Journal of Research Practice
Volume 4, Issue 1, Article D1, 2008

ISSN: 1712-851X

Research Design:

Genesis of an Academic Research Program

Gautam Bhattacharyya
Department of Chemistry, Clemson University, Clemson, SC 29678, USA
gautamb@clemson.edu

Abstract

As students progress towards their PhD degrees, they will become more independent and practitioner-like; for those moving into academia, it is often assumed the programs of their PhD mentors will serve as prototypes for their own successful research programs. However, the author's research program as an Assistant Professor led him in directions never considered as a graduate student. The author had to make significant decisions in choosing a primary audience, finding an overarching theme, defining the individual problems, and developing these problems into researchable projects. Infrastructure-related issues associated with the author's research program were also considered. The details of his journey from the end of his doctoral degree to his current position as an Assistant Professor are described in this article.

Keywords: research program; junior faculty; chemical education research (CER); practitioner development; organic chemistry

Suggested Citation: Bhattacharyya, G. (2008). Genesis of an academic research program. *Journal of Research Practice, 4*(1), Article D1. Retrieved [date of access], from http://jrp.icaap.org/index.php/jrp/article/view/87/103

---

1. Starting Research

The chief goal of PhD programs is to help students become the stewards of their own education by engaging them in original, scholarly research projects. It is expected that students will use the research phase of their degrees to become more independent and practitioner-like. Furthermore, for students who move on to academic careers, it is often assumed that the research programs of their PhD mentors will serve as prototypes for designing their own successful research programs.

During the course of my PhD training in chemical education, I took many of these steps towards becoming a practitioner. The value of those experiences was immeasurable, but the development of my research program as an Assistant Professor led me in directions that I never considered as a graduate student. Most significantly, due to our different positions in academia, I could not use my mentor's program of research as a blueprint for my own. My mentor is a well-known, highly-respected Distinguished Professor. I, on the other hand, was trying to start a career in which gaining tenure would be one of my priorities. This article will discuss the journey of defining my research program in the context of a PhD-granting university.

Before proceeding to the details of this odyssey, it is important to provide some background information. My entire education has been in the United States. After receiving my Bachelor of Science degree in chemistry in 1992, I enrolled in a graduate program with the intention of pursuing a PhD in organic chemistry. After two years in that program, I realized that I did not want to be a synthetic organic chemist and left the program with a Master's degree in chemistry in 1994. For the next 3 years, I remained affiliated with the same department of chemistry as a Teaching Fellow, primarily helping professors teach their organic chemistry courses. In 1997, I began a Fellowship in a hospital laboratory specializing in insulin signal transduction--the study of how the hormone, insulin, causes changes within a cell without entering it.

Two years into this phase, I recognized, with the help of my research mentor, a couple of important attributes about myself. First, although I liked thinking about science, I did not like doing it. Second, I really enjoyed being in an academic environment where there were undergraduates. Based on these realizations, I moved to Purdue University, USA, in January 2000, and completed my PhD in chemical education under the supervision of George M. Bodner.

Although, I applied for tenure-track positions during the 2003-2004 academic year, the last year of my doctoral training, I was unsuccessful in obtaining an appointment. Therefore, I began an Instructorship at the University of Oregon, USA, in 2004. A year later, I went through the application process again and, this time, I was successful in obtaining a tenure-track position. Thus, after a 2-year stint as an Instructor at the University of Oregon, I began my current position as an Assistant Professor of chemistry in July 2006.

2. The First Steps

The phrase *research program* was deliberately used in the introduction to describe my goal, because I wanted my scholarly efforts to be more than a set of unrelated research projects. During the course of my academic training, I had the privilege of working under and interacting with world-renowned researchers. Through these interactions, I observed that there were two traits common to distinguished scholars. First, these individuals had one or two "big-picture" questions around which they fashioned their entire research careers. Furthermore, they pursued these questions regardless of the prevailing winds of the profession; they did not change their scholarly pursuits based on the popular topic(s) of a given era. As a corollary to the first point, a second trait shared by these distinguished researchers was that their work transcended their specific fields and, thus, affected a broad spectrum of disciplines.

In fashioning my own program after these features, I found that I had to make significant decisions in the following areas: (a) choosing a *primary audience*, (b) finding an *overarching theme*, (c) defining the *individual problems*, and (d) developing these problems into *researchable projects*. Designing the research program required me to address the points in a recursive and nonlinear manner. Although the article will cover each of the points separately, it is important for the reader to remember that, in practice, each point is intertwined with the others.

3. Choosing a Primary Audience

While the ultimate aim of a researcher is to have one's work affect multiple disciplines, dissemination of work in conferences and refereed journals requires a narrower audience because the vast majority of peer-reviewed journals and professional meetings tend to focus on one or two specialized fields. As a researcher in the interdisciplinary field of chemical education, therefore, I had to choose between the chemistry and education communities to determine my primary audience. I chose the former.

This choice was based on several considerations. Prior to my training in chemical education, I spent most of my career as a member of a department of chemistry. Therefore, between the education and chemistry communities, I had a better understanding of the professional culture in chemistry and could communicate with chemists in their language. Thus, I could use my immersion in the chemistry culture to define the problems that would be at the forefront of educational research that chemists would find relevant. This decision, therefore, allowed me to better use my disciplinary training in organic chemistry to address research questions in chemical education.

Choosing an audience was an important step because it focused what I read in the literature to determine the current status of my field and the directions in which it was headed. This, in turn, helped identify the types of research questions I would eventually address. With my strong disciplinary training, I could pursue questions specific to the domain of chemistry which would be more difficult for someone with primarily an education background to tackle. Finally, the choice of target community also helped determine the people--including the leaders of the field--with whom I interacted at conferences.

4. Finding an Overarching Theme

The first time I applied for jobs, I prepared mini-research prospectuses based on the following ideas without articulating a big-picture theme:

(a) What are students' experiences during their sophomore-level organic chemistry course?
(b) What cues do individuals derive from problem statements in organic chemistry?

(c) How can the history of the science of steroids in the twentieth century be used as a case study in science-technology-society (STS) studies?

Not obtaining a tenure-track position with these projects was an impetus to think about the entire research agenda. These reflections helped me understand that without an overarching theme for a research program, I could not adequately articulate the overall purpose behind the work. Furthermore, I could not envision how the results of one project would lead to the next. Without that connection, developing new research ideas from completed studies would be difficult. Therefore, as I prepared to apply for jobs again, I started the process of finding the overarching theme of my research by asking the question: What do I really want to understand? Three themes emerged from this process.

First, I was interested in exploring how to help people learn organic chemistry better. This concern was based on the fact that I had seen instructors teach organic chemistry in, what appeared to me, the most logical of manners; yet the students still had tremendous difficulties with the subject. While conducting research on this subject (Bhattacharyya, 2004; Bhattacharyya & Bodner, 2005), I realized that to make substantive improvements, I had to first understand the barriers the students faced in learning organic chemistry. I formulated this idea into the following research question: How do students learn organic chemistry?

Second, I was interested in understanding what people learn in the research laboratory environment and how that learning occurs. Especially in the sciences, doctoral programs are designed so that students receive the bulk of their training in the context of a research laboratory. There is even a common saying among practicing chemists: “You learn it in the lab.” The “it” in the phrase refers to one’s knowledge of chemistry. However, it is not obvious what the “it” is and how “it” is learned. To explore this topic further, I posed the following research question: How do students learn to do research in chemistry?

Third, I was interested in understanding why even well-prepared students had a difficult time adjusting to graduate school, especially to the research phase of their degrees. Preliminary research results (Bhattacharyya, Johnson, & Bodner, 2004) indicated that one of the main factors contributing to the adjustment problem was that the students had a poor understanding of the nature of scientific inquiry. Thus, I connected this issue to the larger question: How do scientists create valid scientific knowledge?

The underlying theme that emerged from a survey of the questions--(a) How do students learn organic chemistry? (b) How do students learn to do research in chemistry? and (c) How do scientists create valid scientific knowledge?--was *practitioner development*, that is, how chemistry students develop into practicing chemists. Thus, developing a basis for redesigning the process of teaching and learning in the profession of chemistry became the overarching goal of my research program (Schön, 1987).

The motivation for this research stems from my own difficulties in learning organic chemistry and adjusting to my first doctoral program and my realization that these experiences were not unique. Furthermore, since the publication of documents such as

Science for All Americans (American Association for the Advancement of Science, 1989), the American science education community has dedicated itself to increasing the scientific literacy of the citizenry by getting more youngsters involved in the sciences. Considerably less attention has been paid to helping those already interested in the sciences overcome difficulties associated with developing into practicing scientists. My research focuses on these individuals.

5. Defining the Problems

Drawing on the idea of broad applicability of research, my philosophy for choosing specific projects is based on the following belief: Not all good ideas should be researched. This idea grew from the realization that, given the limited amount of resources, research results should impact and benefit the largest number of people possible. Thus, I chose research projects that would not only address specific issues in developing practitioners of chemistry, but could also generate insight regarding important issues in a variety of other fields. I demonstrate these points in two research projects.

The first project is based on recently published work (Bhattacharyya, 2006), which probed how graduate students incorporate multivariate thinking into their conceptualizations of chemical phenomena. Although traditional classroom education in organic chemistry tends to present a single theoretical construct at a time, real-life situations require practitioners to mix these separate, even incommensurable, constructs into working models. Therefore, one aspect of becoming a practicing organic chemist involves developing these multivariate cognitive skills. The broader implication of this study is that multivariate thinking is not only a valued skill for organic chemists, but it is also a cornerstone of any professional practice (Schön, 1987). For example, problem-based learning (PBL) exercises in medical schools were developed, in part, to promote this skill (Gallagher, 1997). Thus, the results of this research could not only affect graduate students in organic chemistry--a relatively narrow population--but they could also affect students in the other sciences and beyond.

A second project, which is currently under development, is a study on cueing in problem solving. Although expert systems and other computer-based models are frequently used as analogies to describe the problem-solving processes of practitioners (Scudder, 1997), research on how practitioners solve problems suggests that practitioners, unlike computers, do not screen all possible solution paths (Kozma, 2003; Kozma & Russell, 1997; Preece Stucky & Bond-Robinson, 2004). The parsimonious approach adopted by experts cannot be simply explained by their greater background knowledge. Rather, Kozma’s work suggests that it is, in part, based on the greater *meaning* that practitioners attribute to the individual elements of a problem. It is, therefore, proposed that this deeper, culturally-embedded significance helps practitioners derive cues from problems that others are unable to detect. The goals of this study, therefore, are to understand how individuals--undergraduate and graduate students and practicing organic chemists--derive cues from commonly-used organic chemistry representations and execute subsequent problem-solving acts.

This research aims at identifying some of the representation-related difficulties students encounter in organic chemistry. McKendree, Small, and Stenning (2002) aver that “to understand the abstract properties of the representation [is what] makes it a useful one in a particular instance. It is this which often holds the key to transferring learning from one problem to another” (p. 62). Thus, developing deeper meaning for representations is a critical factor for achieving transfer. Helping students transfer knowledge from one context to another is a fundamental goal of education that is yet to be fully characterized. The results of this study, therefore, are expected to impact the educational literature on transfer and, thereby, affect how students learn in any field.

Due to a lack of broader applicability, I did not pursue one of the early research ideas I had--understanding students’ experiences in sophomore organic chemistry. As I put more thought into developing this project, it became clear that it would be nearly impossible to minimize the effect of a specific instructor. As such, the results of such a study would be barely applicable to another organic chemistry course with a different instructor in the same institution.

6. Developing Research Projects

Although I had a considerable amount of educational research experience--including writing research proposals--by the end of my doctoral training, carrying the research questions to fruition as a professor is significantly different. The main source of this difference lies in infrastructure-related factors. As a graduate student all the resources I needed to perform my research, including supplies, equipment, and space, were provided by my research mentor. As a professor, since I am responsible for providing these amenities, I must write grant proposals to obtain research funds. As I have found, writing grant proposals is significantly different from writing proposals for PhD candidacy because of several reasons. Some of these reasons are:

(a) *Feasibility and viability*: Do I have access to the research population specified for this study? Do my department and university have the resources to allow me to perform this research?

(b) *Researchability*: Can I produce publishable results in a reasonable amount of time, that is, can I publish at least a couple of articles per academic year? Will the current results open new avenues of inquiry?

(c) *Collaboration*: How do I involve students of all levels in the research program? How do I ensure their professional and academic growth as they participate in the research process? How can I create an environment where they are able to also pursue some of their own research interests?

In addition to infrastructure-related issues, choice of methodology is an area in which there can be significant difference between professors and graduate students. During the training phase, the primary goal is to choose existing methods that will allow for successful completion of a research project. As a professor, however, it is important to develop *new* research method(s) during the course of one or more research projects. The most accomplished researchers are known not only for their research results, but also for developing new tools on the way to those results. Although, I am far from contributing a new research method, I have already begun to address this issue in my independent career. In a study on how organic chemistry graduate students conceptualize acids (Bhattacharyya, 2006), a Model-Eliciting Activity (MEA) was used to probe the participants' conceptions. For the past several decades, problem solving had been a dominant paradigm in chemical education research. Although this approach produced many important innovations, it has experienced limited success in uncovering underlying conceptions of chemical phenomena held by students. Thus, this research was one of the few studies in chemical education to use an MEA and has a potential to help establish MEA as an alternative method in chemical education research.

7. Conclusion

It is important to note that the preceding description is only one way of establishing a research program, certainly not the only way to do so. The most important aspect of my research program is that it is dynamic; the program is always in evolution as some projects finish and new ones are contemplated. Thus, my adherence to the program is flexible enough to incorporate new and interesting avenues that may arise in the course of the research.

Perhaps the most important resource in this journey has been time. The seeds of this process began in the early stages of my graduate training in chemical education, not just in the final year. Since that time, I have taken the time to reflect on what I wanted to accomplish during my independent career in academia. In creating this program, I have used my own experiences as a researcher to define the problems I wanted to address. However, the countless conversations I had with experts in my field and the opportunities I had to observe them were equally important. These interactions helped me appreciate the factors that went into making ideas researchable and creating methods to perform investigations.

In closing, it is important for aspiring professors to realize that creating a research program involves a complex interplay of a variety of factors over a long period of time. The time to start on one's own plan is at the beginning of one's graduate training. The time to stop is at the end of one's career.

Acknowledgements

The author wishes to thank Godfrey Kimball for his help in editing and formatting this manuscript.

References

American Association for the Advancement of Science. (1989). *Science for all Americans*. New York: Oxford University Press.

Bhattacharyya, G. (2004). *A recovering organic chemist's attempts at self-realization: How students learn to solve organic synthesis problems*. Unpublished Doctoral Dissertation, Purdue University, W. Lafayette, IN.

Bhattacharyya, G. (2006). Practitioner development in organic chemistry: How graduate students conceptualize organic acids. *Chemistry Education Research and Practice, 7,* 240-247.

Bhattacharyya, G., & Bodner, G. M. (2005). "It gets me to the product": How students propose organic mechanisms. *Journal of Chemical Education, 82,* 1402-1407.

Bhattacharyya, G., Johnson, A., & Bodner, G. M. (2004, July). Getting philosophical about the PhD. Paper presented at the 18th Biennial Conference on Chemical Education, Ames, IA.

Gallagher, S. A. (1997). Problem-based learning: Where did it come from, what does it do and where is it going? *Journal for the Education of the Gifted, 20,* 332-362.

Kozma, R. (2003). The material features of multiple representations and their cognitive and social affordances for science understanding. *Learning and Instruction, 13,* 205-226.

Kozma, R., & Russel, J. (1997). Multimedia and understanding: Expert and novice responses to different representations of chemical phenomena. *Journal of Research in Science Teaching, 34,* 949-968.

McKendree, J., Small, C., & Stenning, K. (2002). The role of representation in teaching and learning critical thinking. *Educational Review, 54,* 57-67.

Preece Stucky, A., & Bond-Robinson, J. (2004, April). Empirical studies of scientists at work: Analysis of authentic inquiry experiences. Paper presented at the National Association for Research in Science Teaching Annual Meeting, Vancouver, BC.

Schön, D. A. (1987). *Educating the reflective practitioner: Toward a new design for teaching and learning in the professions*. San Francisco: Jossey-Bass.

Scudder, P. H. (1997). Database vs. expert system teaching paradigms: Using organic reaction mechanisms to teach chemical intuition. *Journal of Chemical Education, 74,* 777-781.

Received 12 February 2007

Accepted 16 May 2007