

Essay

Balancing Teaching and Research Experiences in Doctoral Training Programs: Lessons for the Future Educator

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While a variety of alternative careers has emerged for Ph.D. life scientists in industry, business, law, and education in the past two decades, the structure of doctoral training programs in many cases does not provide the flexibility necessary to pursue career experiences not directly related to a research emphasis. Here I describe my efforts to supplement my traditional doctoral research training with independent teaching experiences that have allowed me to prepare myself for a career that combines both into a combined educational program. I describe the issues I have come across in finding and taking part in these endeavors, how these issues have affected my work in pursuing my Ph.D., and how my experiences translate into my hopes for a future education-based career in molecular and cell biology.

Keywords: graduate training, teaching experiences, doctoral programs, independent teaching, outreach.

INTRODUCTION

It is no secret that American universities have produced an abundance of life science Ph.D.'s in the last 15 years and that this abundance has fundamentally changed the way in which newly minted cell biologists perceive the way in which their careers will unfold. Indeed, a 1998 National Research Council (NRC) study showed that the number of Ph.D.'s awarded by American universities rose 42% between 1987 and 1996 (Wadman, 1998). During this same period, the rate of job growth was a meager 2.5% in academia and 7% in industry and government (Smaglik and Russo, 1998). These statistics were dire enough to encourage the NRC to advocate a freeze in future growth in both new and existing life science Ph.D. programs. The last 15 years, however, have also brought with them a wide variety of novel career options available to new cell biology Ph.D.'s. Many recent Ph.D. graduates now pursue what are commonly known as "alternative" careers in law, business, medicine, and education, and the number of recent doctoral graduates that pursue a traditional postdoc-assistant professor career pathway declines on a yearly basis (Horn, 1999). This increase in career options has done much to provide an outlet for the increase in American life science Ph.D. production, as seen in the minimal rise in the overall rate of biomedical Ph.D. unemployment, from 0.9% in 1973

to 1.9% in 1995, as more and more recent Ph.D.'s find permanent employment outside academia (Amidon, 1998). It would seem, therefore, that Ph.D. programs and the principal investigators affiliated with them must adapt to the changing realities of the Ph.D. job market and the fact that the ivory tower is no longer the likely final destination of their products. This need to adapt has been recognized through the formation of consortia between higher education institutions under the umbrella of, for instance, the Preparing Future Faculty program (<http://preparing-faculty.org>) and the Re-envisioning the Ph.D. project of the University of Washington, Seattle (<http://www.grad.washington.edu/envision>). In both cases, the object is to study the changing Ph.D. job market of the 21st century and to pinpoint its impact on how Ph.D.'s are trained and advised during their educations. Most individual principal investigators also recognize this shift in the Ph.D. job market and the explosion of varying career possibilities available to new doctoral degree recipients. However, they are in many cases unable to advise their students as to how to approach such alternative careers. This is largely due to the antiquated assumptions made by doctoral training programs with regard to the career objectives of their students and the pervading mentality within these programs as to what constitutes an "acceptable" or "useful" career upon completion of a Ph.D. Indeed, alternative careers are still referred to as alternative in most academic circles since doctoral training programs are structured around the assumption that one will ultimately pursue a research-based career in an academic setting.

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If a research-based career is not the ultimate plan for doctoral candidates, then they must consider ways to supplement their education with experiences that directly complement their career goals. It seems, though, that current methods of doctoral training, while fundamentally sound in preparing students for research-based careers, in many cases do not expose students to careers beyond traditional pathways or how to approach becoming a part of them. How, then, can one adequately prepare for a career requiring a Ph.D.-level education in which research is not necessarily the primary focus? The answer to this question lies not only within the need to seek out advice and guidance from principal investigators but also with the necessity to seek out educational enhancement opportunities for oneself.

LIMITED TRAINING OPPORTUNITIES FOR TEACHING IN MOST DOCTORAL PROGRAMS

I have long held a passion for teaching and for pursuing a career that allows me to incorporate innovations in learning and education as a significant component. In addition to teaching, I discovered an interest in the pursuit of knowledge through hands-on research. These combined interests pointed me in the direction of a career in which I could combine the best of both worlds, a career that would focus on education but would also allow research work to be an extension of an innovative educational program. It was with great excitement, then, that I entered a Ph.D. program immediately following completion of my undergraduate degree that would allow me to strengthen myself not only as a scientist but also as a teacher.

My naivete about the realities of graduate training became evident in short order, as it does for the majority of entering students. I was not ready for the demands of time and mind and the numerous scientific setbacks that define a normal graduate career. I had made it a point to affiliate with a program that required multiple semesters of teaching from its students and eagerly anticipated my teaching appointment, looking forward to it as an opportunity to build my teaching skills. To a limited extent, my expectations were met. I taught laboratory sections of introductory genetics where I delivered laboratory lectures as well as advised students on their laboratory work and projects, held office hours on both laboratory and lecture material, and graded papers and examinations. The experience allowed me to develop my teaching and lecture skills at the university level and to develop a stronger classroom presence. However, it left little room for innovation or variation from rigid prepared lectures that, by necessity, were common to all laboratory sections.

This teaching assistantship, while providing me with invaluable lecture experience and confirming my passion for a career in the education field, was typical of the experiences available to many graduate students at American research universities. Most, if not all, doctoral programs profess to stress the importance of required teaching opportunities to the development of a successful scientist, and an experience such as the one just described would be more than adequate for those students who do not wish to pursue teaching careers. However, it is evident that students who are indeed interested in a career in the classroom would greatly benefit from instructional training above and beyond what is required by their Ph.D. programs. While Cornell and most other

institutions offer resources and workshops in training teaching assistants and in fortifying overall teaching skills, these resources are geared primarily toward the general satisfactory completion of teaching requirements by all students as opposed to more specialized, long-term training for future teachers.

WHY ARE OPPORTUNITIES SO LIMITED?

As the economic realities of the university have changed in the past few decades, an alarming trend has developed in which full-time faculty are replaced upon retirement by temporary adjunct faculty or by the taking-in of additional graduate students to perform the necessary teaching duties (Benjamin, 1997). Such a system, while saving the university money in the short run, is illustrative of the secondary importance teaching has taken in many cases within academia. In many cases, teaching has become viewed not as a central mission to the university or as a critical arm of doctoral training but rather as a commodity, a necessary evil and distraction that must be fulfilled as quickly and cheaply as possible. How else can one explain the fact that unprepared graduate students bear the burden of over half the total teaching load at many research universities while teaching loads for tenured faculty have dropped off over the past two decades (Benjamin, 1997)?

There is also the matter of one's laboratory research, the necessary primary focus of a Ph.D. program. In many instances, teaching is viewed by graduate student advisors as an unnecessary distraction from one's thesis research and, ultimately, timely graduation. Under the traditional structure of doctoral training programs, they are correct in this assessment. This leads to discouragement from principal investigators for their students taking on additional teaching opportunities, even if such opportunities could further their students' interests and development as competent teachers.

The current structure of doctoral programs will not change significantly in the near-future; nor should it, since they continue to be serve their original purpose of providing the next generation of great researchers to the academy and industry. As career opportunities outside the research laboratory increase with each passing year, however, it is apparent that alternative careers need to be seen by doctoral programs and advisors as less alternative. This requires increased flexibility and acknowledgment of the full litany of career opportunities by doctoral programs and an increased knowledge of the resources necessary to help students pursue these careers by their faculty. Also, it is important for graduate students like myself considering nontraditional careers to remember that it is not entirely up to our programs and advisers to provide for our needs. If an exact doctoral program for what we ultimately wish to pursue as a career does not exist, then we must seek out opportunities to augment the traditional Ph.D. curriculum with career experiences that shape us and allow us to confirm our passions for the career in question. In my case, I have sought to supplement the mandatory teaching requirements of my program with educational experiences both on and off campus that will allow me to become a more skilled teacher. These experiences, in combination with the traditional research training of my dissertation, give me greater confidence to ultimately pursue a career in which both teaching and research can be put to use as arms of an innovative educational program.

AUGMENTING TEACHING OPPORTUNITIES AVAILABLE WITHIN MY DOCTORAL PROGRAM

I had hoped that my mandatory teaching experience would allow me more opportunity for innovation and curriculum development. As I learned, however, the role of the graduate student in teaching assistantships is in many cases that of a cog in a wheel, a role that develops lecture prowess but little else. In this light, it is imperative to take advantage of other teaching opportunities that present themselves within the department and to take advantage of traditional department activities such as journal clubs and seminars to build on teaching skills. For instance, I am a member of a dynamic cell biology journal club that covers a wide range of topics largely based on the research interests of the presenter. Over the years, I have found that my teaching skills are best served by selecting a topic not researched in my department, performing some rudimentary research on the topic based on current literature, and preparing a comprehensive introduction to the paper for an audience with a knowledge of basic concepts but not the specific topic. In this sense, the journal club becomes a teaching experience and an opportunity to prepare a "class" on a foreign topic to a group of "students" in a way that captivates their interests. This also transforms the journal club from a required mundane activity into a challenging project that hones all the skills necessary for a successful teaching experience. Likewise, seminars and presentations to the department, in addition to their obvious importance to one's graduate career, can be perceived as a challenge to present one's research in a compelling manner and at a level that is able to be understood by all with a molecular biology background yet still be provocative.

In certain cases, sporadic teaching opportunities may present themselves in the form of guest lecture opportunities in established department classes. Our department's undergraduate cell biology survey course offers an optional "Explorations" session in which each class is taught by a representative of one of the department's laboratories based on the material covered in the class that week. I received the opportunity to deliver this lecture for our laboratory and treated it as my first chance to truly teach a college classroom in an independent manner. The same educational challenges mentioned before applied to this experience as well: preparing a comprehensive introduction, teaching the material at the appropriate level of difficulty, and producing a class that would make the material compelling to the students. The class was small, as could be expected for any optional exercise, but the experience of being the sole instructor to a college class with material entirely of my own design was truly exciting and invaluable.

SUPPLEMENTING GRADUATE TRAINING WITH NONTRADITIONAL TEACHING OPPORTUNITIES

While the experiences mentioned above have allowed me to further hone my teaching skills, I have also looked outside traditional department channels for opportunities that would provide me with greater independence and the ability to develop my own teaching style. One potential outlet for this sort of independent experience has been found by many graduate students via adjunct teaching appoint-

ments or PFF fellowships at local colleges or community colleges. Such an independent experience is obviously top-notch in getting first-hand experience managing a university classroom but can in many cases be difficult for the graduate student to manage simultaneously with a full research schedule.

For students preparing for careers in teaching, a variety of fruitful opportunities exists within the K-12 outreach programs available on most research campuses. The value of K-12 educational outreach has been recognized for some time as an invaluable tool for bringing the resources of the university to the K-12 classroom (Bonnen, 1998). While there are obvious differences between the dynamics of K-12 and university classrooms, it is also apparent that the same fundamental teaching skills of time management and development of a challenging yet appropriate curriculum apply to both situations. Therefore, an independent K-12 teaching experience can help the future teacher master skills critical to successful university teaching as well. The boldly innovative Graduate Student Outreach Project (GSSOP) (<http://www.psc.cornell.edu/gssop>), a program of the Cornell Public Service Center, is a prime example of a program that provides for such a teaching experience. The GSSOP matches graduate students with the K-12 teachers of Tompkins, Tioga, and Seneca counties of New York State. In this partnership, graduate students do not merely prepare a guest lecture but are expected to develop a compelling eight- or nine-session minicourse in a subject of the student's choosing. Within this framework, schoolchildren have the opportunity to explore a variety of long-term projects with the graduate student teacher that would not be possible in a one-time guest speaker setting. Graduate students apply and are selected for the GSSOP program on the basis of showing an enthusiasm for teaching combined with the motivation to develop, in collaboration with the K-12 teacher with whom they are paired, a curriculum that is rigorous yet appropriate for a target audience that can range from the kindergarten to the advanced placement (AP) level. Teachers, in turn, apply to the program to be paired with a GSSOP student in the hopes of establishing a fruitful partnership that will lead to the enhancement of the curriculum. The graduate students are also expected to document their work for publication on the GSSOP Web site so that their course concepts will be available to all interested teachers who may not have had the opportunity to be paired with a graduate student as a result of the limited resources of the program.

I entered the GSSOP program as a first-year Ph.D. student in genetics who was looking for a teaching experience that would provide me with both the freedom to make my own intellectual contributions to the curriculum and the collaboration and feedback necessary for me to improve my classroom presence and teaching abilities. I have since offered a course in basic genetics in each of the past 5 years. The course has evolved significantly over that time in response to progress in genetic and cell biology research as well as the grade level to which the course has been taught. Each experience was a unique product of extensive collaboration between myself and the K-12 teacher with whom I was paired.

With GSSOP, I entered into an equal partnership with a K-12 teacher who understood much better than I did how to work with a group of students in a coherent and effective manner. The teacher was excited to have access to

Cornell's resources and I was excited to have the opportunity to present a curriculum that I designed according to the educational goals of the teacher. In each instance, I benefited immensely from the unique mentoring I received from each of the K-12 teachers with whom I worked. It allowed me to assimilate the teaching ideas from multiple mentors into my own teaching philosophy and style. These partnerships were indeed effective: The teachers were able to incorporate the innovations I presented into their curriculum, while I learned more about classroom management than I thought was possible within eight classroom visits. Most important to my work in GSSOP, however, has been the satisfaction I have felt from seeing the spark of excitement about biology in the face of a student. Whether it is from observing DNA firsthand after an extraction protocol, participating in a gel electrophoresis exercise, or working with crossing fruit flies, the look of excitement and intrigue is unmistakable and reminds me that the work that partnerships such as the GSSOP do is indeed vital for engendering excitement about biology among K-12 students.

Another unique opportunity for teaching is available here at Sciencenter (<http://www.sciencenter.org>), Ithaca, New York's children's science museum. The museum recently completed an expansion that tripled its exhibit space and produces an outstanding range of exhibits and programs for a relatively small community. I came to Sciencenter in 2000 as a volunteer and found an amazing and unexpected teaching opportunity. It is a fundamental teaching rule that if one expects a group to understand a basic concept or idea, it should be able to be broken down in a way that children will understand as well. Sciencenter has provided me the opportunity to participate in countless science demonstrations on the exhibit floor as well as to develop my own sessions for their Saturday Showtime series, in which local experts deliver presentations on their area of expertise. This experience provides me with a great challenge: How should I approach the presentation of compelling science concepts to a casual audience of young children? The museum is founded on the principle of a hands-on educational experience, and the presentations I have developed on DNA, cell biology, and genetics seek to embrace this philosophy. By having the children at my presentations assemble giant models of cells or DNA, observe their own cells under the microscope, or extract DNA from raw wheat germ, they can appreciate firsthand the excitement that can be found in science that extends much farther than what can be found in textbooks.

SUMMER TEACHING OPPORTUNITIES ON AND OFF CAMPUS

Opportunities for further teaching experience are also available through summer experiences. Most major research universities have a summer school that requires teaching assistants in a variety of subjects. In addition, institutions such as Duke (<http://www.tip.duke.edu>) and Johns Hopkins (<http://www.jhu.edu/cty>) offer summer programs for gifted middle- and high-school students that require motivated instructors in the biological sciences among other disciplines. I recently completed teaching a 3-week summer course in genetics as a part of the Johns Hopkins Center for Talented Youth (CTY) program, an endeavor that proved to be my most challenging teaching effort to date. In this program, I was

responsible for designing the curriculum and laboratories, choosing the textbooks, and ordering the relevant supplies for the course. For the 3-week session, I saw one group of students for morning, afternoon, and evening sessions. This experience provided me with the challenge of producing an extensive and rigorous curriculum for a talented group of individuals, devising innovative means of student assessment and learning modes, and devising a classroom community that was inclusive, compelling, and able to recognize the differences in learning styles between students. In effect, this was my first long-term independent class, and though it was an intense experience, it has prepared me like no other teaching opportunity I have found for a future career in the classroom.

CHALLENGES FACING THE PROSPECTIVE TEACHER IN A DOCTORAL PROGRAM

I have described a myriad of teaching opportunities that I have discovered in my time as a graduate student both inside and outside my program. The goal of these experiences has been, of course, to improve my independent teaching skills, innovation, and curriculum development and to fill in the gaps that I felt existed in my education as a teacher. It is important, however, to remind myself from time to time that while I build my teaching portfolio, my research portfolio must grow as well. The establishment of an appropriate balance of time between teaching and research is challenging, since every minute spent preparing for or teaching a class is a minute in which my research lies stagnant and my graduation time is potentially delayed. The maintenance of such a balance requires the development of a strong sense of time management, with long-term experimental planning necessary to ensure that my research continues to move forward during periods when I am frequently in the classroom. Another critical consideration is the relationship between student and adviser. When I selected a laboratory for my dissertation research, one of the central considerations for me was to be able to work under an adviser sympathetic to my teaching endeavors and tolerant of my taking the time to pursue them.

In a sense, my teaching endeavors have allowed me to consider the dilemma faced by many professors at small liberal arts colleges: How can one simultaneously be an inspiring teacher and a successful research scientist? How may teaching and research be best balanced in a career? In my experience both as a graduate of a liberal arts college and as a researcher/teacher in a doctoral program, it seems that the best model is to strive to integrate the two as closely as possible. What better way to introduce students to the idea of biology as a science of inquiry than by integrating the concepts of research into the laboratory component of the classroom? By not simply lecturing but by assigning projects that allow students or groups of students to arrive at their own conclusions based on research and current literature? By encouraging a journal club setting where original research can be presented in the classroom? In my hopeful future career, I will strive to bring the fundamentals of teaching and research together, to present my future students with coursework in which research is a cornerstone to effective learning and educational innovation.

The system of American doctoral training in the biological sciences is fundamentally sound. It merely needs to adapt to the changing face of the Ph.D. job market and mold itself into a model that is better able to advise its students on the wide range of opportunities available after graduation and to provide them with the resources necessary for the attainment of these goals. With this acceptance, I am certain that future Ph.D. candidates will have the greater freedom necessary to explore all their career options in the rapidly expanding and exciting realm of career opportunities for Ph.D. biologists.

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