Versuche über den Haufen geworfen, es ist gar keine Freude mehr Chemiker zu sein.*
>
> Liebig an Berzelius; Giessen, 22 Juli 1834

… which, roughly, translates as "The most beautiful theories are thrown onto the heap by these damned experiments, it is no fun at all to be a chemist any more."

Prior to his work on "practical" and "animal" chemistry *(1),* Justus Liebig was a theorist *(2).* Of course, this does not mean he was a computational chemist! Theorists contemplated the world in the way of the ancient Greek scholars, where the purity of thought could only be uselessly cluttered by the reality of phenomena. This quote *(3)* provides a delightful insight into the frustration Liebig may have been feeling as empirical evidence and careful documentation began to dominate scientific practice in chemistry prior to his own deep embrace of these principles.

Today, less than 200 years later, an array of exacting standards guides scientific practice: that one must understand what has been done before, that scientific knowledge is verifiable and reliable, that results are made publicly available in archivable form, that there needs to be sufficient credible evidence to warrant claims, and that Occam's Razor should be used liberally to winnow indefensible fantasy from our models. As academics, we use these "tenets of scholarship" and "scholarly practice" in order to differentiate good science from bad science.

Education, I think, is populated by instructors who hold "beautiful theories" about teaching, about students, and about student learning—uncluttered by knowledge of what is known experimentally about education, unaware of how to couple their understanding of science with designing and assessing learning environments, without access to a body of knowledge about how to promote mastery of the subject that has been learned by others, and unable to translate their work into forms that are useful for others. This is less a criticism than it is a simple description of current practices. Instructors' beautiful theories work for them, they explain their worlds; and when challenged that they might do better, many are quick to tell you their favorite maxim: nothing is broken, why fix it? Unfortunately, these theories about teaching are comparable to Liebig's theories about chemistry in the 1830s. And as was clearly true for Liebig, the prospect of change creates anxiety, and anxiety creates resistance.

Photo by Alan Kiste, University of Michigan.

Figure 1. Brian P. Coppola.

In this paper, I want to contrast how two centuries of scholarly practices have transformed the way in which science is done with the way we think about education. Drawing significantly on my work with the Carnegie Foundation for the Advancement of Teaching, I will emphasize the non-synonymous relationship between "scholarship" and "research," and suggest structures that we might create, based on what we understand from scholarly research, in order to advance the profession of teaching and learning.

The Meaning of Scholarship

The term "scholar" has been around for a millennium, and its meaning has shifted over time. A brief history of the term "scholar" is provided in the Supplemental Material.[W] In 1990, in the most recent contribution to this story, Ernest L. Boyer, President of the Carnegie Foundation for the Advancement of Teaching, and his colleagues published *Scholarship Reconsidered,* a slim volume with a single, simple message *(4):*

> 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.

Boyer argued that scholarly practices, which advanced spectacularly the discovery of knowledge (to the point where scholarship and research became synonyms) could also advance the teaching, integration, and application of knowledge as well as its discovery. After 17 years, the Carnegie Foundation's effort to make the meaning of scholarship more encompassing has had some success: many institutions (and individuals) have integrated a broader definition of scholarship into the way they think about faculty work, including into their promotion and tenure guidelines.

The meaning of scholarship continues to evolve. Today, I would say scholarship is the process by which, over 200 years, the discovery of knowledge has evolved from personal and idiosyncratic "beautiful theories" to become a system of reliable community practices that moves our understanding of the world forward. Scholarship is not a mere synonym for the research that discovers new knowledge, but it is the process by which we design and implement good research instead of bad research, and it is the lens through which we assess the documentation of research presented to us, by others, in order to evaluate it—for publishing, for funding, for elaborating, and for advocating.

Characteristics of Scholarship in the Discovery of Knowledge

In both of the Carnegie Foundation's books, *Scholarship Reconsidered (4)* and *Scholarship Assessed (5),* the characteristics of scholarship and the criteria that are used to assess it, respectively, are derived from studying existing practices, finding commonalities, and putting these into a common language. In working with the Foundation, I became intrigued by what had not been covered in these books, namely, the question of scholarship developed. What is the process by which, in a roughly 10–14 year period, academics do their most distinctive work: how do they help transform high school graduates into the next generation of professionals who not only (literally) represent the state-of-the-art in research, but who are also responsible for defining and cutting the leading edge of their professions?

I think role reversal, for example, is a key strategy for developing scholarship. During formal education in discovery research, we are compelled to catapult our students ahead of us. Indeed, perhaps the most important criterion used to assess professional readiness is when the student knows more about a research project than the advisor does, and becomes its director.

When I examine the history of scholarship, and particularly its modern meaning, I see four characteristics of what it means to learn how to discover new knowledge according to the tenets of scholarship. For the sake of clarity, and acknowledging what is still familiar practice, I will use the terms "researcher" and "research" in the text of these descriptions for the people and practices associated with the discovery of knowledge.

1. Scholarship in the discovery of knowledge means that the work is *informed*.

   A researcher should know as much as is knowable about the problem at hand, how to search that information out, how the problem fits into the overall needs and interests of the research community, and how to evaluate the scope and limitations of the research methods that were used to generate the resulting knowledge. A researcher understands the standards of practice that affect the design of a project, including critical issues of intellectual property, authorship, ethical conduct, and resolution of conflicts.

2. Scholarship in the discovery of knowledge means that the work is *intentional*.

   A researcher should be able to link explicitly, or align, the informed goals of a project with the methods being used to implement it, and to have defensible arguments for why these choices will result in the expected knowledge gains. A researcher should provide multiple and reliable sources of evaluation data that address directly the goals set out by the research objectives and the methods used to implement the research design.

3. Scholarship in the discovery of knowledge means understanding that the model is *impermanent*.

   Researchers understand that their contributions are tentative and theory-laden, and the new questions that arise from their research will make the work itself a target for falsification. The decreasing half-life of information *(6)* has significant consequences for the lives of academic researchers *(7)*, or, said more plainly, it is not so much that we are eliminating the flat earth model as much as we are creating the next best version of it. Only intellectual arrogance makes us think that we have finally found a single, immutable answer to anything. The phenomena (e.g., gravity, chemical affinity, hurricanes) remain, but at any moment the model is open to evolution or revolution. Understanding impermanence can keep researchers critical about their own work and less inclined toward conservative critics who say "Science progresses funeral by funeral." *(8)*

4. Scholarship in the discovery of knowledge means that both results and processes are *inheritable*.

   Researchers provide the kind of documentation of their work that allows other researchers to evaluate it without having looked over the shoulder of the practitioner. A researcher's body of work exists in forms that can be shared, learned from, and built upon. However, there is much more to the process of becoming a researcher who follows the tenets of scholarship than having access to a good library! All of the characteristics of scholarship… work that is informed, intentional and documented, and acknowledges impermanence… need to be learned, too. And as with most things, explicit and deliberate instruction is better than implicit and haphazard instruction.

I have called this fourth characteristic of scholarship "inheritable" for this reason: the mentor/protégé relationship is more than just the transfer of information or generic habits of scholarly practice. Instead, learning is intimately tied to the individual mentor who "passes on" what he or she knows. Academic pedigree, which is often referred to in genealogical terms, is a primary part of a researcher's identity. The essayists in DiLeo's volume on the "you are who you know" culture of academia *(9)* would rightly agree that the researcher you will be, and the opportunities you will have available, are tied to the particular people who mentored you during your undergraduate, graduate, and post-doctoral education.

The concept of inherited wisdom is particularly keen in the sciences. For the past 60 years, the mechanisms for educating the next generation needed to be more complex than simple one-on-one interactions because, in great part, accessible public funding (NIH, NSF, etc.) made the large, multigenerational research group the norm for how research gets done. As a consequence, ironically enough, the senior member of an academic scientific research team (the faculty advisor) is generally identifiable as the person who does not personally carry out experiments. And if you remove the research students from any science department, it is fair to say that the amount of new knowledge produced would damp to zero in short order.

Is the research group a peculiar invention of science that is somehow tied to the scientific disciplines? I think not. My assumption is that research groups were a response to an opportunity, made available by funding, for academic scientists to take on scientific projects that had only otherwise been possible for their non-academic counterparts in industrial and private institutional settings. Although it is fair to say that science, engineering, and manufacturing have taken the most advantage of this strategy, faculty members such as my colleague, Eric Rabkin, a professor of English, has adapted the research group model to take on a problem in analyzing short stories in his Genre Evolution Project *(10)*.

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Unlike for the majority of our colleagues in the arts and humanities, where the work of individual faculty members produces outcomes directly (as single-authored articles, books, paintings, compositions), research groups rely on an important quid pro quo relationship among their members. The most important of these is an implicit contract between the research advisor and the group: the advisor can take on a scientific research agenda that is much larger in scope than any individual might accomplish, and in exchange, the group members receive an education, and usually financial support, that enables them to develop their research scholarship. There are other important social contracts, such as how senior group members are responsible for helping to train the junior ones, how all members of the group are responsible for their own independent parts of the larger project, and how each member of the group tends to have some sort of group responsibility, or chore, that contributes to the operation of the group as a whole.

From a student's perspective, there is a 10–14 years continuum as one moves from being an undergraduate in one setting to a graduate student in another, and then to being a post-doctoral associate, gathering experiences and increasing levels of responsibility on the way to becoming an independent researcher. Figure 2 represents the progression of responsibilities that one takes through this professional development process while a faculty member's research program is simultaneously moved forward.

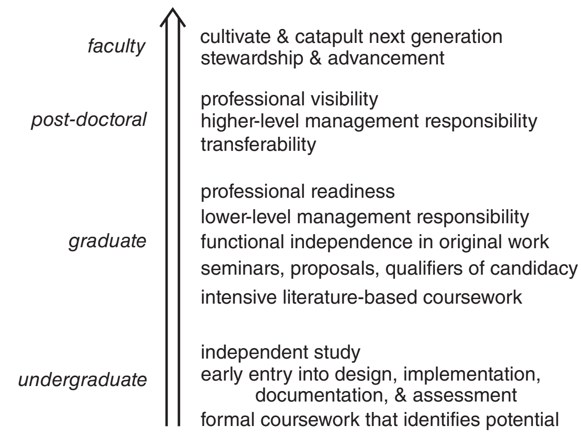

Figure 2. Progression of responsibilities taken on during the professional development of a faculty member.

A research group is a spectacular model for how to get large and complex work done, as well as to provide a structure in which scholarship is developed. Roald Hoffmann *(11)* believes that research groups, as we know them, are the primary reason why graduate students in the U.S. hopscotch in creative ability over their better-trained European and Asian counterparts during graduate school. Is this true? We do not know. As a mid-twentieth century phenomenon, large academic research groups have been studied as organizational structures by only a few educational researchers *(12–16)*. Much more work is needed to understand research groups, because they are an important mechanism by which the intellectual and social "genes" for learning about scholarship (what Dawkins calls "memes") *(17)* are inherited.

Extending the Discussion to Teaching and Learning

In arguing for a "broader, more capacious meaning" of scholarship *(4),* Boyer and his colleagues proposed that, in addition to a scholarship of discovery (that is, the tenets of scholarship as applied to research), that there could be a scholarship of teaching and learning. Going by its clumsily pronounced acronym (SoTL), the SoTL community comprises a widespread group of faculty members, administrators, and personnel from college and university teaching centers *(18)*.

Randy Bass, in a seminal 1999 article ("The Scholarship of Teaching: What's the Problem?"), provides what I think is a powerful litmus test for the existence proof of a scholarship of teaching and learning *(19):*

> One telling measure of how differently teaching is regarded from traditional scholarship or research within the academy is what a difference it makes to have a "problem" in one versus the other. In scholarship and research, having a "problem" is at the heart of the investigative process; it is the compound of the generative questions around which all creative and productive activity revolves. But in one's teaching, a "problem" is something you don't want to have, and if you have one, you probably want to fix it. Asking a colleague about a problem in his or her research is an invitation; asking about a problem in one's teaching would probably seem like an accusation.

In other words, we readily differentiate between the meaning of the word problem in the following two phrases: "my research problem" and "a problem with my research." In the first case, we mean a project in which we are investing our scholarly energy, into which we welcome students and faculty collaborators in an intellectual pursuit. In the second case, the sense of the word "problem" shifts to a difficulty that needs to be fixed. When you quite literally swap the word teaching for the word research in those phrases, the dual meaning of the word problem disappears. We read and understand "my teaching problem" as synonymous to "a problem with my teaching." Language, once again, is revealing. A scholarship of teaching and learning will not exist, I believe, until we have language (and therefore the idea) that differentiates the meaning of the two teaching phrases to the same degree that we differentiate the two research phrases.

If the meaning of scholarship is broad and capacious, then, as a first approximation, the teaching for research swap can be used to help understand what a scholarship of teaching and learning looks like. By studying and describing the characteristics of scholarship that we understand so well from research, we can then quite literally read how the tenets of scholarship suggest what is needed to advance teaching and learning.

To be fair, replicating the tools and features of research for teaching purposes is the basic strategy that a number of projects hosted by the American Association of Higher Education used during the 1990s, such as developing course portfolios *(20)* as a source of documentation for the peer review of teaching *(21)*. In working closely with many of the people in these projects, my concerns remained constant: scholarship as we know it is not one thing, such as peer review, but a highly evolved network of things that all may need to be developed in concert. Creating a sophisticated version of only one aspect of scholarship might be like trying to hang a custom-made Tiffany chandelier in the foyer of a house whose foundation has not yet been dug.

I saw a two-staged approach to the question. First, what are the characteristics of scholarship? And, then, what are the characteristics of a scholarship of teaching and learning? If scholarship not only includes the objects of and processes for carrying out scholarly work (informed, intentional, impermanent), but also pays explicit attention to how we educate the next generation (inheritable), then an approach where all of these pieces are staked out and allowed to grow together might be necessary.

Extending our understanding of scholarship from research to teaching can be done using the Bass substitution strategy *(19).* In every case, except for the examples of phenomena in the "impermanence" paragraph, only the word "research" has been changed to a form of the word "teach" in the following four texts from earlier in this paper:

1. Scholarship in teaching and learning means that the work is *informed*.

   A teacher should know as much as is knowable about the problem, how to search that information out, how the problem fits into the overall needs and interests of the teaching community, and how to evaluate the scope and limitations of the teaching methods that were used to generate the resulting knowledge. A teacher understands the standards of practice that affect the design of a project, including critical issues of intellectual property, authorship, ethical conduct, and resolution of conflicts.

2. Scholarship in teaching and learning means that the work is *intentional*.

   A teacher should be able to link explicitly, or align, the informed goals of a project with the methods being used to implement it, and to have defensible arguments for why these choices will result in the expected knowledge gains. A teacher should provide multiple and reliable sources of evaluation data that address directly the goals set out by the teaching objectives and the methods used to implement the teaching design.

3. Scholarship in teaching and learning means understanding that the model is *impermanent*.

   Teachers understand that their contributions are tentative and theory-laden, and the new questions that arise from their teaching will make the work itself a target for falsification. The decreasing half-life of information has significant consequences for the lives of academic teachers, or, said more plainly, it is not so much that we are eliminating the flat earth model as much as we are creating the next best version of it. Only intellectual arrogance makes us think that we have finally found a single, immutable answer to anything. The phenomena (e.g., motivation, cognition, creativity) remain, but at any moment the model is open to evolution or revolution. Understanding impermanence can keep teachers critical about their own work and less inclined toward conservative critics who say "Science teaching progresses funeral by funeral."

4. Scholarship in teaching and learning means that both results and processes are *inheritable*.

   Teachers provide the kind of documentation of their work that allows other teachers to evaluate it without having looked over the shoulder of the practitioner. A teacher's body of work exists in forms that can be shared, learned from, and built upon. However, there is much more to the process of becoming a teacher who follows the tenets of scholarship than having access to a good library! All of the characteristics of scholarship… work that is informed, intentional and documented, and acknowledges impermanence… need to be learned, too. And as with most things, explicit and deliberate instruction is better than implicit and haphazard instruction.

Reflections on Current Practices

In my award address, I called this "the part where I bite all the hands that have fed me".

Over the years, I have worked with many of the people and organizations that have been concerned with improving higher education. These interactions have helped shape my thinking and ultimately moved me to the positions I have taken on this subject. I want to provide brief reflections on the six efforts that, in my view, comprise the main landscape for thinking about teaching and learning in the United States. As with all broad characterizations, there are better and worse exceptions than a single caricature can provide. Far from a critique, I am attempting here to convey a general impression about these systems and to provide a fair comparison about the limits that make up any system. This is a personal view based on my experiences.

The Professional and Organizational Development (POD) Community

What I think is good: The typical place where you find POD activity is in a campus's Center for Teaching Excellence (or whatever it is called locally); these organizations recognize that faculty members hit the ground of their new positions under-prepared, and the staff of these centers provide much-needed intervention and service to their constituencies.

What I think is not as good: While POD staff recognizes that faculty members are the incomplete product of a flawed system of faculty preparation, there is a tendency to treat faculty members as students. And by treating faculty members as students, and waiting until the start of one's professional appointment, the POD approach epitomizes the "I have a teaching problem" mentality and does not address solutions for the flaws in the system that gave rise to the need for Teaching Centers in the first place.

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The Scholarship of Teaching and Learning (SoTL) Community

What I think is good: The SoTL initiatives have inspired mainstream faculty members to think about reflective practice, and to treat one's individual activity in the classroom as an object of inquiry. There is an excellent focus on learning to document artifacts that provide evidence for student learning.

What I think is not as good: Since the outset, the SoTL community has wrestled with its relationship to the education research community. In the first issue of the *International Journal on the Scholarship of Teaching and Learning (22),* the opening essay by Pat Hutchings focuses on the growth of using educational theory (and other theories) as a basis for carrying out classroom research. Nearly all of the articles in this issue, gathered in a section titled Research, are indistinguishable from the papers I review for various education research journals. If the scholarship of teaching and learning reduces to the subset of educational research where your own class is the object of the research, then I do not think there is a need for the SoTL label. What is missing from the articles in this inaugural issue is any sense of faculty members who are teaching their subject, reporting on how they are making informed pedagogical choices, and where their instructional goals are aligned with the teaching methods they are using. The scholarship of teaching and learning is too often used only as a noun… as a thing that is being done, rather than as overall process concerned with informed design, aligned implementation, and how the next generation is educated.

The PhD in Chemistry Education Community

What I think is good: This group fills a significant void in many schools of education where there is no research focus on post-secondary teaching and learning, so some good research is getting done in this area.

What I think is not as good: There is an unfortunate tendency for this group of faculty to see themselves as the self-appointed "chemical educators", and an even more unfortunate tendency for the rest of the faculty to think that this is just fine *(23).* Two-tier faculty systems are intrinsically problematic. More than that, though, I cannot support a system that dissociates and absolves people who are called "professors" from their responsibilities as educators. I also think that locating these degrees solely in departments of chemistry is an error because they are that much more removed from the learning sciences. Even more importantly: education is not a dissociable sub-discipline from the academic disciplines; it is the one common interdisciplinary connection that is shared by everyone who holds the title professor. Advancing the profession, in my view, derives from individuals who possess a deeply integrated understanding of the subject and its pedagogy *(24, 25).*

The Teaching As Research Community (26)

What I think is good: This group recognizes the need to integrate mainstream students and faculty members on teaching projects, and otherwise shares many attributes with the SoTL community. The program has assembled extensive bibliographies.

What I think is not as good: The bulk of the investment is in workshops and classes, and the open concern is the degree to which the actual teaching activity is marginalized. More than that, however, is the language: the slogan "teaching as research" misses the point by a country mile. Like it or not, learning is significantly a social science, and there is no evidence to support the idea that bringing the armature of the physical sciences to the interesting problems in education can yield useful information. Let me explain with an example: a physical scientist might look at the study of some Ansel Adams photographs and decide that measuring the black-to-white ratio is something that could be done with the instruments at hand. But in the end, knowing that a given photograph is exactly 45.86% black is quantitatively accurate and intellectually meaningless. "Teaching as research," rhetorically, misses completely that research can be done badly by ignoring the tenets of scholarship in order to sort out what is interesting and important from what is not.

The Adapt and Adopt Community

What I think is good: Robust deliverables.

What I think is not as good: Robust deliverables. I have enormous respect for the community of people who have worked so hard to make active classroom practices, as an example, accessible to faculty members who were otherwise treating classrooms as a place to deliver seminars as a form of instruction. Personal responses systems, Peer-Led Team Learning *(27),* Process Oriented Guided Inquiry Learning *(28),* and so on, many of which are the stepchildren of Angelo & Cross's Classroom Assessment Techniques *(29),* have actually changed practice on a measurable scale. This is terrific. Unfortunately, there is a methodological evangelism (a magic bullet syndrome) that does not care to link, or align, specific learning goals with a rationale for why understanding the subject matter will improve when these methods are used. In addition, because improved test scores is a ubiquitous measure of academic achievement, evidence for improved learning is inferred from higher scores. And while this might be an indicator, we also know that students can learn to pass tests, particularly multiple choice ones, without learning the underlying concepts *(30–34).* With the adapt and adopt strategy, I have observed well-intentioned faculty who think about education as a trip to the supermarket, to see what new products there are to pull from the shelf.

The Preparing Future Faculty (PFF) Community (35)

What I think is good: PFF programs have raised the level of consciousness about improving professional readiness and substantively educated students about both the depth and breadth of faculty life. PFF, in great part, was a response to the reports and concerns of young faculty and graduate students *(36, 37)* on whom expectations were rising but for whom there were diminishing resources. One of the important rationales for PFF programs was the fact that only 6% of schools grant doctoral degrees, so, by definition, the sort of school where a Ph.D. is likely to get an academic position is unlike the place where their doctorate was earned.

What I think is not as good: With some exceptions, PFF is a marginalized activity within departments, and tends to be centralized administratively rather than in departments. There are too many stories of students in PFF programs who keep their participation below the radar for fear of retaliation from their advisors for being away from their research. The PFF curriculum is generally divided between administrative units (such as a graduate school) and the non-Ph.D. granting partner schools; so, in effect, mainstream faculty members have outsourced the "learning about teaching" part of their responsibilities. Perhaps not surprisingly, the national review *(38)* found that PFF had had only moderate impact on change in either the core PhD-granting departments and, interestingly enough, even less on the partnering departments. While there is no single response to PFF programs, a caricature of the reactions heard from the established science faculty is: "I did not need this, and I am a good teacher, why should they?" or "Nothing's broken, what are you trying to fix?" or "There is plenty done for young faculty once they start their careers." You get the idea.

In the following section, I will describe the work that I have been involved with for the last 10–15 years. There are many features in common with the six programs described here. And to be fair, I will also end this section with the same not-as-good look at my own beautiful theory about how to improve the state of teaching and learning.

IDEA: Instructional Development and Educational Assessment

Building teaching groups on the experience of building research groups

Faculty members in the laboratory sciences develop their teaching ideas quite differently from their research ideas. In fact, they carry out teaching projects the same way a historian does research: alone. Yet, particularly in science, we successfully involve inexperienced students in our discovery research plans, using a system that engages potential researchers as early as their entry into college, and one that continues to move them along through the end of their post-doctoral period. That same system should, hypothetically, engage those students who want to add education, along with science, to their professional preparation—not all of our students, but rather that subset interested in academic careers. As I argued earlier, I do not believe that working on large, team-based projects is a priori limited to scientific research just because science caught that particular wave when the tide of public funding came in.

As a strategy to improve professional readiness for future faculty members, building teaching groups from the personnel in our research groups and taking on the teaching missions of our departments, serves everyone. The demands for excellence in teaching have increased, as have what we understand about teaching and learning. As academics, attending to the best possible professional readiness for those who become professors is our unique and key obligation; our only choice is how well (or badly) we do it.

In our departments, we have faculty members who have broad, big-picture ideas about what they want to accomplish in their teaching; at the same time, we have, depending on the institutional setting, undergraduates, graduate students, and post-doctoral associates, a subset of whom are interested in academic careers. My goal, starting in the early 1990s, was to lower the barrier to bringing these two groups together and to enable their work. As a strategy to address the scholarship of teaching and learning, my proposition was that focusing on the "inherited" characteristic of scholarship, that is, how we develop scholarship, would subsume all of the others.

Building "teaching groups" started by simply following the Bass substitution strategy. The things we do to promote professional readiness for research already exist, and these are represented in Figure 2. Over the last 10 years, if I was asked the question "How do we handle this for doing teaching projects?" then I have learned that my first, best answer is "Let's take a look at what we already do in research and create an analogy."

In an abstract sense (following Figure 2), that means thinking about instructional design that will not only identify students for their potential as researchers (such as with discovery-based laboratories), but also for their potential as teachers. It means you can think more expansively about what you ask students to do in a course because you are going to partner with your instructors-in-training on your teaching ideas in the same way you partner with your researchers-in-training on your research ideas. It means thinking through what parts of a project can be implemented by undergraduate collaborators, graduate collaborators, and post-doctoral collaborators. It means working with people outside your own areas of expertise in order to innovate with instructional design or to collect and understand assessment data. It means coursework and seminars for students in areas of education. It means finding fellowship support for Ph.D. students and post-doctoral associates, because that is how we operate, in general, when we carry out interdisciplinary work. And it means that all of the participants are still first and foremost (in my department) chemists; they are not a separate or segregated subset of faculty members and students who are the educationalists, rather that subset of mainstream scientists in the department who simply want to add this work to their

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portfolio. And in the first iteration, it means having one or two people around who can take leadership for organizing and administering this activity within the department.

A decade later, we have made progress *(39).* When my colleagues think about doing instructional development, they think about partnering with students in order to get that work done. We have sections of our first-year courses where the instruction is deliberately designed to help reveal both disciplinary expertise and the ability to teach along with creating instructional materials *(40, 41).* Our colleagues in the School of Education have adapted some of their graduate courses so that post-secondary education is featured along with pre-college science education, and our graduate students take these courses. We have used funding from the U.S. Department of Education's GAANN program (Graduate Assistantships in Areas of National Need) to support graduate students who wanted to add significant work in education to their chemistry Ph.D. program (as one might with a training grant), and a number of these students have included chapters on their scholarship of teaching and learning in their written theses. In Fall 2007, we had eight post-doctoral associates in the department whose primary residency was in one of the department's research groups, into which they had been recruited, but who also held a mentored teaching assignment as an instructor in one of our courses—generally, but not always, as part of a multi-person team in the introductory program.

My colleague, Mark Banaszak Holl, has probably taken the greatest advantage of these resources. Mark had a vision of studio-based instruction, where there was no separation between lecture and laboratory, just a series of learning goals that would be addressed by the most effective teaching method that might be aligned with that goal. Mark has premiere research programs in inorganic chemistry and nano-medicine, and his work spreads from physics to biology; naturally, the only way he can involve himself in this degree of research activity is as a part of an interdisciplinary research team. The scope of this studio idea represented exactly the same challenge, and, to date, he has worked with a steady-state team of a post-doctoral associate, 3–4 graduate students, and 1–3 undergraduates, as well as 2 faculty collaborators, on the development, implementation, and assessment of his vision of studio chemistry. In fact, just as in any successful research group, Mark's post-doctoral associate, Amy Gottfried, quickly took on the intellectual leadership of the studio project, and has been much more involved than Mark has in the day-to-day details of its implementation *(42).*

Banaszak Holl passes the litmus test for having pursued teaching with an eye to the tenets of scholarship. His work has been well informed, and the team has been quite intentional in explicitly identifying and linking instructional goals with instructional methods, and then collecting assessment data that derives from their particular objectives. Every year, the design of the studio course has been built on a critical examination of the data and experiences from the last iteration; and many of the original ideas have had to be modified or abandoned based on these results. Currently, the team is facing the question of what compromises can be made in the design in order to integrate faculty instructors who are not the innovators. And the work is inheritable. The team is leaving robust artifacts behind, and students who have participated as team members are carrying these experiences into their own faculty careers.

Reflections on the Program

In 2003, I invited Janet Lawrence, a faculty member in our Center for the Study of Higher and Post-Secondary Education *(43),* to carry out a review of our program. We had three overriding questions:

1. Was there evidence that graduate students participating in our program were becoming better educated about concerns and issues related to education?
2. Was there evidence that graduate students participating in our program were more aware of concerns and issues related to faculty careers?
3. Was there evidence that the department had embraced this program as a core part of its mission?

The results for all three questions were positive. It is unusual for a large research department to bring education on teaching and learning into its central mission, and one of the common questions we got early on was, "I can see how this might be accepted once it is established, but why did it survive in the first place?" William Roush, who was the department's chair at the time, gave perhaps the best answer. In his interview with Lawrence, he said:

> $600K in graduate fellowships per year and a competitive advantage for recruiting graduate students and new faculty members creates lots of agnostics… they might not be believers, but they are not willing to get out the torches and pitchforks, either…

Roush's comment is remarkably resonant with Planck's actual comment about scientific change; from Planck's autobiography *(44, 45)*:

> A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it.

There is a lesson about change here that is worth reflecting on. As a strategy, providing resources that attract faculty participation, in their familiar role as faculty advisors, appears to be much more effective than scolding them because of what they are not doing as well as you think they might.

My colleagues and I are certainly not alone in these efforts, although we think our plan is both philosophically and qualitatively different in its conception from other approaches. There are examples of work across the country that could be interpreted as using one or more of the four characteristics of scholarship to engage students and faculty in teaching and learning. Undergraduate peer-led instructional programs *(40)* speak directly to student engagement in this work (Figure 3). At the graduate level, there are a large number of *Preparing Future Faculty* programs *(35).* Chemistry and physics departments that offer Ph.D.s in chemistry or physics education are carrying out informed and credible research *(23).*

Creating the various pieces at the University of Michigan is not enough, either, because the scholarly professional development plan (Figure 2) eventually requires a cohort of schools, just as in research, so that the undergraduate from an institution that provides scholarship training in both research and teaching can join a graduate program that does the same, then does so in a post-doctoral position, and then is hired by an institution that shares these values or wants to bring them into their setting.

The IDEA Institute

Looking ahead, we are actively pursuing resources to jump-start a campus-level project we are calling the IDEA (Instructional Development and Educational Assessment) Institute *(46).* We imagine a more or less virtual structure to the Institute, one that will primarily fund and provide an intellectual focus for collaboration between faculty members from our College of Literature, Science and the Arts (LSA) and our School of Education, on instructional projects that will use the "teaching group" model of scholarly professional development in teaching and learning. While the details are still evolving, we are thinking of this as a three-fold expansion of our previous work: (1) broadening the mission, first to the sciences and then to all of LSA; (2) deepening the mission, with projects that address K–12 teacher education concerns in addition to future faculty concerns; and (3) expanding the mission, to include cross-cultural work in international settings.

The IDEA Institute is an experiment; so let me turn a critical lens onto my own ideas. There are things not to like about my teaching group approach. First, following the research group model might, in fact, be a fool's errand. What works for scientific research may be idiosyncratic enough to not encompass all the disciplines except for some infrequent exceptions, and even within disciplines, only with some individuals. There is reason to worry: with its VIGRE (Vertical Integration of Research and Education) program, for example, the NSF has quite literally funded departments of mathematics and statistics to integrate research group activities into their stereotypically solitary work. After a number of years, the most troublesome concern is whether the research group idea has affected the core of these fields, or whether it is simply a marginalized curiosity *(47, 48).* Second, my demands for significant funding need to be weighed against tangible outcomes, and the real experiment is not nearly done: are the students who have participated in this sort of work more effective instructors earlier in their careers, will any other institution provide an environment to do this, can the benefits be realized in significantly different settings, and is there actually going to be a way to preserve and build on the work of others? Third, and I say this for myself and consider it to be a systemic challenge for everyone else, too: understanding that students are learning better is a more complicated problem than determining percent yield and purity ever were, even 200 years ago. In my experience as a collaborator on education research, it takes a great deal of research effort to pin down even a small portion of an answer to an extremely narrowly defined question, so the issue of investing significant time and energy on a wholesale change in the way we think about teaching requires an equally large leap of faith that there is a payoff on the other side.

Photo by David Bay, University of Michigan.

Figure 3. Senior undergraduate leader and future faculty member Keary Engle (seated, dark shirt) makes a point during a Structured Study Group meeting for honors organic chemistry (ref *40*).

If we do not educate better, and come to agreement on what it means to do so, and how we evaluate it, then we are left with a collection of individual efforts and beautiful theories. These are significant problems… significant teaching problems. I dismiss the typical throwaway line that "we cannot possibly know the effects of education until 10 years after graduation, so why bother?" because that is not how we should approach a complex problem; and if that statement is true, then let's start now to think of some good experiments to carry out over the next 20 years in order to follow through on that hypothesis. I am most interested in how to create a system for people to be able to work on this.

Conclusion

In building this program, and my arguments, I am as guilty as anyone of bias that shapes the way I think about solving a given problem. I am swayed by the idea that the most distinctive and important thing we do, as academic scientists, is identifying, nurturing, and ultimately, as I put it earlier, catapulting the next generation past what we could accomplish. Doing research is critical to this. Our system of scholarly development in discovery research is built on using discovery as a vehicle for educating students to be the next generation of discoverers! But that is not enough, and it never has been. The obligation we have to replace ourselves, in academia, is profound. If academic scientists stopped doing discovery research, discoveries would still be made. If academic scientists stopped filing patents, inventions would still be invented *(49).* But if academic scientists stopped educating the next generation of academics, the entire system of educating scientists would come to a swift and grinding halt.[2] And if we educate poorly or even inadequately, the consequences may not be as dramatic, but I would argue that this is the situation that we find ourselves in today. We owe it to the next generation to educate as well as possible, and because following a scholarship model in research has enabled spectacular success in those aspects of our mission, including the ability to get beyond a collection of "beautiful theories," I think that integrating a scholarship model in teaching and learning—for all of those who become the next generation of academics—is the necessary next step in the evolution of our profession.[3, 4]

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[W]Supplemental Material

A Brief History of Scholarship: 1000–1990 is available in this issue of *JCE Online.* In this essay, the author traces the evolution of the term "scholar" from a reference to schoolchildren to its familiar, 20th century synonym for "an academic researcher".

Notes

1. Adapted from the 2006 James Flack Norris Award address given on November 16, 2006, at the University of Massachusetts at Boston and is dedicated to the memory of Seyhan Nurettin Eğe (1931–2007).

2. At the reunion of the generations of his research group members (June 2, 2001) at the symposium honoring his 60th birthday, my own Ph.D. advisor (Barry M. Trost, Stanford University), remarked directly to colleagues who saw research productivity as the sole outcome from doctoral education (paraphrasing): ...after all, if research productivity was the sole outcome, why would we then choose to do it with untrained scientists?

3. Although these comments are made strongly about the preparation of the future faculty member, many of the goals that one might set for this program (better teaching and presentation skills, better organization and time management) are not exclusive to the academic professions. The students from our program who have gone on to non-academic positions have reported that the skills they learned as a part of the program were valuable to many aspects of their new careers.

4. In 2006, the author was a member of a task force of the American Chemical Society Committee on Education (SOCED) that proposed a revision to the *ACS Statement on Scholarship in the Chemical Sciences and Engineering.* This statement, which appears below, was approved at the Fall 2006 ACS National Meeting of the Society, and may be found at *http://acswebcontent.acs.org/education/student/statement.pdf* (accessed Sep 2007). As stated in a National Research Council report,

> ...research is a process for obtaining information, and scholarship is a process for converting information into knowledge." Scholarship requires originality, creativity, a thorough grounding in the previous accomplishments of other scholars, and effective communication of new contributions, making them available for analysis, critical review, refinement and elaboration by other scholars. Scholarship in the chemical sciences and engineering may include discovery of chemical principles, integration of chemical knowledge within both formal academic and informal public arenas, application of chemical knowledge to new problems and situations, and the study of teaching and learning of chemistry and related sciences.

Literature Cited

1. Liebig, J. *Animal Chemistry or Organic Chemistry in its Application to Physiology and Pathology*; New York: Wiley & Putnam, 1842.
2. Brock, W. H. Justus von Liebig: *The Chemical Gatekeeper;* Cambridge: Cambridge University Press, 1997.
3. Berzelius, J. J. *Berzelius und Liebig—Ihre Briefe von 1831–1845;* Göttingen, Germany: Jürgen Cromm, 1982; p 94.
4. Boyer, E. L. *Scholarship Reconsidered: Priorities of the Professoriate;* Princeton, NJ: Carnegie Foundation for the Advancement of Teaching, 1990; p 16.
5. Glassick, C. E.; Huber, M. T.; Maeroff, G. I. *Scholarship Assessed: Evaluation of the Professoriate;* San Francisco: Jossey-Bass, 1997.
6. Machlup, F. *Knowledge Production and Distribution in the United States;* Princeton, NJ: Princeton University Press, 1962.
7. Blackburn, R. T. *Annals of the American Academy of Political and Social Science* **1980,** *448,* 25–35.
8. Samuelson, P.; McGraw, Jr., H. W.; Nordhaus, W.; Ashenfelter, O.; Solow, R. *J. Econ. Educ.* **1999,** *30 (4),* 352–363. Nobel Laureate Paul Samuelson is widely credited for having popularized the brief, colloquial version of Planck's original statement (see *44*).
9. DiLeo, J. R., Ed. *Affiliations: Identity in Academic Culture;* Lincoln: University of Nebraska Press, 2003.
10. The Genre Evolution Project. *http://www.umich.edu/~genreevo/* (accessed Sep 2007).
11. Hoffmann, R. Private communication (10/05/03): "The research group social/family structure is one of the great inventions of American graduate education, a part of what makes our graduate students catch up to their Asian and European counterparts, when they start out two years behind (my guess) at the beginning of graduate school. The group is where two other essential pieces of education take place—the moral education, for better or worse, seeing what the professor thinks is ethically good, what he or she allows to slip by. It is also where one learns what the unspecified quality judgments of science, what work is routine, what is more than that." Cited in *40*.
12. Lave, J.; Wenger, E. *Situated Learning: Legitimate Peripheral Participation*; Cambridge, England: Cambridge University Press, 1991.

13. Latour, B. *Science in Action;* Cambridge, MA: Harvard University Press, 1987.
14. Latour, B.; Woolgar, S. *Laboratory life: The Construction of Scientific Facts*; Princeton, NJ: Princeton University Press, 1991.
15. Goodwin, C. *Social Studies of Science* **1995,** *25,* 237–274.
16. Newstetter, W. *J. Engineering Educ.* **2005,** *94 (2),* 207–213.
17. Dawkins, R. *The Selfish Gene* (New Edition); New York: Oxford University Press, 1989.
18. International Society for the Scholarship of Teaching & Learning. *http://www.issotl.org/* (accessed Sep 2007).
19. Bass, R. *Inventio,* **1999,** *1 (1); http://www.doiiit.gmu.edu/Archives/feb98/rbass.htm* (accessed Sep 2007).
20. Hutchings, P., Ed. *The Course Portfolio: How Faculty Can Examine their Teaching to Advance Practice and Student Learning;* Washington, DC: American Association for Higher Education, 1998.
21. Bernstein, D.; Burnett, Amy N.; Goodburn, A.; Savory, P. *Making Teaching and Learning Visible: Course Portfolios and the Peer Review of Teaching;* Bolton, MA: Anker Publishing, 2006. See also: *http://www.courseportfolio.org/peer/pages/index.jsp*, Peer Review of Teaching Project (accessed Sep 2007).
22. International Journal for the Scholarship of Teaching & Learning. *http://www.georgiasouthern.edu/ijsotl/* (accessed Sep 2007).
23. Coppola. B. P., Jacobs, D. Is the Scholarship of Teaching and Learning New to Chemistry? In *Disciplinary Styles in the Scholarship of Teaching and Learning. A Conversation*; Huber, M. T.; Morreale, S., Eds.; Washington, DC: American Association of Higher Educaton and The Carnegie Foundation for the Advancement of Teaching, 2002; pp 197–216.
24. Shulman, L. S. *Educational Researcher* **1986,** *15 (2)*, 4–14.
25. Magnusson, S.; Krajcik, J.; Borko, H. Nature, Sources, and Development of Pedagogical Content Knowledge for Science Teaching. In *Examining Pedagogical Content Knowledge: The Construct and Its Implications for Science Education*; Gess-Newsome, J.; Lederman, N., Eds.; The Netherlands: Kluwer Academic Publishers, 1999; pp 95–132.
26. CIRTL—Center for the Integration of Research, Teaching, and Learning. *http://cirtl.wceruw.org/* (accessed Sep 2007).
27. Peer-Led Team Learning. *http://www.sci.ccny.cuny.edu/~chemwksp/* (accessed Sep 2007).
28. Process Oriented Guided Inquiry Learning. *http://www.pogil.org/* (accessed Sep 2007).
29. Angelo, T.; Cross, K. P. *Classroom Assessment Techniques;* San Francisco: Jossey-Bass, 1993.
30. Nurrenbern, S.; Pickering, M. *J. Chem. Educ.* **1987,** *64,* 508–510.
31. Sawrey, B. A. *J. Chem. Educ.* **1990,** *67,* 253–254.
32. Pickering, M. *J. Chem. Educ.* **1990,** *67,* 254–255.
33. Nakhleh, M. B.; Mitchell, R. C. *J. Chem. Educ.* **1993,** *70,* 190–192.
34. Beall, H.; Prescott, S. *J. Chem. Educ.* **1994,** *71,* 111–112.
35. Preparing Future Faculty. *http://www.preparing-faculty.org* (accessed Sep 2007).
36. Golde, C. M.; Dore, T. M. The Survey of Doctoral Education and Career Preparation: The Importance of Disciplinary Contexts. In *Path to the Professoriate: Strategies for Enriching the Preparation of Future Faculty*; Wulff, D. H.; Austin, A. E. & Associates, Eds.; San Francisco: Jossey-Bass, 2004.
37. Caserio,M.; Coppola, B. P.; Lichter, R. L.; Bentley, A. K.; Bowman, M. D.; Mangham, A. N.; Metz, K. M.; Pazicni, S.; Phillips, M. F.; Seeman, J. I. *J. Chem. Educ.* **2004,** *81,* 1698–1705.
38. Boylan, M. Evaluation of the PFF Program. CIRTL Annual Forum, November 5–6, 2003; *http://cirtl.wceruw.org/Forum2003/speaker_presentations.html* (accessed Sep 2007).
39. (a) Coppola, B. P.; Roush, W. R. *Peer Review* **2004,** *6 (3),* 19–21. (b) Coppola, B. P.; Banaszak Holl, M. M.; Karbstein, K. *ACS Chem. Biol.* **2007,** *2 (8),* 518–520.
40. Varma-Nelson, P.; Coppola, B. P. Team Learning. In *Chemist's Guide to Effective Teaching*; Pienta, N.; Cooper, M. M.; Greenbowe, T., Eds.; Saddle River, NJ: Pearson, 2005; 155–169.
41. Hayward, L. M.; Coppola, B. P. *J. Physical Therapy Education* **2005,** *19 (3),* 30–40.
42. Gottfried, A. C.; Sweeder, R. D.; Bartolin, J. M.; Hessler, J. A.; Reynolds, B. P.; Stewart, I. C.; Coppola, B. P.; Banaszak Holl, M. M. *J. Chem. Educ.* **2007,** *84,* 265–270.
43. University of Michigan's Center for the Study of Higher and Postsecondary Education. *http://www.soe.umich.edu/cshpe* (accessed Sep 2007). The final report is an internal document and is unpublished. Interested readers may request a copy directly from the author.
44. Planck, M. *Scientific Autobiography and Other Papers*, trans. Frank Gaynor; New York: Philosophical Library, 1949; pp 33–34; *Eine neue wissenschaftliche Wahrheit pflegt sich nicht in der Weise durchzusetzen, daß ihre Gegner überzeugt werden und sich als belehrt erklären, sondern vielmehr dadurch, daß ihre Gegner allmählich aussterben und daß die heranwachsende Generation von vornherein mit der Wahrheit vertraut geworden ist.*
45. Blackmore, J. T. *The British Journal for the Philosophy of Science* **1978,** *29 (4),* 347–349.
46. As of this writing (September 2007), the name and designation of this project as "The IDEA Institute" is still subject to final approval by the Regents of the University of Michigan.
47. Durrett, R. *Notices of the American Mathematical Association* **2002,** *49 (10),* 1237–1243.
48. *http://www.nsf.gov/attachments/108219/public/DMS-Response-to-COV-2004-Report-updated-January-2007.doc* (accessed Sep 2007). In a January 10, 2007 Memorandum from the Associate Director of Mathematical and Physical Sciences is the continuing question, raised by a review committee in 2004, of "[concern] that core components of the mathematical sciences are not receiving adequate attention and resources in the overall work of the NSF [VIGRE] institutes."
49. LaPidus, J. B. Scholarly Research: Oxymoron, Redundancy, or Necessity. In *Assessing the Value of Research in the Chemical Sciences;* Washington, DC: National Academies Press, 1998; pp 82–88.

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