What You Need for the First Job, Besides the Ph.D. in Chemistry

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What You Need for the First Job, Besides the Ph.D. in Chemistry

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Foreword

The ACS Symposium Series was first published in 1974 to provide a mechanism for publishing symposia quickly in book form. The purpose of the series is to publish timely, comprehensive books developed from the ACS sponsored symposia based on current scientific research. Occasionally, books are developed from symposia sponsored by other organizations when the topic is of keen interest to the chemistry audience.

Before agreeing to publish a book, the proposed table of contents is reviewed for appropriate and comprehensive coverage and for interest to the audience. Some papers may be excluded to better focus the book; others may be added to provide comprehensiveness. When appropriate, overview or introductory chapters are added. Drafts of chapters are peer-reviewed prior to final acceptance or rejection, and manuscripts are prepared in camera-ready format.

As a rule, only original research papers and original review papers are included in the volumes. Verbatim reproductions of previous published papers are not accepted.

ACS Books Department

Preface

"I never let my schooling interfere with my education."

- Mark Twain

It is fair to say that most chemists and chemical engineers who earn a Ph.D. in their field take their schooling much more seriously than Mark Twain, aka Mr. Samuel Clemens, apparently did. However, his aphorism does make the poignant observation that schooling and education is not always the same thing. This volume is an attempt to educate, to provide a source of information, knowledge, and wisdom to the person who has spent so long, and worked so hard, on his or her schooling.

The Council for Chemical Research and the American Chemical Society have both spent considerable effort over the past decades focusing on how to ensure that graduate education in the chemical sciences remains at the absolute highest caliber, and produces the best possible professionals. The ACS is justifiably proud of its publications on education, including the downloadable document, "Graduate School Reality Check," and the recent presidential commission report, "Advancing Graduate Education in the Chemical Sciences." Additionally, it has spearheaded active graduate education efforts within the Division of Chemical Education and elsewhere for decades. The Council for Chemical Research has maintained an active Graduate Education Action Network for nearly thirty years. Yet in that time, neither organization has specifically asked what a person needs to be successful once they have both the Ph.D. and the first job in hand.

Put succinctly, there is much more to being successful in a career in chemistry than just the hard-earned Ph.D. degree.

This volume is based on the symposium "What You Need for the First Job, Besides the Ph.D. in Chemistry," held at the 246th National Meeting of the American Chemical Society, which took place in Indianapolis, Indiana in September, 2013. But the book and symposium are also the result of several chapters authored by leading scientists who were not able to attend and present at the symposium, but who were kind enough to contribute chapters based on their years and/or decades of experience in corporations, government labs, and academia. This book is the result of seeds that were planted during numerous informal conversations at the annual meetings of the CCR, as well as during such discussions at national and regional meetings of the ACS, and at the ACS employment clearing houses. It was felt that the same intense focus a person needs to earn a Ph.D. might actually work against the attention to other details needed in order to be successful once he or she has obtained a position.

Leaders want to ensure that new hires are working effectively toward tenure, are quickly becoming productive members of their corporate team, or are well integrated into their government laboratory research group. While it is easy to lump factors other than technical competence in one's job under the term "soft skills," this is an oversimplification. This book represents an attempt to have voices from all three pillars of the chemical enterprise — academia, industry, and government laboratories — heard in terms of telling us what is important for their newly hired Ph.D.-holders. Drs. Truitt, Selcuk, Ranbom, and Plaumann do this from perspectives within the corporate world, while Drs. Sullivan, Snyder, and Bohn do so from points of view in government laboratories. Successful academic leadership is discussed by Prof. Donohue and Kilburg, while several other viewpoints from within the academic sphere are provided by Profs. Bodner, Mio, Otto, Marincean, Kolopajlo, Howell, and Ray. Thank you to all of the authors, as well as to the numerous reviewers who have checked these chapters. A special "thank you" goes to Ms. Megan Klein of Ash Stevens, who willingly took on the task of performing numerous chapter reviews, and who made several valuable suggestions.

Perhaps obviously, no such book can present perfectly all the additional factors and requirements that enter into every possible equation which equals success in a chemical career. We hope though that we have made a very good attempt at it. We also hope that even though this book is not quite as witty and succinct as Mark Twain's one-line comment made over a century ago, it will be a valuable resource for as many years.

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Editor's Biography

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Mark Benvenuto is a Professor of Chemistry at the University of Detroit Mercy, in the Department of Chemistry & Biochemistry. His research thrusts span a wide array of subjects, but include the use of energy dispersive X-ray fluorescence spectroscopy to determine trace elemental compositions of aquatic and land-based plant matter, food and dietary supplements, and medieval and ancient artifacts.

Benvenuto received a B.S. in chemistry from the Virginia Military Institute, and after several years in the Army, a Ph.D. in inorganic chemistry from the University of Virginia. After a post-doctoral fellowship at The Pennsylvania State University, he joined the faculty at the University of Detroit Mercy in 1993

Chapter 1

What Do You Need for the First Industrial Job, Besides the Ph.D. in Chemistry?

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A chemist's first industrial job after leaving school or a post-doctoral appointment involves a transition to a work environment oriented around commercial imperatives along with the scientific or engineering principles from the recently ended educational experience. Four attributes of industrial chemist job success are described. They are business awareness, team skills, time management, and communication skills.

All chemistry students leaving graduate school or academic post-doctoral appointments expect new experiences in their first job as an industrial scientist. You are entering a new environment and an interesting learning experience. Not so apparent is that you will go through a transition period involving changes that are sometimes stressful, especially if they are not expected. At the start of the author's own first job experience, it was quickly apparent that my technical education and personal development would be continuing with some intensity, not downshifting after graduate school. Showing up with technical expertise and a sincere welcome from my new boss and colleagues was the beginning of another education, and I had a lot to learn quickly.

Having coached or supervised many people in their first industrial scientist jobs, a few general comments are possible about culture, skills, and behaviors that really matter. With this essay, I offer insight and advice that I believe will minimize the length and stresses of that transition. To help those still choosing their work-life direction, I provide some perspective on how an industrial chemist career often begins.

Before the advice, here is context for the recommendations to come. First and foremost, keep in mind the mission: You were hired to assist a commercial enterprise. Even if your job is a technical function in early stage research, you are ultimately expected to contribute to business success. Though that may seem obvious, I find this perspective is not given enough emphasis, is sometimes a surprise, or is ignored. So, as well as social and organizational orientation in your new job, pay attention to the company's business and your role in it. You will find company commercial needs have an overarching influence on your job. Business imperatives influence technology directions, organizational culture, and career paths.

With that context, I selected four success factors that should assist with the transition period from student to effective industrial scientist. These factors are found in diverse business environments and have paid the greatest benefit when addressed, in my experience. Out of many possible topics, the four are business awareness, team skills, time management, and communication skills. Obviously there are other important issues, including some that will have great relevance to your particular situation beyond the four I selected. To capture topics crucial to your new job, I suggest that you ask about job success factors as you begin working with your supervisor and new colleagues. You can properly emphasize the four I chose after those conversations.

Business Awareness

We start here because I find it is the perspective most commonly overlooked by new employees. Start early knowing the value of what you do and who cares. With every new assignment, you should know how you fit into the big picture. Clarity about your work's value leads to good decisions about where to put your efforts and making appropriate commitments (time management is discussed later), but also where to contribute beyond basic obligations. Learn the priorities and imperatives. Understand what is important to your employer's business, and what is urgent. Understand what makes your department, your division, and your boss achieve their objectives. Ensure your efforts are related to goals that matter and are in proportion to their priority.

Joining any new organization will require technical acclimation and socialization time, but as early as possible, identify and begin to participate in high priority programs, projects, and goals. Performance appraisals and salary increases are affected by the impact of your work. In the long view, career progress, which usually results from increased responsibility, is a function of your cumulative accomplishments and their business/division impact. Access to job opportunities and greater independence to define your role can also come from a record of consistently helping where it matters most.

It should be no surprise that all initiatives are not equally urgent and that priorities shift. However, putting emphasis or too much time on lower priority goals is a common performance problem with new employees, arising from being misinformed about priorities, not willing to say no to requests from influential project leaders or colleagues, or from just ignoring a company imperative he or she finds uninteresting. Exploratory work and pursuing personal ideas beyond objectives are important, but they must be done in addition to, not instead of, addressing critical business needs. Deciding how to accommodate what is urgent without ignoring what is important is a constant tension in a business environment. I will return to this topic in the time management discussion.

Learn key values. Every company culture has preferred behaviors and operating values. There are usually some that matter very much. Actively developing them and ensuring they are followed is everyone's responsibility. An outstanding example is safety. Safety is a universal value in the chemical industry, where accidents can cause permanent injury or fatalities and sometimes have significant financial consequences. Typically, there is little tolerance for carelessness and none for negligence in following safety rules. Examples of other values cited on company websites include quality (meaning meeting customer expectations), people development, market leadership, innovation, and being entrepreneurial.

How you work is as important as what you do. Cultures vary considerably, but there are always core rules, especially the boldfaced or bright red boundary lines in company values.

Teamwork

In a company, which is literally a group of people, getting significant things accomplished depends on effectively interacting with others. Teams and good teamwork matter in industry. They are more likely to be engines of project success than individual efforts, and there are myriad examples of how poor team effectiveness is deadly to projects. I recommend that you actively seek collaborations and assist wherever you can throughout your career.

Collaboration is a key success factor because valuable problems tend to be complex and available resources are usually scarce, especially time. Your significant progress in complex assignments or new environments benefits immensely if you have partners with complementary expertise, experience, or knowledge, who share your goals. Intensive collaboration is a disconcerting new activity for some new-to-industry scientists who may have had a solitary or competitive existence prior to the first industrial job, but there is no way around working with others in industry. At a minimum, everyone has a boss, customers, and support providers.

Of course there are individuals who start businesses essentially by themselves, develop new products, or make technical breakthroughs. But by far, especially for moderate to highly complex or innovative projects, teams are responsible for results that matter. Even in smaller companies where individuals carry many roles and proportionally carry more of the responsibility for results, it is often pairs and trios of collaborators that pull everything together. Hard problems, when solutions need to be exactly right, multicomponent projects needing breadth of expertise, or just a critical level of effort for speed, are where teams become progress multipliers.

Another reason you need to become collaborative in industry: job functions are distributed. Except in the smallest industrial lab, you will be handing off parts of your projects or be handed someone else's, depending on your role and expertise. There is either not enough time to sequentially accomplish tasks or some deep expertise may be needed to get all parts of the program done. A typical industrial project requires specialists to do their unique part and project managers to coordinate all the concurrent efforts toward a goal.

Function specialization extends into the whole enterprise. Companies of a certain size and larger are organized in separate commercial support and development components. Typically these are research, development, production, and sales/marketing. There are also separate infrastructure components that enable those functions, like purchasing, technical services, and human resources specialists. Each has special processes and knowledge, and all these efforts must cooperatively contribute to sales and profitability. A new employee's transition into this specialization paradigm requires understanding how your role contributes eventually to commerce, and how you fit into the organization of people and processes that must all work together. It also presumes you work effectively with others to get things done. Looking in the reverse direction, poor collaborators are poison to project health. It is a tough career path for those who are notorious for interacting poorly with people, no matter whatever else they bring to the job.

As a new scientist in this kind of environment, quickly embrace collegiality with high levels of information and idea sharing, and sharing credit for success. Effective teamwork is based on trust among the members. A reputation for hiding results, ignoring assigned partners, or not valuing other project members for their contributions is a substantial career impediment.

Time Management

You may join a company that plunges you into the swirl of business priority chaos on your first day. On the positive side, if that happens, you can learn a lot quickly and make life-long friends among your coworkers by coping together. The most common experience, however, is a more gradual integration that ends when the assignments get complicated and having enough time becomes a daily dilemma. When the job responsibilities mount, orientation efforts get much less attention.

Time spent getting oriented and acquiring knowledgeable is a great investment, and the forbearance given to new employees is not likely to return. As much as you can, use the first days and weeks to learn about people and rules, and have them meet you. Don't abandon this important but unfortunately unsustainable opportunity to meet people, learn the new jargon (and acronyms!), learn the critical technologies, and begin assignments designed to integrate you into the community. Spend as much time as you can reading and learning from experts and veterans. Even though it is a period with a flood of HR new-employee courses, safety training, and one-on-one introductory meetings with your new stakeholders, your management and your key coworkers, don't stop this learning phase too quickly.

Time management becomes crucial in the next phase of your job when projects and tasks dominate your day. I find that as soon as new employees are perceived as valued technical partners, their orientation period shifts rapidly to being busy with commitments that can be overwhelming in number, size, or speed. Time becomes scarce: time to think, time to meet commitments, time to learn. It is easy to get time taken away. Customers usually do not wait, and coworkers will transfer tasks or responsibilities to you if you accept them.

Actually, being in demand for the right reasons is what you want to happen. You are valued. The problem becomes managing commitments safely and correctly while reserving time for personal growth and learning. Please note: coping by ignoring or missing obligations is not a good way to start your career in a new job. You need to rigorously meet commitments, so do not make them when you cannot deliver results.

There are a great many time management tools, options, and ideas if you do not already use any. While you should find the set that suits your needs and personality, here are a few suggestions for everyone.

- Keep Action Item or To Do lists to track commitments and due dates.
- Keep an appointment calendar that only you or your assistant can change.
- Reserve times of the day for email or catching up on writing. Don't fall behind.

I recommend a written set of personal objectives you and your supervisor agree are important to accomplish each year, to keep the big-picture goals in sight, and define which are of the highest importance. Best of all, be careful not to overcommit in the first place, and let your customer or colleague know immediately when any commitment will not be met as circumstances change. Learn to diplomatically say "no" or its equivalent, "I can't right now," when requests for your contributions are really not possible or are not appropriate uses of time.

Meetings are a common time-sink. Obviously, don't commit to meetings that have questionable value. For all the rest, I recommend scheduling regular meetings for critical projects but cancel or truncate those where you find there are not enough compelling reasons to meet. On the other hand, do not go too far in the direction of avoiding meetings.

Finally, being busy is not a virtue and it is certainly not an accomplishment. Some people see working hard and long as a measure of their work's value. We appreciate those who put in enormous effort and extra effort is necessary for achieving results in some cases, but in fact you will be rewarded more for delivering results than the effort. Better to deliver on a few substantial assignments than not having much to show for 60-hour weeks and lots of meetings. As a supervisor, I am not convinced that long weeks and impossible workloads ensure folks are contributing as needed. I respond best to results, especially those derived from proper priorities and from distilling assignments to critical tasks that target goals. Find ways to meet or exceed your objectives without wearing out.

Effective Communication

Despite a lot written about communication in the workplace, this skill remains underdeveloped in new industrial staff and I find it is underappreciated among new employees. I also find "better communication" implies more is needed, when effective and trusted communicating is the real need. Being effective is getting and receiving information correctly to and from the appropriate people, when it is needed and at the right level of detail. When more communication is actually needed, use multiple media or communicate more often as opposed to adding complexity or length. Simple and concise is always better.

Communicating effectively saves time, avoids misunderstandings, and ensures your contributions are used and valued. Doing it well matters because job-essential functions like receiving assignments and information, collaboration with coworkers, and relaying results are all done by speaking or writing. An important subset of communicating is the use of email, texting, and voice messages, since they are the most used communication tools in business. They are speedy and direct communication but they are prone to imprecise, incomplete or unintended messages.

Being an effective communicator means being read (or heard) and understood. These happen when you are concise and clear. Develop a habit of editing or reviewing what you write for clarity and brevity before it is sent. A great deal has been published on this topic and many training courses are available to assist. Here are some useful pointers from journalists:

- Shorter is more likely to be read than longer.
- Simple is more likely to be understood than complex.
- Make your key point or request at the very beginning. Background, data, commentary, etc. should follow for anyone interested in details.
- Use an editor whenever you can. Fresh eyes are much more likely to spot mistakes and weaknesses. At least review what you wrote before sending it.

I recommend a technical writing course if you have not had this training, emphasizing clear and concise messaging through editing. Skills for effective presentations, reports, and email are very valuable, and your coworkers will be grateful for concise, to-the-point messages.

Your industrial career is starting. You are learning the science and technology of your employer. You are also going to learn more about yourself, what motivates you, and how organizations really work. You will learn when your preferred work style is appropriate or inappropriate for the tasks at hand. You are going to meet people who will teach you a great deal, and some who will be dependent on you. The next phase in your education is just starting. I wish you much success and satisfaction in your new job!

Chapter 2

What Do You Need To Know To Work in Industry Besides a Ph.D.?

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Gradate students preparing for positions in industrial research focus on the scientific knowledge gained from research and course work. While this is critical to success in industrial research, other skills and expertise are also important. These topics may not be stressed in graduate school, and the approach is not always aligned with the approach taken in industrial research organizations. A new researcher can be more effective in his position by having an understanding of these issues and skills. These topics include working safely; the fundamental principle within industry is that laboratory work will be done safely. Research is becoming more collaborative, and the ability to communicate and to network internally and externally is extremely important to industrial research organizations. Researchers should have an understanding of intellectual property. They should have a general understanding of the principles of toxicology and toxicity testing and an appreciation for product safety and regulatory affairs issues that arise in the course of research. Finally, researchers must recognize that R&D is one part of a business. Researchers must appreciate that the objective is to develop technology that will bring value to the company, and they should understand how company leadership makes decisions related to investments in R&D.

Introduction

Welcome to the world of industrial research. You are completing an advanced degree in science or engineering, and you are preparing to enter the field of industrial research in the chemical sciences. You can expect to find this to be scientifically challenging and personally rewarding.

Industrial organizations invest in innovation and in research and development with an expectation of a future return. Ultimately, the return is a profit that is derived from the sale of a new or improved product or technology, or the savings obtained from a new or improved manufacturing process. Incremental, short term improvements in a product or process will provide a modest return, while much larger returns can come from longer term research that leads to breakthrough innovation.

Successful innovation starts with a specific need or problem to solve. The need or problem must be connected to some one who will pay for a solution. If no one will pay, there is no return and no reason to do the research. Usually, this need is described in very general terms. It can be for a material that has some new or improved properties, a drug with increased effectiveness toward a specific disease, or a new process that produces less waste and is more energy efficient. The first step for the researcher is to convert this need into a scientific challenge. Researchers then seek to find new and better solutions to the problem, and the solutions will deliver value to the company. Ideally, this solution will be based on an invention that will lead to one or more patents. Patents are one of the best ways that researchers can provide differentiation from the competition and a sustained competitive advantage.

Companies do not just invest in new product development; research portfolios will also have exploratory research projects. While new product development is expected to deliver a financial return, the return from exploratory research is increased knowledge in a specific area. Ultimately, this knowledge serves as the foundation for future new product development efforts. This mix of development and exploratory research creates a virtuous cycle in which profits derived from new product development are invested into exploratory research which then leads to future new product development.

Industrial research can be both rewarding and positively affect our future. One of the current trends in industrial research is to direct research toward solutions to major societal challenges such as energy, water, health and food supply. Industrial researchers are increasingly bringing life cycle considerations into their work. This requires them to complete an assessment of the full range of environmental impacts of a new product or process. Working in these areas will provide industrial researchers with the opportunity to have a real influence on quality of life issues and the challenges facing a big part of the world's population.

Safety

Every research organization has an obligation and duty to provide its employees the safest environment possible. This is a fundamental principle in the operation of chemical research laboratories in industry and at government laboratories. Research can involve the use of highly reactive or toxic chemicals, high energy sources, extremes of temperature, and high pressures. The potential for accidents and exposures is always present, and the consequences can range from relatively minor (a first aid case) to severe (a loss of life). The fundamental principle in industry is that laboratory work must be done safely; if it cannot be done safely, it will not be done.

An important element in the safety efforts in industrial laboratories is the creation of a "Safety Culture." These are common beliefs that are embraced by everyone associated with the lab. The Safety Culture leads to an environment in which researchers are engaged and commit to working safely and to watching out for their colleagues. The Safety Culture also demands a commitment from R&D leadership to provide a safe environment, ensure that researchers are properly trained and equipped, and that everyone puts safety first.

It is important for researchers to be active and engaged in the safety effort in all of their work. This is a major component of the annual performance review. Researchers are held accountable for their own safety and for the safety of those they supervise. Everyone is expected to be watching out for the safety of others. The ability to recognize and anticipate potential hazards is a skill that industrial researchers must master. In addition, researchers must always be focused on identifying ways to reduce these hazards.

Industrial chemical research laboratories make every effort to reduce the hazards of laboratory work to acceptable levels. Hazard controls are used to lessen workplace hazards that pose a threat to the safety of researchers. The "hierarchy of control" provides a framework for the types of hazard controls and the risk reduction that is expected. At the top of the hierarchy are elimination and substitution: either remove the hazard entirely or replace it with a safer alternative. The next levels, used when elimination and substitution cannot be applied, are engineering controls and administrative controls. This leads to the design of a safer environment (using things like fume hoods and pressure cells) and to the establishment of rules and policies. Personal Protective Equipment (PPE) ranks last on the hierarchy of controls and is used to reduce researcher exposure to hazards when engineering and administrative controls are not feasible or effective.

Personal Protective Equipment is equipment designed to protect the researcher's body from injury. PPE includes safety glasses, gloves, lab coats and shoes. Industrial chemical laboratories require that appropriate PPE be worn at all times in the laboratory. PPE is selected based on the hazards expected in specific laboratory operations. Safety glasses are a minimum requirement for entry into a lab, but specific tasks may require more substantial protection that would be provided by goggles or a full face shield. Researchers wear a variety of gloves in the lab. There are different gloves to protect against exposure to different chemicals, and there are specific gloves to protect against exposure to high and low temperatures and against potential cuts and bruises from working with glassware or with tools. All researchers wear a lab coat that is appropriate for the specific hazards.

Industrial laboratories emphasize good housekeeping. This is considered to be a prerequisite for safe lab operations. It is difficult to work safely and efficiently in a lab that is cramped, cluttered, and dirty, and where it is difficult to find equipment or glassware. Industrial researchers are expected to maintain clean bench tops and hoods, to organize storage areas (drawers and shelves), to dispose of unnecessary equipment and chemicals and to maintain this on a daily basis.

An important element of any Safety Culture is that all researchers are properly trained to do the specific experimental work they are assigned. Achieving this has led to the development of written procedures that serve as the basis for training. Simple, everyday lab work can be described as common practice or prudent laboratory practice. More significant and potentially hazardous lab work uses Safe Operating Procedures (SOPs) to describe how the work is to be performed. The SOP provides detailed instructions for safely performing the task; the operational boundaries including items such as scale, temperature and pressure; emergency shut-down procedures; and PPE requirements. An SOP is reviewed by other scientists to ensure that it is correct and complete. The collection of common or prudent laboratory practices and SOPs defines how normal laboratory work is to be conducted.

Experience has shown that many safety incidents occur when researchers go beyond the scope of these written instructions. To deal with this, industrial laboratories have adopted the Management of Change process. When starting laboratory work, researchers ask themselves if what they are about to do is specifically covered under existing procedures. This can include the nature of the chemicals being used, the scale or reaction conditions, and the laboratory equipment. If the answer is that it is something new, the normal procedure is to stop and complete a detailed hazard review for the proposed experimental work.

These procedures are not intended to stifle creativity. They are intended to slow down the rush to run poorly conceived or ill considered experiments that may jeopardize the safety of researchers. Remember that the fundamental principle is that if work cannot be done safely then it will not be done.

Industrial laboratories operate under very stringent standards for disposal of laboratory wastes. This includes chemicals that are no longer needed. All of these materials to be disposed of must be properly labeled and packaged for disposal through an outside vendor. Nothing is ever poured down the drains.

Communication and Presentation Skills

Excellent communication skills are valued highly in industry. Industrial researchers must be able to skillfully articulate key information, both verbally and in writing. They must be able to present their ideas clearly and concisely. The ability to share ideas and information on projects, science and technology with colleagues is at the heart of the collaborative process. Communication skills also include the ability to listen carefully and to understand various viewpoints.

Strong communication skills can mean the difference between an outstanding industrial career and a good industrial career.

Writing and presentations are equally important to an industrial researcher. Written reports provide regular updates of progress on projects and document advances in technology. They also serve as the basis for drafting patent applications. Internal presentations provide many of the same benefits, but they also provide opportunities for researchers to demonstrate their abilities. A good presentation provides a researcher with the opportunity to demonstrate mastery of a topic and the ability to think on her feet. She can show the ability to organize information, to be concise and focused and to understand and answer questions.

Graduate students likely have experience in writing update reports, papers for peer review and grant applications. They have made presentations within a research group or department, and perhaps at scientific conferences. In these instances, the students are writing for or presenting to an audience that can easily understand the topic. In the industrial world, researchers will present to a much less homogeneous group. Researchers will often be asked to explain technology to people who do not have a comparable technical background. They may be business colleagues, executives who make decisions on the future direction of the company, patent attorneys, manufacturing staff and/or customers. Researchers should be able to present information in a way that anyone can understand, regardless of their educational background.

Another important communication skill is the ability to deliver an "elevator speech." Imagine a researcher on a two minute elevator ride with the company president. The challenge is to explain clearly and concisely what she is working on and why it is important to the company. Similarly, a researcher may be asked to make a brief presentation to a venture capitalist seeking his support for a great idea.

Networking and Collaboration

Innovation often occurs at the intersection of diverse fields, industries, disciplines and cultures. As a result, research everywhere is becoming more collaborative. Researchers who will be successful in collaborations will have strong networking skills and the ability to successfully manage relationships internally and with customers and partners. Opportunities to collaborate start with internal research projects which almost always involve multi-functional teams. Successful industrial researchers must be able to work with a variety of people and disciplines. New researchers will join a project that can include experts in synthesis, applications, characterization and analytical chemistry, and process research. Other functions also contribute to projects; these include engineers from process technology, patent attorneys and safety and environmental experts. New researchers should seek to participate in internal networks and to create their own networks. Developing an informal, internal network consisting of both peer scientists and experienced, scientific experts can lead to success in many areas. Who you know can be as useful as what you know in solving technical problems, so researchers should find the experts in their company, get to know them, and utilize their skills.

Collaboration and networking within a company's global organization is also important. The chemistry related industries are global in scope, and this has extended to the research efforts. As companies globalize their research efforts, projects utilizing global research teams for global opportunities are becoming common place. It is unrealistic to believe that the smart people only work in laboratories in the U.S. Researchers must be able to function as part of a global scientific community. They must be able to network with the company's scientists around the world, and be able to communicate with many different cultures. This is essential to achieving innovation breakthroughs.

Working with customers is another aspect of collaboration and networking. Really successful innovation requires a deep understanding of customers' needs and problems, and the best source of this understanding is to work directly with the technical staff at a customer. Researchers often work with customers to introduce new technology. A Joint Development Agreement (JDA) with a customer is an excellent way to collaborate with a customer already committed to using the new technology that they are helping to develop. Leading companies are increasingly using JDAs to increase their probability of success in innovation.

The need for innovation has led many companies to embrace the concepts of "Open Innovation." Companies are seeking external ideas and capabilities to complement the ideas and capabilities within their own laboratories. Companies seek ideas through partnerships with customers, suppliers, universities, government laboratories, and start-ups. Networking and collaboration skills become really important when looking for innovation outside the company.

Toxicity and Regulatory Affairs

Research in the chemical sciences supports some of the most regulated industries in the world. The concerns over the safety of products from these industries continue to grow, and have become global concerns. These product safety questions can have a major impact on the success of a product in the marketplace. A fundamental objective for industrial research is to create something new: a new pharmaceutical, a new chemical, a new polymer, and these new materials must be evaluated for their safety. The testing to ensure compliance with safety and toxicity regulations can be expensive and is increasingly global in scope. Ultimately, the regulatory requirements can be a significant roadblock in the development of a new product.

All researchers should have a general understanding of the principles of toxicology and toxicity testing. This would include an understanding of the issues associated with making and using toxic materials, an awareness of new tools being developed for predictive toxicology and the knowledge of when to involve product safety experts. This understanding can bring a number of benefits to the researcher and to the company. Identifying the critical toxicity issues early will help researchers to focus on reducing hazards as much as possible. This can accelerate the development by anticipating toxicity concerns and can save resources and money.

University researchers should already have a good understanding of Material Safety Data Sheets (SDS). Every chemical in an industrial lab will have a SDS readily available. SDSs are also required when sending samples outside the company (for example, to customers for performance evaluations). Researchers will work with Product Safety specialists to create SDSs for new chemicals. Many companies will create a research SDS for samples being provided to customers. The SDS addresses three major issues: the known hazards associated with the substance, how to protect the environment and the people who use the material, and what to do if an accident occurs.

Intellectual Property

Research in the academic world is directed toward a discovery and a publication while research in the industrial world is aimed at discovery and the creation of intellectual property. Intellectual property is all of the proprietary knowledge that a company uses to provide differentiation and competitive advantage in the marketplace. Intellectual property related to research activities includes patents and trade secrets. Both can play a major role in a company's business strategy.

A patent provides an exclusive right to practice an invention for a limited period of time, in exchange for a public disclosure of the invention. A patent does not give the right to make, use or sell an invention, but it does allow the patent owner to prevent others from making, using or selling the patented invention. Patents can add significant value to a business by preventing the competition from using a patented technology. Patents claims can be sufficiently broad so that it is difficult for competitors to design a way to get around the patented invention. As part of the commercialization of technology, companies will attempt to erect barriers to prevent competitors from entering this market with similar technology. A strong patent estate can provide a significant barrier.

Researchers should understand the technology landscape of the field in which they work. This includes patents as well as publications in the open literature. This understanding provides insight into the state of the art and prior developments. Prior disclosures (sometimes called prior art) may define what is patentable and not patentable, and a challenge to the researcher is to find a way around the prior art to a patentable invention.

Another means of protecting intellectual property is to maintain the information as a trade secret. The information is kept confidential while still providing a competitive advantage and thus value to the business. While the protection that patents provide generally expires 20 years after the patent application date, trade secrets can be maintained forever. Companies and employees must be very diligent about protecting their trade secrets. Industrial processes are often kept as trade secrets.

Industrial researchers often engage in collaborations with universities, government laboratories and other outside research organizations. These collaborations can be significant in advancing technology in a new area of research. Defining the ownership of intellectual property arising from these collaborations is an important element in establishing the collaboration agreement. For example, these agreements may allow for the university to own the intellectual property with the company agreeing to either an exclusive, royalty bearing license or a non-exclusive, royalty free license.

R&D Is a Part of the Business

The objective of industrial research is to develop technology that will bring value to the company. Researchers can improve their effectiveness by having an understanding of how senior management makes decisions related to investments in R&D. Some of the key concepts include business and technical strategies, R&D project portfolios, how R&D projects are valued and managed, and how capital investment decisions are made.

The business strategy will set the direction for the organization. It should identify where the organization wants to grow and what markets are critical to its future success. The strategy should connect to innovation and technology. It will help to identify key technologies that must be developed and maintained to support the anticipated growth. It will be used to identify new products, technology and services to be brought to the market, and it will identify critical manufacturing processes that must be developed or improved. Research leadership will use the business strategy to develop an innovation and technology strategy. An important component of that strategy will be to identify and fill technology gaps. These are competencies or technologies that the company will need but does not currently have. Those gaps can be filled internally or outside the company through collaborations, partnerships or other examples of external innovation.

R&D projects are expected to be aligned with the business strategies; the strategies identify what should be done and the projects are early steps toward execution of the strategy. However, R&D projects must make sense; they must deliver an acceptable return on the investment that the company is making. If there is no return, if the project does not have significant value or impact, the company will not start the project or will not continue the project. The financial impact is based on the net income derived from the project. The income would be from the sales associated with a new product or application or the savings associated with the implementation of a new or improved process. Commercialization of a new product or process may require a capital investment for new equipment or a new manufacturing platform. Companies expect that a capital investment in a product or process will deliver an acceptable return (just as an R&D project must deliver an acceptable return). Companies have sophisticated processes and financial tools for evaluating these capital investments.

Breakthrough innovation is risky, and companies try to manage that risk by maintaining a portfolio or group of R&D projects. The portfolio enables the company to find the right mix of projects. Companies will seek to balance around a number of dimensions; some of these dimensions are low or high risk projects, shorter or longer commercialization timelines, line extensions/improvements or innovative new products and technologies.

Most companies have a systematic process for evaluating, managing and moving major projects from start to finish. The process is used to ensure that the proper resources are available for the project at the right time and to accelerate the development efforts. Projects are completed by a multi-functional project team that can include representatives from, for example, R&D, Sales and Marketing, Process Technology, Engineering, Manufacturing, Safety and Environmental Engineering. The work to complete a project is divided into discrete, sequential phases or stages. Within a phase or stage, the project team will only do what is required for the current stage. Progress is measured against objectives and deliverables that are specific to the phase or stage. The team must achieve sufficient progress in a stage to proceed to the next stage. The stages are separated by decision points, often referred to as gates; the project must pass through a gate in order to proceed to the next phase. At the gate meeting, the decision makers and the project team assess the project. They could decide that the project is ready to move to the next phase; they may even decide to accelerate the project by adding more resources. They may decide that the project team has to redo some of their work, in which case the project stays where it is. Or they may decide that the project is no longer worth doing and stop the project with the resources reassigned to other, more promising projects.

Conclusion

The introductory understanding of safety, intellectual property, and regulatory issues complements the scientific knowledge obtained in graduate school. Together, this body of knowledge provides a good starting point for a career in industrial research in the chemical sciences. The ability to work safely, to communicate clearly, and to collaborate with colleagues combined with an understanding of regulatory requirements, intellectual property and the relation between industrial research and business will have new researchers well prepared for their first assignments.

Good researchers will never stop learning; they are continually learning about new science and developing new skills. This also applies to these complementary areas. Mastering these skills and developing a deeper grasp of these topics are important in creating an effective researcher who can make a significant contribution to the success of a company. This can also prepare scientists for expanded leadership responsibilities.

Scientists may also find that these present future career options beyond industrial research. Many who started in industrial research have made career changes to work in safety or regulatory affairs or to become patent attorneys. Others have moved into positions where they have developed and managed collaborations with universities, national laboratories and start-ups, or have taken their interest in working with customers to positions in sales, marketing or general business. Overall, these complementary areas can help to provide a challenging and rewarding industrial career.

Chapter 3

Academia to Industry: Getting Ready for the First Job after Graduate School

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An overview of core competencies and skills that are desired specifically within the chemical industry is presented in this chapter. The core competencies discussed below are desired in almost all work environments. Until these competencies are addressed as a part of an academic curriculum, self-education and self-preparation will help you transition smoothly from an academic mind-set to that of an industrial chemist or chemical engineer. Learn how the chemical industry of interest functions and develop yourself within that industry by focusing on these core competencies.

> *There are painters who transform the sun to a yellow spot, but there are others who with the help of their art and their intelligence, transform a yellow spot into sun*—Pablo Picasso

Introduction

What do you need for your first job besides a Ph.D. (Doctor of Philosophy)? As one may expect, the answer varies depending on who you ask. If we put academic positions aside, some people are convinced that you do not need a Ph.D. or any other advanced degree to succeed in business. Interestingly enough, they are probably right. But before jumping out of your chairs with joy or anger please continue reading. In reality, success is not determined by your title, what you have studied, or where you studied. It is measured rather by what you have contributed, how you delivered, and the impact you created. The level of education you have, whether it is a bachelor's, master's or doctoral degree simply places you at a different starting point both in terms of salary and position. Each degree has its pros and cons. The education is undoubtedly a very important tool, but no matter what your starting position in industry, in addition to the technical qualifications your degree provides, you need to have other skills, or at least an understanding of and ability to develop other skills, to advance in your career. These skills are called core competencies, and how you develop and utilize them is very important to your success in industry. Typically candidates applying for their first job will not have most of these competencies. However, knowing what competencies are desired and how you can use them in the new position will help you develop those skills more quickly. Just like a chemical reaction, the outcome of a successful career depends on the reaction conditions, activation energy, rate of reaction, molecular orientation, and bonding affinity between you and the company that hired you. Then your education and skills act as the catalyst to accelerate the reaction.

During the last decade the economic fluctuations, which resulted in a search for cheaper manufacturing options, left many qualified, experienced scientists and engineers without jobs. As a result, the job market got very competitive. New graduates found themselves competing with experienced candidates for many of the positions. Especially in volatile economic times, the competencies covered in this chapter become more important to obtain, succeed in, and maintain a job. Fortunately, the unemployment rates are lower for chemists and chemical engineers based on the 2012 unemployment rates released by the Bureau of Labor Statistics (*1*) and the American Chemical Society (ACS) 2013 Salaries & Employment Survey (*2*). As seen in Figure 1, in 2013, the unemployment rate for Ph.D. Chemists was 3.0%. compared to 4.7% MS (Master of Science) and 4.6% BS (Bachelor of Science) chemists. Clearly, having a higher education degree brings an advantage in finding employment.

As educators, mentors, and researchers we are doing a good job of studying and understanding what drives student career preferences and their pursuit of advanced degrees. On the other hand, when it comes to understanding the expectation of industry (or academia), we strongly rely on recruiters and Human Resource Departments. Unfortunately, they may not have enough time or resources to educate candidates. Typically, the demands of industrial positions are not clearly communicated to educators and students. It would be more beneficial and effective for the industrial sector to work with universities and graduate advisors to include the development of core competencies that are important for success in industry as a part of graduate program curricula. This would provide graduate students with better guidance in making an informed career choice. Roach and Sauermann (*3*) studied over 400 science and engineering Ph.D. students' preferences for research careers in industry versus academia. Their study indicated that Ph.D. students who prefer research careers in industry show a weaker interest in science, greater concern for resources, and stronger interest in downstream work compared to Ph.D. students who prefer academic careers. From an industrial chemist's perspective, the outcome of this survey indicates that we need to do a better job of explaining the expectation of industry and the desired qualifications to have satisfied and successful scientists.

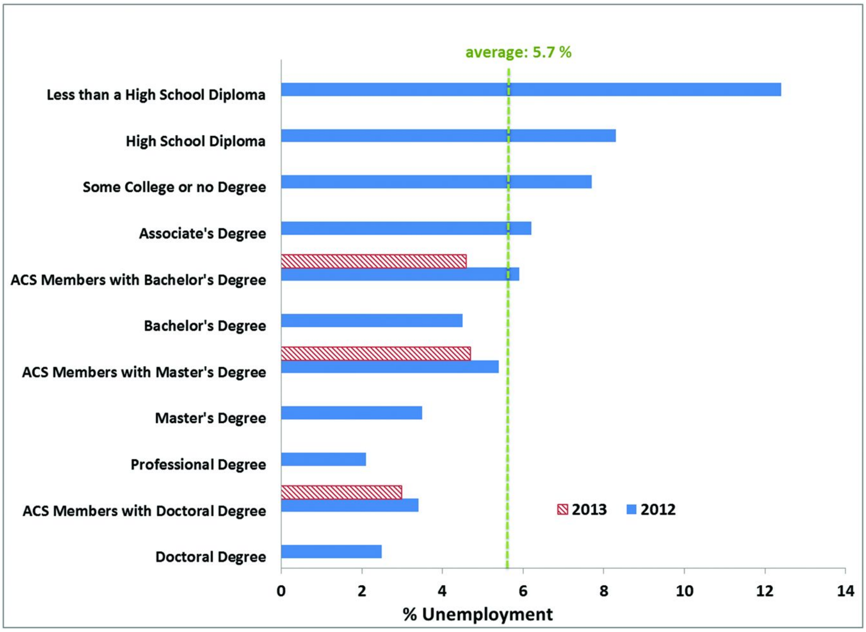

Figure 1. Unemployment rates by educational background (1-2).

So what do you need to be competitive and sought after in the job market and to succeed in your career if you are transitioning from academia to industry? This chapter focuses on five core competencies summarized in Table I that will help you to stand out and advance in your career.

Table I. Core competencies overview

Competencies	***Skills***	***Challenges***	***Strategy***
Technical	• Commitment to safety • Technical expertise • Analytical thinking • Problem solving • Thinking outside the box	• Analysis paralysis • Time • Practicality	• Ask questions • Co-workers • Mentor(s) • Staying current • Life-long learning
Personal	• Collaboration and teamwork • Empowering others • Adaptability • Communication • Personal	• Competitiveness • Power search • Management support	• Team work • Open mindset • Modesty

Continued on next page.

Table I. (Continued). Core competencies overview

Competencies	*Skills*	*Challenges*	*Strategy*
	management • Modesty • Integrity/Ethics		
Business	• Management and leadership • Prioritization • Decision making • Forward, analytical and strategic thinking	• Not science • Insufficient background • Lack of initiative	• Leadership courses • Mentor(s) • Learn from successes and failures: your own and those of others
Networking	• Networking • Professional associations • Communication • Involvement	• Comfort zone • Time balance	• Technical conferences • Memberships • Volunteerism • Governance
Legal	• Confidentiality • Social media sharing • Patents	• Social habits • Work versus social life	• Separate work and social life

You may possess some of these competencies already, but it is necessary to continue looking for opportunities and resources to further develop them. As scientists with advanced degrees, we are always focusing on improving technically; but advancing in other skills is key to developing a successful career path. Your first job will be a great place to develop these skills. Find a mentor who can help you develop them. Don't be afraid to ask questions and observe your co-workers. What characteristics do they have that you desire?

Technical Competencies

Technical competencies are specific skills, knowledge, and attributes you need in your job. As a chemist or chemical engineer, if you are hired to develop a new polymer that can be recycled, you need to have polymer synthesis expertise, an understanding of challenges of recycling, and problem solving skills. But technical competencies are not limited to the technical expertise. As a scientist or engineer, the most important technical skill you will need in your career is a commitment to safety whether you have a desk job or work in a lab. Safety is a culture that needs to be nourished daily. It is critical to understand that you are responsible *not only* for your safety but your co-workers' safety as well. It is unfortunate that academic practices do not prepare students adequately to practice safety in an industrial environment. Typically, a new employee needs a significant amount of time to "unlearn" the unsafe practices they may have developed in school.

Analytical thinking and problem solving are other important technical skills that are desired. They are important attributes that complement your expertise by helping you to identify possible causes of a problem and finding solutions. The chemical industry is a very competitive field. Cost, feasibility, functionality and originality of products and services are just a few of the criteria that scientists and engineers have to consider in their jobs every day. That is why creativity and innovation are crucial technical skills desired by industry. Thinking "outside the box" is key to fostering these skills. In order to understand what it takes to accomplish this, I would suggest the TEDx talk by Logan LaPlante (*4*). He is a 13-year-old who has been home-schooled since he was nine. He calls his education "hackschooling," because it encourages him to approach everything with a hacker mindset, which in return increases his creativity. We all need the hacker mindset, as Logan calls it, to think outside the box to develop creative solutions which provide a competitive advantage for our industry.

The biggest challenges in utilizing technical competencies in an industrial setting are limited time to develop and deliver solutions and the requirement for practical solutions. In academia, students are often trained to come up with the most appealing science without considering its applicability. Coming back to the recyclable polymer example above, the ability to efficiently scale up polymer synthesis must be considered. While these considerations are crucial for understanding the theory as well, they are often not considered in an academic research lab. Although lately there are more Ph.D. advisors encouraging the evaluation of industrial applications and feasibility, traditional academic research does not typically include feasibility studies. That is why the survey by Roach and Sauermann (*3*) showed that Ph.D. students assume they cannot pursue the projects they want in industry. How many Ph.D. students do you know who have spent seven or eight years on their research to prove that a theory is not correct or that a synthetic route does not work? In industry it is very important to recognize the limitations of the research and redirect resources to another approach or a different project altogether if the probability of success is determined to be too low. The inability to decide when to stop a project (which is the result of "Analysis Paralysis") and not considering practical aspects of the research such as the scale up (bench to production) process are some of the biggest challenges that Ph.D. researchers will face in the first years in an industrial research job.

One way to improve technical skills is to deliberately think about the next steps for your research. Let's assume you have developed the new synthetic route to make the new polymer mentioned earlier. Then you need to think about minimizing the number of steps it takes to synthesize, whether it can be manufactured safely on a larger scale, what it takes to scale up, recycle/reuse options, customer demand, etc. Another great way to develop new technical skills is learning from others. Working with different projects and different team members will provide many opportunities to develop new technical skills. Taking advantage of the experience of co-workers, staying current with new technologies, and understanding the needs and challenges in your field and what others are doing are additional ways to develop these skills.

Personal Competencies

Personal competencies are important skills that will eventually define who you are in business, such as how you handle the tasks and challenges given to you, which impacts how others perceive you. The most important skills you will need are the ability to collaborate and work in teams. Most of your career you will be working with a team whether you are leading the project, contributing part time, or involved throughout the project. It is important to understand that failures, successes, and challenges are not yours personally but, rather, belong to the team. As you advance in your career, empowering others should be a skill mastered to become a great mentor.

Flexibility and adaptability are other important personal skills needed to survive in an industrial career. Research projects are very dynamic in an industrial environment. Tasks, teammates, priorities, budgets, and customers are always changing. Demonstrating openness to such changes is very important. Accepting change rather than resisting it complements creativity and innovation.

Personal management skills as simple as time, calendar, and email management are necessary and greatly impact your communication skills. The tools and technologies available in today's world make it easier to be organized and accessible.

Self-confidence and personal credibility are other important attributes that are desired. Approaching challenging tasks with a "can-do" attitude, fulfilling the commitments, and taking responsibility are characteristics that are valued by co-workers and employers.

Regardless of your career path, integrity and ethics go hand in hand. If either of these is compromised, your career will likely spiral downward beyond repair. The ethical responsibilities that you have in industry involve not only exercising a high level of integrity in your daily activities, but also include understanding the implications of your research.

One of the biggest challenges in transitioning from academia to industry is controlling your competitiveness, an attribute that is cultivated particularly among students seeking advanced degrees. People who can prevent their own level of competitiveness from getting in the way of teamwork and stay modest adapt to the industrial environment more quickly. A good strategy for developing these skills is to work on projects that encourage team work and to emulate the behavior of people you consider great mentors. Management support of these endeavors is also critical.

Business Competencies

The skills that are considered business competencies are typically those developed with time and experience, such as leadership skills. Unfortunately, most of these skills are not emphasized in Ph.D. programs unless you are getting an MBA or a doctoral degree in business. Most companies send their promising employees to leadership courses to introduce them to and develop such skills.

Management skills such as time, project, and information management are crucial in business. Some of the most precious commodities in business are time and allocation of resources, especially talent. As a Ph.D., how you use your time and how you prioritize your tasks and projects are skills that you need to have when you start a new job, although as with all skills, development is a journey.

Another important skill you need is decision making. This can be utilized in different stages in your career but in your first job you need this skill to evaluate the feasibility of your project, processes used, to tackle challenges and find alternative routes, if applicable. It is very important to recognize when a project is not working and, if necessary, make the decision to stop and find an alternative path or cease before spending more time and money on it.

Strategic thinking is necessary to succeed in any aspect of life, but it is particularly important in business. The ability to anticipate the implications and consequences of situations, evaluate and identify ways to tackle those challenges, and position the research/project/team/organization for success based on identified strengths, weaknesses, and trends are very valuable leadership attributes.

The obvious challenge in possessing business competencies is inexperience. Although academic research can clearly benefit from business competencies, traditionally this has not been an educational focus in science and engineering. A good strategy to develop these skills is to cross-train, attend leadership programs, and self-develop. There are many leadership and development books and courses available through schools, academic institutions, organizations, and associations. If you are a member of the American Chemical Society, you can take advantage of its professional development courses. Learn from successes and failures, both your own and others'. It is critical to learn the causes of failure and make sure it is not repeated! One way to achieve this is, if possible, get involved with different stages of projects and assess the projects' level of success at the end with others.

Your ability to keep pace in a technology intensive, fast-changing business environment requires the development of business competencies which will dictate your ability to strengthen the firm's competitive position, ensuring its future viability and your own position within the company.

Networking Competencies

As simple as it sounds, networking and relationship building are very important skills in business. Despite the perception that scientists and engineers are lab rats, mass balancers, and mostly socially inept characters, they can be great networkers, thanks to the many technical conferences they attended as graduate students.

The network and professional relationships that you have are important assets that you bring to your new company. Continually building great technical and business connections can be a powerful asset in your career. Networking is not only about making such connections, but building enduring, mutually beneficial relationships. Attending technical meetings, conferences, and visiting clients are examples of helpful ways to catalyze face-to-face network collaborations. Social networking websites and tools have greatly facilitated the ability to build a broad professional network, but it is important to remember that it is the quality of your connections that far outweighs the quantity of your connections. Volunteering for leadership roles within related industry organizations is a great way to not only get better connected, but to develop other core competencies already discussed.

The challenge is maintaining the network and keeping in communication with key contacts. The best strategy is to attend technical and scientific meetings, utilize professional social networks, and become members of professional associations. Many people think that due to secrecy and confidentiality issues it is hard to maintain your connections; however, this is not true. The technical connections are great assets in problem-solving and developing lasting partnerships.

Legal Competencies

Legal competencies are, unfortunately, underdeveloped skills in most new job seekers. Confidentiality is of the utmost importance in the competitive environment of chemical industries. All the ideas, research, knowledge, and information pertaining to customers are the property of the company you are working for; therefore, you are bound to keep that property confidential. You should quickly learn the legal requirements and policies within your company to understand your responsibilities. Company manuals that outline the organization's goals, policies, and protocols are good resources. Misuse of confidential information can be intentional or a product of negligence or inadvertence. Both types are a serious breach, with the former having more severe consequences.

Within the last few years the popularity of sharing in social media brought a different level of confidentiality concerns. Based on a presentation by Spilman Thomas & Battle, PLLC Attorneys at Law, in 2011 42% of corporate compliance officers reported disciplining for misuse of social media (*5*). The popularity and temptation of using social media is the challenge for the generation of social networkers. The best approach is to avoid sharing anything that can be linked to your work in social media. It is also important to realize that what you share in social media can be seen by your future and/or current employer and co-workers, so be mindful of what you share.

Conclusion

The transition from an academic mindset to an industrial one can be difficult for the new employee, co-workers and employer. Fortunately, for most, the transition does not take too much time with the guidance of mentors and co-workers. Typically, the hard work required to get your Ph.D. places you in a well-deserved, respected position. With such a position, expectations are typically high, which can be stressful. The core competencies discussed in this chapter are the skill sets that you can highlight when interviewing for that first job and possessing them will ease the transition from academia to industry. All the core competencies listed are skills that are applicable to everyone.

It is important to remind yourself that most people start their first job with very limited skill sets and develop mastery during the course of their career. What will distinguish you from others is how quickly and how well you optimize those skills and, most importantly, how well you put them to good use to make a difference within your organization. Try to become the one who can transform the yellow spot into the sun!

Acknowledgments

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Chapter 4

So You've Got Your Ph.D.....Now What? A Primer in Career (and Life!) Planning

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Completing an advanced degree is always a laudable achievement – Congratulations! Even more so, a Ph.D. in chemistry has required considerable commitment, lab or library sweat, along with courses, teaching assinments…and sacrifice of your personal life! A life and career phase only for the brave at heart. Career planning is an activity in which, neither enough fresh Ph.D. graduates nor more seasoned colleagues engage. This summary of a conference presentation offers the reader the opportunity for sufficient self-analysis and reflection to learn whether they are in the "right place", considering their passion, interests, skills, and general life situation. Several tools such as mind-mapping and creation of a Career Roadmap enable the reader to assess where they are and to formulate a strategy for moving to the next step.

Let's Start Here…

Slowly and cautiously, I climb the stairs to the stage, step up to the podium, and greet the audience.

"Ladies and gentlemen, I have 10 seconds to capture your interest for the remainder of my presentation… and the rest of the time to lose it. However, we have two secret weapons working in our favor to make this an interesting, fun-filled learning experience. First, I am speaking with a very intelligent, curious and eager audience – That's you! We will share the second secret weapon at the end of the presentation…"

This is how we would begin our journey together, lasting about 10 to 15 minutes in a conference or seminar presentation. Versions of this presentation have had many titles: "What Then? What Now? What Next?", "A Tale of Two Stories", "So You Really Want to be a Chemist?", and others. Only a handful of slides suffice and we would focus on "connecting in friendly conversation". (See Duarte (*1*), Simmons (*2*) and LeFever (*3*)).

I hope this written version titled "So you've got your Ph.D…Now, What? A Primer for Career (and Life) Planning" captures and holds your interest… and gives you some tools for planning.

My esteemed, competent and eloquent colleagues will be writing additional chapters for this monograph about such very necessary topics as Resume Writing, Cover Letters, Interview Preparation and Questions. Additionally, key skills needed to establish oneself in the first and latter positions include effective Planning and Organization skills (*18*), clear, concise and effective communication, and presentation competencies along with their technical expertise! I will not presume upon their expert writing and will look only at the development of future career plans and options.

In the Beginning…My Story

To set the stage for our conversation, you should know something about me. Bill Cosby on some early vinyl stated the obvious: "I started out as a child…". Born in a small, sleepy railroad town in southern Ontario, Canada of immigrant parents from Europe, my siblings and I learned early that hard work and education were prized values. Even so, the first day of school was very traumatic, lots of crying, hanging onto the schoolyard fence. My older, wiser (and physically domineering!) brother said "Look fathead, get in school! You are embarrassing me!" This same sibling later sparked in me a curiosity to read, to learn, try new things, to take (measured!) risks… all leading to learn that most of questions could be answered through a developing insatiable interest in science.

Once I got the hang of school, I could not stop. After about 20 years, I completed a Ph.D. in Chemistry at the University of Waterloo in Canada. This graduate education provided, of course, the necessary technical skills to call myself an organic chemist. In the process of conducting the research (labwork, literature research, etc.) the additional skills of problem analysis and solving, planning, organizing, communication, and effective presentation to both technically expert and uninformed audiences.

Along the way, few interesting tidbits – A Macho Moment playing varsity football in University (see Figure 1. photos!) and helping fund my graduate education by playing pedal steel guitar professionally. Music has stayed with me, still playing jazz guitar and bass!

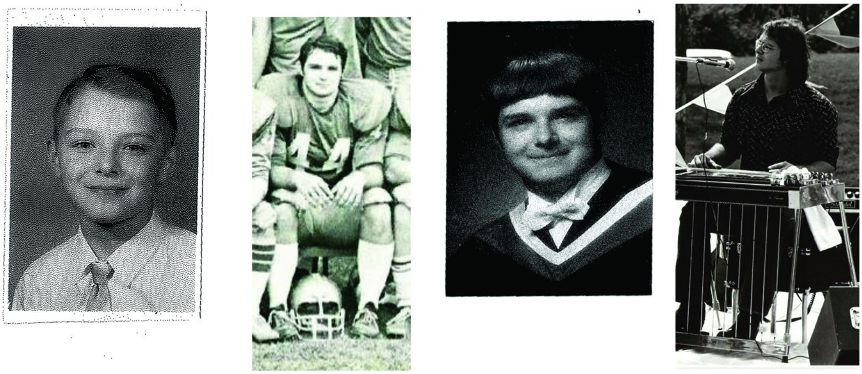

Figure 1. Started out as a child: First grade, University Football, graduating (almost out of school!) and helping pay for grad school by playing pedal steel guitar.

After my first few years in industry, I returned to school and completed a Masters degree in Chemical Engineering, also at Waterloo… and this cross-disciplinary duality has served me well. After about a decade with a leading Canadian chemical company, I moved to a larger, more global firm and this afforded my family and me the opportunities to live in Germany twice, as well as in several parts of the United States. During most of my career, I have been engaged in technical leadership roles, ensuring that R&D projects were focused, leading to commercially successful products. However, my passion in supporting others, helping them create their own career plans, has grown increasingly and become very rewarding for me, mentoring others to success. Among other "hobbies", I teach part-time at a few universities, stay as fit as I can, occasionally running some 5-10k races with family members…A life fully lived!

But that's more than enough about me! Let's talk about…

Your Story: Where Am I?

Futurist Daniel Burrus presents an interesting mental image of a windshield: You need to know where you are coming from (rearview mirror) and use that to determine where you are going (windshield) (*4*). But the windshield is much bigger than the mirror: Your future is much bigger than your past! In a workshop setting, participants put pencil to paper and describe several things that brought them to their current state in life (See Figure 2). **Most would agree: Life is not linear but more like a Random Walk** (although we can still plan!) (See Savage (*5*), Fung (*6*) and Gottman et al. (*7*).)

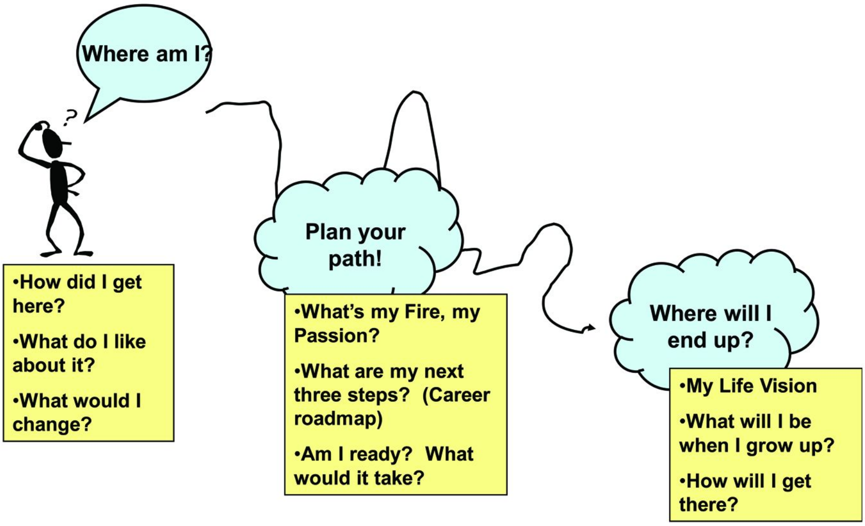

Figure 2. The Non-Linear Life Plan…ain't it the truth!

Guiding questions may be:

- Where am I today? My current situation? (Grad student, assistant professor, R&D chemist, bank teller, stay-at-home dad)
- What skills have I acquired in completing my Ph.D.? Working hard, planning, organizing, problem solving, team cooperation?
- What are the things I like about it? (Learning new things, hopes of employment, rewarding hobbies or social activities)
- What are things I would change? (Geography, financial state)

Now What?

Once you have established and clarified your thinking about you current state, we are compelled to think about our longer term state:

- Do you have a Life Vision or Mission Statement? Covey (*8*) and Smye (*9*) provide for thought-provoking ideas. The Life Mission Statement can serve as a "true North", a check-point to confirm we are headed in the correct direction career- and life-wise.(See also Rath (*16*).
- What ever happened to childhood dreams? Give up on them? Not realistic enough? These may play roles in understanding our adult interests and passions.
- What will your legacy be? How will others remember you?

Plan It! Do It!

Now is the time to start connecting "Where You Came From" with "Where You are Going" and how you will get there! (**Recall: Your Future is bigger than Your Past!)** I can almost hear the reader exclaim "Yeah but, you don't understand!", to which I would reply "By the way, the Yeah-But bird is extinct" and "of course I don't understand: So explain it to me!"

A way to start creating and sorting through options is to create a MindMap. (See example for My Story in Figure 3). An excellent tool created by Buzan (*10*). It is not the only tool but can be of great use for many things – brainstorming, idea gathering, project planning, etc.

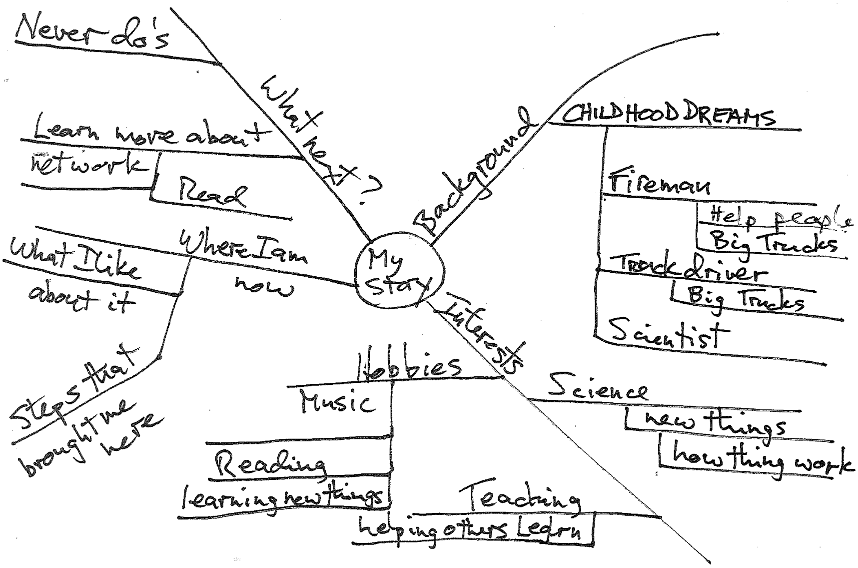

Figure 3. Mindmap summarizing "My Story".

Dr. Seuss may have described it like this:

You can do it by yourself, You can do it in a crowd
You can do it in your head, You can do it way out loud
You can do it for your work, You can do it just for fun
You can do it for your projects until the project's done!

Take the time to create a MindMap for such branches as your Background, Interests, Childhood Dreams, Hobbies, What is Fun, Never-Do's, anything else you can write or draw.

Once you have a page full, talk to a confidante to check….Am I on track here… or way off base? The more input you get the more realistic it can be. **And remember: It's just a piece of paper – IT'S NOT YOUR LIFE!**

From this, you can now start creating a **Career Roadmap**, a fancy word for a flow diagram summarizing your possible next steps. (Sandberg says in her book "Lean In" that our careers are more like jungle gyms than ladders! (*11*)) An example is shown in Figure 4.

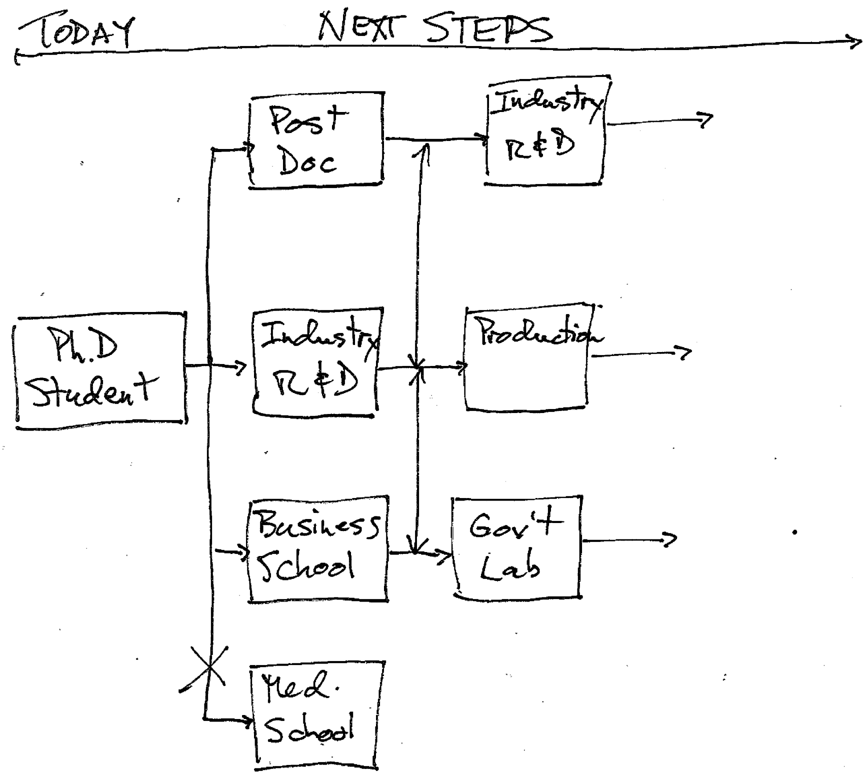

Figure 4. Career Roadmap: What's my next step?

It makes sense to include your present state, a few possible next steps (only your favorites to which you can actually commit pursuing), maybe include a Never-Do or Not Now. I suggest that people only go a few steps into their Burrus Windshield (= future). We learn something every day – we should be smarter tomorrow than we are today! As we learn more and the world around me changes, it makes little sense to go too far down the planning road…

Now the Key: Is there enough information to take start moving on your Roadmap? Do you need to network more? Read more?

Make a decision… and get started NOW!

A Few Key Learnings…

Here are a few **Never Forgets:**

- Failure is a beginning, not an end.
- Never outgrow your childish curiosity (Stay in touch with your Crayons (Pausch (*12*)).
- Time is all you have… and as you grow older you will realize less and less of it (Pausch (*12*)). We only live about 4000 weekends…
- Never stop learning, never stop thinking, never stop asking tough questions! You can't learn less – only more. And many folks know more than you!
- Practice humility. (Not everyone had the chance to earn a Ph.D.!). Be thankful.
- Share the credit generously… and always be honest, polite and respectful!
- What you know gets you started… and as a Ph.D. you should know it well.
- Who knows you is more important than who you know!
- Talk with lots of people…listen to more. (Networking: see for example Bowman (*13*), Welch (*14*), Seidman (*15*), Ferrazzi (*17*)).
- Everybody's different – get used to it… and everybody has a fun-story to listen to!
- The Questions of the Day: Will you make this the best day ever? Tigger or Eeyore? Giving your all… or holding back?

Finally…

For many years, I used this as my final slide in presentations:

- **Get Input**
- **Decide and…**
- **Do!**
- **Only what you do counts!**

(By the way, the second secret weapon I mentioned in the beginning: You have me as a passionate, engaging and motivating speaker!)

'Nuff said!

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Chapter 5

Building Your Career in a Government Laboratory

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This paper describes practices and ideas that a new Ph.D. chemist or chemical engineer will need when starting employment in a government laboratory research environment. We discuss the difference between the government lab environment and the academic graduate research experience, covering an eclectic mix of topics with the intent of providing you the lessons that we believe will aid in your success.

Building Your Career in a Government Laboratory

Congratulations – you've got a new position in a government research laboratory! Now what? How do you build a career?

Obviously you're going to need to do great research and present/publish the results. But there is a lot more to it than that.

In this chapter we cover an eclectic mix of topics with the intent of providing you the lessons that we believe will aid in your success in a government laboratory research environment, though of course most of these cross into other sorts of work environments as well:

- Communication techniques
- Your elevator speech
- Working in a team
- Personal development activities
- Following the rules

- The business of research
- Your personal brand

Your authors have a combined more than 45 years of experience doing research, managing projects, managing programs, and managing budgets on the order of $100M annually in government laboratory settings (as well as in academic and industrial environments). While we in no way claim to know everything and our experiences are specific to our own careers and laboratory settings, along the way we've learned some lessons about how to succeed in the government laboratory environment. In this chapter we will speak in generalities – knowing that someone somewhere will be able to find a counterexample. We hope that you find this information useful as you begin your next adventure.

Communication

> "*The single biggest problem in communication is the illusion that it has taken place.*" – George Bernard Shaw

One of the most important things you must be able to do in order to succeed in your career is to communicate the essence of your work. Give your audience the "bottom line up front" (this is referred to as the "BLUF" method of communication). Many of the people you will talk to throughout your career are not going to be in your technical area, and you will have to get your message across in clear terms:

> "I've developed a new material that can enhance battery life by a factor of 8."
> "I'm working to understand the molecular basis of how catalysts function so we can design better and cheaper catalysts."
> "I've developed an algorithm that allows us to analyze large data streams 100 times faster than before."

This is the opposite of how scientists are generally taught, if they are taught at all, how to present their work. The more usual path – the one you see at technical meetings and in most seminars – generally follows this sequence:

1. I had an idea (often left out)
2. I did all these experiments (in gory detail)
3. I got a bunch of data (often shown in an incomprehensible format)
4. I analyzed all that data and got a bunch of results (often shown in an incomprehensible format)
5. I considered those results and came to this set of conclusions (hoping that the audience is reaching them with you!)
6. Here are the next experiments that should be done (again, hoping that the audience is thinking the same).
7. Any questions? (which should always be phrased as "what questions do you have?" but so rarely is)

While this might be acceptable and even expected for a technical seminar, it's not effective when you've got only a short period of time with leadership – the top executive decision makers for the laboratory – and you want to convince them that your idea is important and worth their time and investment. You've got to respect their time and know exactly why you're there – this latter point is especially critical. In addition to knowing your message, you must know your "ask" – are you asking for money? Are you proposing a new program? Are you simply providing information? Whatever it is, start with that:

> "Today I am proposing we develop a program for internal funding of seed ideas. If we create this program, it will cost $1M per year and could potentially generate $100M in follow-on funding from external sources." --- *now* you've got their attention! In fact, you should stop at this point and be certain they want more information. It's possible they will accept your premise and the answer is yes. If they want more information, it's then time to explain how it would work and why you're the right person to do the job.

Don't Underestimate the Importance of Your Elevator Speech

Whether through your own management or at meetings, you will cross paths with senior people who could have a big impact on your career. You should always have an "elevator speech". In one minute (or less) you need to be able to describe both the significance of your work and your contributions. This is the time to demonstrate that you have a vision of where your work is going. It is not the time to complain about setbacks or to detail your most recent results. In many ways the BLUF sentence is also the opening of your elevator speech. You then add a brief bit of detail – but again, respect the time of the other person. Have this prepared and *practice it out loud.* Make sure you are never caught off guard when someone says "tell me about your work." Offer to provide details if the other person expresses interest.

Working with Others While Developing Yourself

In a government laboratory environment you are working as part of a team even if you have your own research task to complete. Whatever you are doing will have to be understood by others on the team, and you will need input and information from them in order to make sure your efforts are having the largest impact possible. One of the most important things you can do is help your team understand the best way to work with you. Are you someone who needs a regular team meeting? Are you great about keeping up with email but hate talking on the phone? Is texting the best way to get in touch with you? Is a morning coffee meeting your thing? Whatever it is, make sure your team knows the best and most effective way to interact with you. That said, you have to learn what works best for the rest of your team too - when you need something from someone who really prefers to talk on the phone after having seen a lot of background information, you need to make sure you flex to their needs in order to ensure they are working at their best too. It's a balancing act, and it will take practice.

It's also important to know your strengths and what you bring to the team. In this case we are not talking about your technical knowledge or skills - this is about your strengths that transcend the specific area in which you work. There are a variety of tools available from the various "social style" and "personality type" tests to those that are more specific to your innate talents and strengths at work. Are you a natural entrepreneur? A born advisor? These tools are always being refined and updated, so rather than date this section with specific examples, we invite you to search them out or ask your human resources staff for advice (it's entirely possible they have an in-house resources you can take advantage of too!). The goal is to be able to articulate who you are outside of what you do:

> "I naturally make connections between people, ideas, tools - so a role in which I can exploit that strength is ideal. It helps me as a scientist because I can look at a variety of data and weave a cohesive story about what it means. This strength goes beyond that, however. When I meet someone new and learn what they do my first thought is who I should introduce them to or what recent research advances they might be interested in."

Understanding your strengths in this way can also help you determine the best course for your career trajectory. In a government lab the Ph.D. staff members generally follow one of two tracks – research or management. Most entry-level Ph.D. staff will join in a research position. Those who stay in research may lead teams or be individual contributors to multiple projects. There are opportunities to move into management – either as a line manager of a group of researchers or as a program manager. Ultimately the management track leads to executive positions. Either track can lead to a fruitful and satisfying career making meaningful contributions – it is really up to the individual to determine which is right for them. Some people even manage to combine both.

Most research teams include members from other countries or cultures. Some cultures are very informal and team members will express their ideas when they believe they have something to contribute. In other cultures, respect for superiors or elders may restrict a junior team member from contributing to a discussion even if they have great ideas. Be cognizant of the culture norms of your team members and develop ways to leverage the best of the whole team's capabilities.

A diversity of people can lead to a diversity of approaches. Researchers develop their skills in their training environment. A person from a different country might have been trained with different access to facilities and supplies. They might have developed a radically different approach to solving a technical challenge. This is another great reason for soliciting opinions from across your team.

Breadth as Well as Depth

To succeed in a Ph.D. program you need to take a deep dive and become a "subject matter expert" on your dissertation topic. As you move through your career you need to see problems from a variety of contexts and to be able to identify whether you or your close colleagues have the expertise to attack the challenge. If you don't have the requisite expertise you need to decide if is it worth it to develop the needed skills or whether you should pass the project to someone else.

This takes a growth in "breadth" not just depth. You must understand the importance of a wide range of subjects, even if they are peripheral to your core work. Part of maturing as a professional requires you to be able to see a new subject and develop enough of an understanding to identify both the value and the key challenges. You might call this learning to "talk the talk" even if you don't know how to "walk the walk". As an example, if you are participating in a discussion on analyzing samples with HPLC or Mass Spec, or high throughput DNA sequencing, you need to be able to have a professional discussion about the impact of the technology even if you have never personally operated one.

Understanding the basic economics of a process is a significant portion of developing technical breadth. For example, what are the contributing factors to the cost of synthesizing a molecule or material? If they are the raw material inputs then identifying substitute inputs is most critical. If the critical contributing factor is the number of reaction steps or unit operations, then designing a simpler process is most critical. Frequently the number of operations is defined by the complexity of the material and the purity and quality requirements of the product. Without understanding the quality requirements, it is easy to cause project failure by producing materials either out of specification or out of cost range.

It's likely there are regular announcements of seminars or other meetings, and to the extent you can you should attend as many as possible. Learn where your laboratory (not just your group, but the larger organization) is expecting to grow and ask how you can contribute. Volunteer to lead tasks when you feel there is a good match to your expertise. You might not get to do so right away, but it is important people know you are interested. Volunteer to help on tasks when you have less expertise but are willing to put in the effort to learn. This will always help your breadth and will expose you to new areas. Finding out new ways to use your knowledge and skills will help you no matter where your career takes you, and people will see you as a valuable team member.

Rules of the Road

Transitioning from an academic laboratory to a government research lab takes an adjustment. Not only are you living in a new place, meeting new people, and getting up to speed on a new research area - you also have to learn the culture associated with your new environment. One of the biggest changes is going to be the culture around safety. In a government lab, there will be steps you must go through in order to carry out experiments - steps that are related to understanding the risks and how to mitigate them, how waste will be managed, how regulations will be followed, fiduciary responsibilities, and so forth. Some other person will be required to review your safety/risk plan and approve it before you can begin work. This culture of quality and safety is all about ensuring that every person goes home in the same (or better!) condition that they arrived, and to ensure that no research time is lost (or funding) due to a safety incident. Violating safety protocols or policies is taken very seriously and can result in immediate loss of your position. One of the authors of this chapter has terminated staff on the spot based on disregard of safety rules. Many government labs have a “stop work” policy which means if you see something you find unsafe - even if it’s not your work or related to your job - you have a responsibility (not just a right) to stop the work until the issue is mitigated or the responsible authority deems the operation safe to resume. This is not just following a set of rules. This is a mindset and everyone around you will appreciate it if you pay attention to safe operations. No shortcut is worth injury!

Another cultural shift is to know and understand your responsibilities and to determine what work that is outside of your scope or authorization. In graduate school you might have learned to change the oil in a mechanical rough pump because you were running a mass spectrometer. It’s a good skill to have and it’s important you understand how the instruments operate. However, in a government laboratory environment it’s very likely that the mechanical pumps are tended to by technicians who have great skill in that area, and that you are not supposed to interfere. You might know how to run an NMR, but if you haven’t been approved by the person who oversees that instrument it doesn’t matter. Make sure you ask how you get access to instrumentation, and learn who is authorized to do which tasks. Going around these kinds of rules might seem like a small thing, but the reality is the penalties can be severe. Depending on the infraction you could even be violating a labor agreement with a union which could mean serious consequences for both you and the laboratory. In addition, there are going to be administrative specialists available who will be better than you at things like filing expense reports for conference travel, and you should learn to leverage all parts of the team. Having experts handle those tasks means you have more time to plan and carry out experiments, analyze data, and publish great work.

Isn’t That What It’s All About?

As a new staff member you are of course going to be curious about how people submit proposals and get new ideas funded. Again, in a government laboratory setting there will be a team of people involved to evaluate and determine which ideas will go forward in response to calls for proposals and how instrument time will be allocated. Depending on the position you hold you might be eligible to serve as a principle investigator (PI), or you may need to be a co-PI at first. You should ask all these questions early on. In fact, you should ask a lot of questions about the culture and environment. How do people move forward in their careers? Is it a match for you and your style and aspirations or should you be using this as a path to a different career? When you arrive (or ideally, during the interview phase), have a frank discussion about what your expectations are and learn from your (prospective) manager/team what their expectations are. While it will never be a perfect match, you can’t over communicate expectations. Make sure you understand how and when you will get professional feedback and evaluations. What are the opportunities for development (beyond doing your research)? How can you take advantage of them? Is there a mentoring program? If not a formal one, how can you connect with informal mentors? If it’s not a routine activity, you should create an individual development plan that details what you and your manager both commit to each year so you can be sure you understand how you're growing as a professional. In the future, whether you develop you career at the laboratory you just joined or elsewhere, this will serve you well. You will always be prepared to explain what you were expecting to achieve and how well you did.

It's Business

An important part of research that is often neglected in graduate school training is the business aspect. Research costs money - and it's a lot more than just paying for instruments, supplies, and the salaries of the researchers. The money coming in has to pay for the buildings, electricity, administrative support, groundkeepers, lawyers, travel to conferences, and on and on and on. There are various "colors" of money (meaning, money that is for a specific kind of activity) and these colors can't always be spent in any way you wish. Spending money the wrong way on the wrong items can land you in hot water (this is another reason your administrative support staff are so important – they know these rules!). You probably are not allowed to just head to the store for supplies, even if it seems expedient and even if that's what you did in grad school. Learn to read a balance sheet and spend some time understanding the cost of doing research. Spend time learning how money flows in the organization and how decisions are made. It's vital to understand when you are authorized to spend money and when you are not - depending on the funding source these rules will vary, so ask lots of questions!

Laboratories have a vested interest in maintaining a reputation for quality work. A technical publication, presentation, or proposal has the name of your organization as well as your name. If inaccurate or low quality work is allowed to be submitted or issued, it impacts the reputation across the organization. Therefore your management has a justification to review proposals, presentations or any other work prior to release and restrict or block low quality work that doesn't meet laboratory standards. Although it may seem logical that submitting a weak proposal has a small but finite chance of success, if could affect reputation and reduce future success rates.

Dissertation and thesis projects are typically a complete study in the context of the graduate advisor group theme. The main outputs are technical publications and presentations, and possibly patents. Government laboratory projects are frequently components of much larger and more intricate projects or programs. Programs may span decades and involve multiple laboratories. The individual projects may be parallel tracks to identify the best solution or tasks that are part of the more complex pathway. Therefore it is much more important to use statistical design of experiments. In academic research, the goal is frequently a publication detailing observation of a phenomena or synthesis of a molecule. The work is free standing and does not need to be statistically evaluated as part of the larger project. Develop the skills and capabilities to design your work with statistical relevance. Be able to review other people's work from a statistical standpoint.

In graduate projects, the goal is frequently to prove that you can accomplish a particular task. In government laboratories, the goal is mission-directed and researchers depend on each other to achieve deadlines. Success is not defined by proving your initial hypothesis, but by solving the critical challenge. When you are put in charge of a research task, think carefully about planning the work. Determine what the most important achievement is - that thing that if you cannot do it, nothing else matters. For example, if you must increase detection efficiency by a factor of five in order to measure the effect you are looking for, then that is the critical path, and your initial efforts need to focus there. It's vital you give yourself a reasonable time limit to achieve the critical path. Design your experiments to identify failure modes rapidly. The goal is to fail fast. Be willing to fail. As you identify failure modes you refine the fundamental understanding of the problem and increase success rates. This enables you to redirect your effort and resources towards more promising pathways. Of course everyone wants to succeed all the time, but if you do it also means you are not trying the most difficult and risky experiments that can have the biggest impact. If you communicate to your management what you are doing and why failure is an option, but that you plan to fail as quickly as possible if it comes to that, you will find that people will understand and appreciate your efforts to conserve resources (money, supplies, time, and effort).

You might even consider seeking formal training opportunities in project management or seek a mentor with expertise in that role. And remember, there will be subject matter experts around who can help you and who will want you to do well. Someday because of your technical expertise you may be asked to lead the acquisition of a major item of equipment, and at that point you will need to understand a lot more than just your science – at the very least you need to know who to ask questions of! Start early to build a strong internal network.

It's Personal

You should always keep your resume/CV and your professional social media up to date. Use updates and stories in professional social media to highlight your engagement in the field. If necessary, sever connections between your personal and professional social media. Make sure the public face you have is the one that you would want a prospective employer to see.

Track yourself on the internet, including automatic searches. People will look there before they interact with you so it is always better to know what they will find. If there are places that you prefer people to find you, then point to it often - this is your own version of search engine optimization for your career.

In this chapter we've covered some communication techniques, ideas on working in a team, the importance of personal development activities, the necessity and value of following the rules, the need to understand that research is a business, and the need to be the person who controls your own personal brand.

In the end, your career and its success belong to you. We wish you the best in all you do!

Chapter 6

Life Beyond Chemistry

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This article points out an approach to a career search by providing the reader with a series of tools and exercises to enumerate and characterize their chemical skill set and personal inventory of skills, motivations and goals for a career. Through a process of aligning the skills, abilities and motivators, and assessment of the results, the reader should have a clearer idea of what careers suit them. Ideas for creating and conducting a job search and the thoughts on the interview process conclude the discussion. Earning an advanced degree in chemistry is not easy. If you are working toward one, then you are experiencing it. If you have one, then allow me to personally congratulate you on your accomplishment. In either case, graduating was a two-edge sword. You leave the secure world of academia and then step into the real world. Change can be scary, but with change comes opportunity especially for those who can recognize it. Whether you are about to embark on your job search or you are in the process, you should know how to identify the opportunities that may be right in front of you. Many people miss opportunity since it doesn't hold up a sign saying "Opportunity Here" or other blatantly obvious signals. In this chapter, I hope to give you tools and advice on recognizing different possibilities for future employment based on the skills which you learned during your chemical education coupled with your unique skills which will lead to not only future employment, but to a fulfilling career. That is your goal. Do not waiver. Stay on target.

1. In the Beginning

1.1. Compiling Your Inventory of Skills

When starting off with a task, having an inventory of the resources available will determine your final output. This is always good planning exercise. You do not want to get into the middle of a project, for example, painting a bathroom and you run out of paint or you forgot to buy a drop cloth. Most people have an inventory they use to introduce themselves to the public and they refer to it as their resume. I invite you to take a step back before you create your resume and compile a list of your inventory of skills. You are certainly more than a chemist. I know you are. What were you before you became a chemist? Your skills as a chemist only enhance your innate set of skills.

To get started, here is an exercise that will help take stock of your skills. You will be able to do some now and come back to it later. In fact, you will probably find that you will be adding to the list as time goes on. The goal of the exercise is to get you to be objective about yourself. Keep in mind, a hiring manager will be objective about you. You want them to consider you as qualified, if not well-qualified.

Ask yourself a few questions. We will cover these questions in depth. This is the time to be honest. Only you will see this list for now:

1. What are your chemical skills?
2. What are the things you are good at doing?
3. What are some of your desires or personal motivators?
4. What are the things about you that made you go into chemistry?

1. What Are Your Chemical Skills?

This question is designed to ask you about your skill set as a chemist. No doubt that all chemists have a basic set - a variety of lab skills, e.g., using glassware, transferring liquids, purifications, or using an FTIR. Chemists also exhibit another skill set that is more cognitive: balancing equations, calculating molecular weights and moles, determining what the peaks are in an NMR spectrum, etc. We will refer to the lab skills as motor skills and the thinking or problem solving aspects as another set of skills.

By attaining a Ph.D., you also gained some very specific skills. At this point, you should be considered as an expert in your field. What did you do that is unique? You might have been a synthetic chemist that created new molecules, or developed new synthetic pathways that lead to increased yields. Perhaps you were a biochemist and used a suite of instrumentation to isolate DNA strands. You may have worked with a mass spectrometer as an analytical chemist; as a tool to study chemical pathways of reactions or you designed better instrumentation. In any case, you used inherent skills in conjunction with some of the basic skills to create a new set of more specialized skills.

Write down your *general* motor skills and/problem solving skills in two columns. Write down your specific Ph.D. level skills in another. You should further categorize them into *specific* motor skills and /problem solving skills as you did for the general case.

You can use this basic template as a guide.

Table

General Chemical Skills		*Specific Chemical Skills*	
Motor	Problem Solving	Motor	Problem Solving

2. What Are the Kinds of Things You Are Good at Doing?

In this section, we explore some of your innate skills. I'd like to start with the word "good" though. "Good" is just a form of relative evaluation. There can be good chefs, good pilots and good knives but they really have nothing in common with each other except for the relative concept of being "good." In our example, we want to define the word "good" as the *things that you do well*. For example, you might find that you have an aptitude for mathematics, but you still really consider yourself a chemist. That's fine, but you should include *math skills* as a proficiency in your inventory.

Alternatively, you may be good at fixing things with your hands. People may have been asking you for help when a bike, a lawn mower or wall needs to be fixed. It's nice to get money to do these things, but you may just enjoy the manual aspects of a project. You could also have an artistic flair and be good at things that require visual aspects in conjunction with the fine motor skills to create paintings, sculpting or woodworking. Although, I discussed vision, there are also the auditory skills which create music. These are skills in the truest sense and belong in your inventory. I have only touched on some ideas; you should consider your own case. Be free to let your imagination roam.

One might also be good at writing. Perhaps during the time that you were compiling your graduate research and working toward communicating your scientific findings, you found that you were getting better at written communication. Your career as a graduate student has given you a foundation to explore this option. Although you have written compositions and essays and a few lab reports, putting together a dissertation was something for which you might not have been adequately prepared. I doubt if anybody has a clear concept about the requirements as they embark - except for one's advisor, post-docs and other Ph.Ds. Your dissertation is the vehicle you use to communicate your findings and nobody knows what they are better than you do. Writing is just part of the overall process of putting a dissertation together. As you advance in your career, you are going to do much more writing.

As a graduate student, you were probably a teaching assistant (TA) in a lab or a classroom situation. This is public speaking at a very practical level. In a situation like this, the students look to you as an expert to answer their questions and discuss chemical concepts, setting up lab equipment and so on. In these types of situations, you have to explain the weekly concepts and use practical examples (problems). The skills you display in these teaching situations prepare you for speaking in larger and diverse public settings. Again this could be a new experience for you to do on a regular basis, but it is something that you have experience doing.

There are other examples of scientific communication in which you have participated such as preparing for a seminar or giving a presentation. When putting together a presentation, you start with a concept of what you want to communicate to your audience and then determine the best way of doing that. It is a valuable skill to be able to organize the information (sometimes based on time requirements) in a coherent way that successfully gets your points across. A presentation should contain the highlights of specific content that you use (or want to use) as a way to convey your major concepts into a person's mind and then to use verbal or speaking skills to impart that information to them in common language. In these situations, do not underestimate the power of good visuals to assist in getting your point across. Many organizations which sponsor meetings will request a version of your presentation for archival purposes. This is commonplace and you should be prepared to be associated with that document (in an electronic sense) in perpetuity. Whether or not your presentation is available for public dissemination, you should still be prepared to defend your material. When your thoughts about the material are organized, it is much easier to present and discuss.

You might have found that there are new technological skills that you acquired in graduate school that are now second nature. People have a tendency to ignore the things they do by habit and the skills or intelligence that it takes to accomplish a task. Being in a lab setting exposes one to a variety of different instrumentation and situations that are far too costly for an individual to purchase on one's own. Although you might have written some of these down in question 1, now is a time to reflect on your habits and to further bolster your skill inventory.

Compile a list of things that you do well. You will be surprised by the number of things that appear here.

3. What Are Some of Your Personal Motivators?

The things that motivate a person vary across the spectrum. They each seem to have the ability to stir up emotion and drive one to chase after the thing that they call "valuable". For example, animals might be trained to receive food for doing a task. If the animal started receiving pebbles for payment, it may not be motivated in the same way as it was initially. In this case, you could say that the animal was chasing after a piece of food for a reward.

In this discussion, I will not focus on the reasons why people become motivated. Instead, I want you to ask yourself what motivates you and to compile a list of these things. These types of things will help guide you in a career path. It is best if you feed the things that motivate you during your career. This will lead to more than satisfaction in your career, by giving you a sense of passion and self-fulfillment.

A quick example is your professors. They have research plans and ideas, lead a group of graduate students, do additional work to provide for the financial stability of the program, and teach chemistry at a university level. Each one of them has their own set of motivators that drive them to do all of these things every day. The degrees of their success can be measured in how accomplished they are and also how much personal enrichment they have.

Put together your list of things that motivate you and what gives you personal fulfillment. It could be as simple as the joy of discovery, in which case, you have a good head start as a chemist. You could find that making a positive difference in the world motivates you. There is nothing that says you can't have a career that meets both criteria.

4. What Are the Things about You That Made You Go into Chemistry?

This can have a wide range of answers depending on the person. I think that each person decides for themselves to become a chemist, but of the people I have known in the sciences, a lot of them are driven to have an understanding of the world around them in their own way. They all have a curiosity in finding out what happens when you react A with B and how to separate out the new compounds. Some of them find a challenge in preparing compounds that have never been made while others find the challenge in preparing compounds whose existence has only been theorized. Being able to determine what made you go into chemistry and keeping that as a central theme in your career search will be beneficial to your long term goals.

The interesting aspect of this question is that the answer really has nothing to do with chemistry in the first place. If you need additional input or assistance, ask your friends or your family what they think the answer to this question (as applied to you) should be. They are bound to have some insight or give you answers that you did not expect. Be open to what they say.

1.2. Alignment of Skills, Abilities, Motivators

With list in hand, your goal is to see how well you can align or "match-up" the items that you have from questions 1-3 in the previous section. You may see that there is a significant overlap between items in questions 2 and 3. The answers to your questions 2 and 3 are good descriptions of you. Try to form sentences out of them, for example – *I excel at X because I am personally motivated by Y*. How does that sound? Another way to describe it could be – *I feel at ease doing X because I like the feeling (Y) I get when doing it*. Try to make up more descriptions of yourself.

After you have composed a few of these descriptions, then examine your results to question 1. Do these answers form a basis for some of the chemical skills you have? Think of them as being a "logical conclusion" from the descriptions (alignment of answers to questions 2 and 3). How strong a case can you make according to "*p implies q*" to a stranger? If you have answered them honestly, this should not be a very difficult task at all. You should write down these conclusions. There is a certain power from seeing the words written down that will be realized only after reading them a few times.

At this point, start to include the results from question 4. Are there any additional correlations with these answers and the alignment of question 1-3? Maybe there are things that you don't quite realize about yourself that seem ordinary to you, but *extraordinary* to others. Can you find those qualities? They may be the ones that distinguish you from the crowd.

1.3. Assessment

What are your conclusions so far? My goal has been to get you to a point where you have a list of your skills and your qualities. From the title of this chapter, this writing is not only to help you find the best direction for your career, but to also help you discover an alternative career outside of the chemical field. You are in a position to make an assessment about your own career and how it merges with you as a person with a suite of skills. Some of your skills may be complementary, whereas some of them have a unique quality about them.

Here is a chance for you to be creative. How many different types of employment do you think exist that can match you? There is a good chance that your initial reaction might be to say – "Hardly any." or "Little or none." If that is the case, there are two common reasons for that.

The first reason is a lack of experience in self-assessment. Many people graduate and think because they have been trained in one or two things as an expert for the past four-five years that they have pigeonholed themselves. You need to keep in mind; you have attained this "expert" status because you are a conglomeration of your innate skills and desires. In the exercises above, you listed your "resources at hand" to see what you have to start your project. In the following section, you followed an alignment process to find correlations with your skills. As your career progresses, you will gain additional skills in analyzing resources at hand. Being able to do this to yourself will be a valuable tool.

The second reason is that people set boundaries on themselves and that prevents them from exploring options or even dreaming about them. This is more about one's ability to be open to new ideas and change. In an ever-changing world, it is important to be flexible and to fit into new employment niches. This statement is as true today as it was when the printing press was invented.

Take another look at the work that you have completed so far in this chapter. You started out collecting a lot of data about yourself as any good scientist would do. You solicited the help of others in order to discover data that you may not have found. In some cases, you might have found data that you would probably choose to ignore, but you cannot make a practice of doing that. Be aware that you, as well as other scientists, are also prone to your own human foibles as you sift through the data to reach your conclusions.

This step of the process is about being creative with your findings much like an artist is creative with a blank canvas. At this point, you are allowed to make connections that don't fit the standard model. You can add a certain flair to make your outcome stand out. One could choose to become a gourmet chef investigating molecular gastronomy with the chemical skills that you have in your repertoire. This is in the realm of possibilities so it should not be completely discouraged or tossed aside. You have what it takes to be creative. What other kinds of opportunities or careers can you think of that would fit your skills and your desires? Alternatively, how could your skills be influential or add value to a current career or discipline? That is another way to be creative.

The next step is the step into reality. How many of these opportunities are a good fit for you? Can you do this for 40-60 hours every week and still have drive, passion and a happy life? If you think you can, then you should look into what it takes to do them. Perhaps some of them require some additional skills that you don't have. If that is the case, you should get some additional training either through supplementary coursework, certification or working as an intern or volunteer. Use tools at hand to meet others in that field to ask them about the 'day-to-day' lifestyle of that career. They are bound to come up with some different answers. Listen for the 'golden nuggets' of information that can happen anytime or anywhere.

This is the final point in the assessment. You should have some ideas of opportunities that fit you as a person. The process to get here should not have been easy since truthful assessments of a situation require some brain capital. The list that you have is a valuable piece of information for you. This list is a living document and will change as you grow with experience and you should get familiar with the process.

2. Your Job Search

2.1. You Need a Plan

The introductory section of this document made you compile your inventory of skills along with your personal factors. An assessment was conducted to see what kinds of opportunities might exist out there that suit you well. At this stage, it is important to determine how you will find a position in that field. Don't go into this section as an observer. You need to be an active participant. You are your best salesperson.

In addition to your personal inventory of skills, there are other resources available to assist you in your job search. Look all around you. Your biggest and best resource is people. You have family, friends and colleagues that know you are looking for employment. If they do not know, then it is your business to let them know. In fact, tell everybody you know that you are looking for a job – for example, your dentist and your doctor are two individuals that know a lot of people. See if they can help you. You should be prepared to discuss this with them. They might be willing to help especially if you are a good patient. It is important that you get the word out.

Do you have a specific company in mind? Let your people know and ask them if they know somebody who works there who can help you meet the "right" people at that company. When I say the "right" people, I don't mean a human resource individual. I am referring to the individual who is well placed in that company and is able to make hiring decisions. That is the "right" person to meet. You do not have to find the President or CEO of a company in order to get hired, but if you can find the right group in the organization, the leader or manager of this group should be in a position to hire.

2.2. Interviewing

The interview process is something that everybody experiences in their life. Some of us get to experience it multiple times in a career. The hidden value of eye contact with a solid handshake, clear and concise answers to questions, showing interest by performing prior research on the company and asking questions about the work conditions cannot be overstated. This is the time to show the best "you" that you can muster since you may not get a second chance. Be prepared for a favorite set of questions – "What is your best quality?" and its partner "What is your worst quality?" Everybody should know their best qualities if you have gone through the exercises honestly. The reason you should know your worst quality is that it shows that there is something deeper to you. You have taken the time to analyze yourself and determined what it is and how you take steps to minimize it or turn the quality into a strength. Take time and prepare for this one.

3. Conclusions

This chapter was written to help you in your job search and to reveal that you really don't want a "job" in the proverbial sense. You want a career that can be long-lived, fulfilling and give you satisfaction. The exercises in this chapter should help you take a look at yourself and help guide you along the path.

There was a brief mention earlier about additional education and that might be something that you don't want to hear at this point. I would like to point out that after you leave school, you will continue to learn whether you realize it or not. Learning is something you have been doing your whole life and it does not end after you graduate. In a sense, graduation is liberating since you have completed your requirements. However, you will find that you will also need to develop new skills as you progress in your career and additional skills and techniques will just add to your already full tool box.

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Disclaimer: The opinions expressed in this article are those of the author and in no way represent the official position of the National Institute of Standards and Technology.

Chapter 7

Tenure-Track Position at an Undergraduate Institution − Application Package and Beyond

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Obtaining a tenure-track position at any college or university is a form of a long-term contract between the institution and the future faculty member. As with any contract, the goal is to achieve benefits for all. In the case of a tenure-track position, the objective is to align the institutional needs for teaching, research and service with the needs of the candidate for an environment supporting development and the achievement of long-term professional and personal goals. It is our intent in this chapter to describe the search process at a primarily undergraduate institution so that the reader can understand how an undergraduate institution selects future faculty and how candidates can best present themselves. As faculty who have chaired a recent, successful search for an organic chemist as well as serving on other search committees (SM) and who have served as department chair in addition to serving as chair and member of search committees (CAO), our experiences may prove useful to future chemistry faculty.

Introduction

The opportunities for a career in chemistry at a Ph.D. level are mainly in industry, government or academia. While industry comes first in terms of the number of positions, academia is a strong second with around one third of the job market (*1*).

The specifics of academic positions are tied to the type of institution. Each type of institution (community colleges, liberal arts colleges, primarily undergraduate or Ph.D.-granting institutions) has its own specific and perhaps unique needs. The institution describes its needs in terms of teaching, research and service, the three main aspects of a faculty position, in a written statement, the advertisement. In turn, the candidate presents her/his skills and goals in a package that generally contains the following documents: cover letter, vita, statement of teaching philosophy, statement(s) of research, and references. Upon initial assessment of the candidate's credentials by a search committee constituted of individuals from inside and outside the area of expertise of the candidate, the best matches on paper are selected for further evaluation. Thus the two-way information exchange starts: on one hand the institution aims to fulfill its needs in a particular field, while the candidate examines how well the institution's culture and resources align with his/her desired career path: essentially a best fit is sought for both sides. While there are several resources that provide advice on getting a tenure-track position at an undergraduate institution (*2–5*), including other chapters in this book, it is our intention to share our experiences and perspectives on this process at our institution, a predominantly undergraduate one. It is worth mentioning that we are describing a hiring process for an institution at which both teaching and research are required as opposed, for instance, to a community college where research expectations may not be present, or to a research institution where teaching may not stressed.

Position Description

Prior to posting a description of a position in, for example, *Chemistry and Engineering News* or *The Chronicle of Higher Education*, the department will have discussed its needs for offering specific chemistry courses and specific types of research. Specific chemistry courses that need to be offered to students define the broad area of chemistry, such as organic, inorganic, or physical, that characterize the future faculty member. The type of research generally will relate to the broad chemistry content to be taught and may be quite specific. For example, institutions seeking to support or increase undergraduate participation in research may wish to offer students a smorgasbord of research opportunities from computational chemistry to inorganic or organic synthesis. The department's needs in the position description usually result from an internal review that balances immediate needs and long-term goals. The posted description is official and has been approved by the department and, frequently, other administrative offices. Wise candidates will use the position description to determine if there is a potential fit between the candidate's goals and the institution's needs before proceeding to submission of an application.

The position description contains key words such as undergraduate research, course content or teaching responsibilities, external funding, type of research and references. Each of these must be addressed in the application package and will be described in greater detail below. There may be clues to the culture of the institution (public or private, religious affiliation) and geography. Budget constraints typically mean that the position description is short, thus most institutions will provide more information about the position and the institution on their website. The better the match between the candidate and the needs described in the posting and on the website, the more likely the candidate will be considered. The posting will also contain other critical pieces of information: the required materials for a complete application and the deadline for submission.

While not mentioned in the posting, the department will have appointed a search committee to review the applications, to interview a limited number of candidates by telephone, to identify a few candidates who will be brought to campus for a full interview and to host the candidate during the on-campus interview. While the search committee will be composed primarily of chemists, their fields of research and teaching may not be closely related to those of the prospective faculty member. The search committee chair's name may be provided in the advertisement. The posting will provide information about how to submit the application package.

Application

The application contains several components: cover letter, curriculum vita, statement of teaching philosophy, research proposal(s) and references. Each of these will be addressed below.

Cover Letter

The importance of the cover letter cannot be overstated. This is the most important opportunity available to introduce yourself to the search committee. There are some critical factors that must be addressed. It is critical that the letter be tailored to the institution. A letter for a predominantly undergraduate institution (PUI) will stress different aspects than one for a research-intensive (R1) institution. In other words, candidates should customize the contents of the letter for the type of institution as a single letter will not be satisfactory for both.

Teaching to, and research with, undergraduate students is very important at primarily undergraduate institutions so including a brief description of success in teaching or mentoring undergraduates in research is highly appropriate. The goal for the cover letter is to highlight your successes briefly since separate statements of your teaching philosophy and your proposed research will be included in the application.

Candidates should explain in the cover letter why they want to be a faculty member at this particular institution. The best explanation will indicate to the committee that you understand how an undergraduate institution differs from a major research institution as well as how your personal and professional goals mesh with the opportunities for teaching, research and service at an undergraduate institution. If there are cultural or other reasons that make the posted position desirable, these should be included in this section of the cover letter. Depending on the undergraduate demographics of the institution, teaching/research experience with a diverse population may be a plus. It is wise to match personal ambitions with those that might be achieved at an undergraduate institution. Someone who discusses research goals suitable for multiple graduate students and post docs is a poor match for an undergraduate institution that may not have a master's degree program.

The cover letter should be approximately one to one and a half pages in length and must employ correct grammar and spelling. If you are a non-native English speaker, it is recommended that you ask someone to review your letter to ensure that it adheres to accepted standards of formal communication in English. A casual tone is inappropriate for this formal communication to the search committee. If you include the name of the institution in the body of the letter, make sure that the name of the institution in the letter is the one you are applying to. This is obvious, but we have seen examples in which the institution named in a cover letter was not ours. Finally, be sure to include contact information such as a telephone number or email address. If you have several numbers or email addresses, it is best include the ones that you monitor frequently. Again, it is obvious, but responding promptly when contacted indicates your interest.

Curriculum Vita

Your vita should be well organized and sorted by category. Separate sections for educational background, including dates of degrees awarded, dates of employment, honors or awards, publications, presentations and contact information, should be present and clearly delineated from each other. Remember that your goal is to convince the search committee that you meet the criteria for the position and thus the information in your vita should be easy to locate.

Your education and employment record should be complete and continuous. Gaps in the record should be addressed in the cover letter. For each position or degree, describe in a few words what skills you mastered, what your responsibilities were, or what your experiences were. Since chemists outside your area of expertise will review your vita, it is wise to use vocabulary that is understandable to all chemists.

Highlight teaching experiences with undergraduates including the course titles and your role: for example, teaching assistant responsible for office hours, laboratory instructor or overall course instructor. You may include classes where you gave a lecture or two at the invitation of the course instructor but search committees would prefer to see that you have been responsible for an entire course rather than for individual lectures.

Research publications should be described with complete citation data. At PUIs where research with undergraduates is expected, it is good to indicate undergraduate co-authors if appropriate as this demonstrates your ability to work with undergraduates successfully. The number of papers designated as "in progress" should be limited to three. Too many papers in progress raise questions about your ability to see a project through to publication. If papers are accepted during the search, convey this knowledge to the search committee chair. Oral or poster research presentations should be listed separately with complete citation data. As with published papers, highlighting the contributions of undergraduates helps to establish your credentials in research with students.

A separate section for awards or honors, particularly for research or teaching, is a positive component. Brief descriptions of the award should be provided when the name is not descriptive.

Participation in outreach activities related to chemistry or teaching, such as working with high school students or with the community, are important to include together with a brief description of the purpose and the activity or activities.

Your vita should not include personal hobbies, goals or objectives. As always, proofread your vita carefully to eliminate all typographical errors. While it is not necessary to limit the length of the vita, it is important that all entries are appropriate and accurate.

In short, your vita presents a synopsis of your educational and professional career to date. It should highlight those components of the position description that you best meet.

Statement of Teaching Philosophy

Your teaching philosophy should convey your instructional goals. These goals should be more than simply teaching chemical content knowledge. Goals might include real-world applications of the chemistry, or increasing students' ability to think critically or applications of chemical content to other fields of science or engineering. General terms such as "learning to learn" or "life-long learning" should be avoided. If you must use these terms, be sure to explain how you interpret them. This is particularly true for "critical thinking" which is defined differently for each academic subject. A few examples to illustrate how you have implemented a goal in your teaching are important to include. If you have experimented with forms of pedagogy other than the traditional lecture or chemistry laboratory experiments with detailed directions, describing these efforts provides useful knowledge for the search committee. What led you to try a new way of teaching? What was the result of your experiment? Assessment is important for institutional accreditation and all faculty are expected to know something about assessment and to conduct assessment in their courses. The teaching statement is the appropriate place to discuss your understanding of, and experience with, assessment. Another useful component in a teaching statement is a description of how you would teach (or an example of how you have taught) a particular topic to students of varying background knowledge and understanding — in other words, what is your experience with differentiated instruction?

For applicants who have limited teaching experience, for instance only having graduate teaching assistantships while obtaining a Ph.D., a survey of the most recent literature in terms of pedagogy may expand your knowledge and help clarify your teaching goals. If you are interested in teaching and have not had much experience with teaching a full course, you might consider asking your department about teaching opportunities or seeking employment at a local community college or other college. The experience gained will be valuable to you and will indicate to the search committee a genuine interest in teaching undergraduates. It would be wise to consult with your thesis advisor before seeking these experiences.

In preparing your statement of teaching philosophy, it is wise to consider if your views mesh with those of the institution. If the institutional perspective is not readily available on a website, be sure to ask for information when contacted by the search committee chair (see below). Finally, as much as possible, try to make your statement a reflection of your unique personality.

The teaching statement should be limited to two pages in length, should be error-free and should be written so that non-educational experts can understand the content. Non-native English speakers are advised, as for the cover letter, to have their statements proofread by a native English speaker.

Research Proposal(s)

The typical first question is "how many research proposals should be prepared?" The answer is, unless specified by the posting, at least one and no more than three; however, all proposals submitted must be of high quality. An idea that is not fully described should not be included in your application package. The research proposal is critical for several reasons. It enables the search committee to assess your ability to describe your research interests and immediate goals in a concise, logical manner. It permits the committee to evaluate whether you understand the nature of the position and whether your chemistry background meshes with the institution's needs. A posted description for a synthetic organic chemist means that the research proposal needs to describe a project in synthetic organic chemistry. Someone with a background in computational chemistry may include that in the proposal in terms of how the end product of the synthesis might be used in additional research but the proposal's primary focus must be on organic synthesis. Tailoring your research proposal to match the needs of the department is necessary if you wish to be considered as a candidate. Research proposals also help the committee determine whether you have an understanding of constraints on research at an institution where there is a substantial teaching assignment and where research needs to involve undergraduate students — conditions which are typical at many PUIs. In short, your research ambitions need to match the institutional environment. Search committee members may also evaluate your proposal in terms of instrumentation currently available. We recommend that you either revise or eliminate proposals that rely extensively on instrumentation typically available only at research-intensive institutions. If such instrumentation is critical for your research, be prepared to explain how you would conduct research in its absence. Experience with undergraduates conducting research is a definite positive factor, but this information should be included in the cover letter, not in the research proposal.

New faculty are expected to establish their own areas of research and to be productive in research. Having written this, however, your ability to collaborate with other faculty in the department or elsewhere is a plus for your application. The department's website and links to its faculty should provide sufficient information on the research interests of other faculty. A research proposal based on collaboration with an existing faculty member is not necessary and may actually be unwise but you should be prepared to talk about possible areas of collaboration during an on-campus interview. Possible collaborations may also be included in the cover letter. Caution is appropriate as some faculty may not desire to establish a collaborative experience. You can suggest possible areas of collaboration but do not demand a collaborative project.

In addition to describing the goal(s) of your research, providing enough background so that a non-expert can appreciate the question(s) you seek to answer and elaborating on the experimental details so that an expert can evaluate your research potential, consider incorporating a tentative timeline, identifying possible journals which might publish your work as well as funding agencies that might be supportive of your research. All of these details help convince the search committee that you understand the complete process of conducting research from posing the initial question to final publication and that you appreciate how undergraduates can be engaged. Your research proposal needs to convince the committee that your research is realistic for an undergraduate institution.

References

The desired number of references (a minimum of three) as well as the format will be specified in the posting and the guidelines should be followed exactly. Sometimes only the contact information is requested, other times the actual reference letters should be sent at the same time as the application package. Some committees prefer to read only reference letters of the top candidates and other committees review the letters during the initial selection process. In any event, choosing your references is one of the important aspects of your job search and should be based on two criteria:

- *suitability*: your Ph.D. advisor is a necessary reference, your high school chemistry teacher is not appropriate. If you have postdoctoral experience, your advisor ought to be on your reference list. Besides your Ph.D. and postdoctoral advisors, other letter writers could be research collaborators or colleagues familiar with your teaching. Your goal should be to have references written by people who can comment authoritatively on your qualifications for the posted position. If you are currently in an academic position and are trying to change institutions, you may want to include someone from your present department who can comment on your research and/or teaching. Above all, your references should not include faculty from your undergraduate institution unless you conducted research under their supervision. Family and personal friends are never acceptable references.

- *availability*: once you select your references, you should inquire if they are willing to write letters and if they can do so in a timely manner, i.e., their letter will arrive when the application package is due. It is acceptable to ask your potential reference if they can write a positive, supporting letter.

Accurate and up-to-date email addresses and phone numbers of each reference are important as the chair of the search committee may contact them directly.

The Search

The search committee will read and evaluate many applications. In our recent search for an organic chemist, the search committee considered over 70 applications. The committee meets to rank the applications according to the description in the position posting. The initial goal of the committee is to narrow the pool of candidates to about 10 for telephone interviews. After these interviews are completed, the committee meets again to select the top three or four candidates for on-campus interviews, described in detail below.

First Contact (Optional)

Some institutions arrange for a "first contact," usually with the search committee chair. One purpose of the initial contact is to provide additional information about the institution, the department and the position. Another purpose is to confirm your continued interest in the position and your availability for a conference call with the search committee. The conference call may be scheduled during this informal call or at a later time. Some care should be taken when scheduling this first one-on-one call. For example, you should allow yourself at least one day to prepare for the call. Set a time and location when you can be assured of at least 30 minutes of uninterrupted time and do confirm the time and date of the call with a follow-up email. To prepare for the call, we advise consulting the websites of the department and the institution. Displaying some familiarity with the institution indicates that you are truly interested in the position. Encyclopedic knowledge of the department is not necessary and you should feel free to ask questions about the department and the position. It will be important for you to clearly articulate why you are interested in the position as this will almost assuredly be asked either in the initial call or in the telephone interview with the committee or both.

While all the remaining steps in the search process are stressful, remember that the search committee found your application of interest and that you are among the top candidates under consideration. During the first contact call, mention if you have other interviews scheduled and what time constraints for a potential on-campus interview you may have. This call is an ideal time to ask questions about the department, the university and the position. If there is critical information that you need to have, this is the time to ask. The search committee chair may not have all the responses but s/he will arrange for the data to be provided to you.

Telephone Interview

Generally, the search committee members will conduct telephone or video conference calls with the top candidates before making decisions on which three or four candidates to invite to campus. These calls are typically 45 to 60 minutes in length and, as with the optional first contact call described above, should be scheduled when you can be assured you will not be interrupted. The chair will introduce each member of the committee who will be participating in the interview. Take the time to get these names as you will interact with these faculty during an on-campus interview. Formats for the interview may vary but you should expect that each committee member will ask one or two questions. These questions will cover general information about your research, your teaching experiences, what you would plan to achieve during your first year and why you are interested in the position. Although it may not be obvious, the questions will be similar or identical to questions asked of all candidates interviewed. If a question is unclear, it is acceptable to ask for clarification before offering a response. Some questions may be unique to your application and you should be prepared to answer questions about unusual aspects of your application such as a gap in your educational and employment timeline. You will be given an opportunity to ask questions of the committee such as their views on undergraduate interest in and availability for research but do not ask about sabbatical leaves or vacation time. Questions about the department, the institution and the local area that show that you have some knowledge of the institution are particularly good. It is not advisable to appear to have more knowledge about the institution than the committee members have. The committee will not be able to answer questions about salary or details of a contract but it can describe your expected first-year teaching assignments, typical teaching assignments for other chemistry faculty, and may be able to answer questions about specific instrumentation that is available for research use. The committee can also answer questions about typical service expectations. Asking about the timeline for the search provides you with useful information in terms of other positions you may be considering. If you have not had an initial discussion with the chair of the search committee (see above), it may be advisable to indicate if you have other offers. Share this information without attempting to coerce the committee into making immediate decisions on your candidacy.

Telephone interviews are difficult as both you and the search committee lack the visual signals that aid in normal conversations or in face-to-face interviews. This is a stressful situation but again, it may help to remember that the committee has selected you as one of the best candidates for the position. It is important to speak clearly and to answer questions concisely. It is better to allow the committee to ask for additional information than to provide too much detail. When answering questions be mindful of the fact that the committee members probably represent diverse chemical expertise and they are not likely to be experts in your area of research. Keep the use of jargon to a minimum.

Sometimes this stage of the search is conducted using visual technology that allows for eye contact and in that situation you should be careful when answering questions to look into the camera. Admittedly it is difficult to stare into the camera for an extended amount of time but you do not want to give the impression that your attention wanders throughout the interview. During the telephone interview you should be polite but abstain from flattering any of the search committee members.

On-Campus Interview

The last major event is the on-campus interview which typically takes one to two days. The interview trip has several components including tours, meetings with faculty, students and administrators, a research presentation and social events. Some of these sessions, such as with students and the social gatherings, may appear to be informal but you are cautioned against treating any of your interactions casually. The search committee will seek the opinions of everyone who meets you during your visit.

The on-campus visit is not only critical for the department's decision but also for you. This visit with potential colleagues is your opportunity to evaluate the "fit" between your professional and personal goals and the environment in the department at the same time that the chemistry faculty will be considering how you "fit" into the department. If your research is interdisciplinary, you may ask that a meeting with faculty relevant to your research be included in the on-campus interview. This request should be made when you are invited to the campus as trying to meet your request after the interview schedule is set is very difficult.

You will be asked to make your own flight reservations. Keeping all receipts is necessary as your expenses will be reimbursed by the institution. In our case, a faculty member will pick you up from the airport and drive you to your lodging. This faculty member may provide a brief tour of the area around campus. Depending on your arrival time, you may meet two or three faculty for dinner. At other institutions, you may need to arrange for transportation to your lodging. If this is the case, the search committee chair should be able to provide you with information on shuttles or the best way to get from the airport to your lodging.

Departmental and Campus Tour

A member of the faculty will provide a guided tour of campus and the departmental facilities including major instrumentation for research and teaching and laboratories for research and teaching. You may be shown the space that has been designated for your research laboratory and/or office. The tour will last perhaps 30 to 45 minutes. The intent is to help you become oriented to the campus and the department, and to see the facilities the department has to support teaching and research. Questions about instrumentation and research and teaching space can be asked of your guide.

Research Presentation

Presentation of your research in a seminar is a critical component of your visit. These seminars are typically 50 minutes with approximately 10 minutes or so for audience questions. Be sure to ask the search committee chair about the audience for your talk and about any other guidelines that you should follow. At our institution, candidates are specifically told that the research seminar must be pitched to a general audience consisting of chemistry faculty, other science faculty including biologists and physicists as well as undergraduates. This means that a highly technical presentation appropriate for a graduate seminar or an American

Chemical Society presentation is inappropriate. Some institutions may desire a highly detailed and technical presentation. Be sure to indicate to the search committee chair any equipment capabilities needed for your presentation such as video. Use of correct spelling and grammar in your slides and in your speech is an absolute necessity. For non-native English speakers, having your presentation proofread by a native English speaker will avoid most if not all errors in grammar, spelling and syntax.

Meetings with Faculty and Students

In meetings with faculty, you can expect to be asked about your research, your experiences in working with undergraduates, and your interests and background in teaching including new courses you might offer. These meetings may be one-on-one or with a small group of two or three faculty. You can expect these sessions to last about 30 minutes and you can expect that you will shortly be off schedule. Extra time will be built into the schedule so you need not be concerned about falling behind. During meetings with faculty, you should feel free to inquire about their research, and about their success and/or progress toward tenure. You can ask questions about the climate for research and about the quality of the students you might engage in your research projects or how students were engaged in research. You may also talk to faculty about the requirements for promotion and tenure but do not expect consistent answers. In general, faculty will not be able to answer specific questions about your future teaching schedule or about salary or benefits available.

In meeting with students, ask about their interactions with faculty and about their interests in research participation. Students can provide insights into the culture of the department and the campus from their unique perspectives. At our institution, we try to arrange for an informal pizza lunch with the students. We find that offering food attracts a higher turnout of students and the relaxed atmosphere seems to lead to more give-and-take between the students and the candidate.

Meeting with the Chair

The meeting with the chair is the best place for you to learn about the long-term goals of the department which will be important in determining how you could contribute to the department's future directions. Questions may also focus on how the long-range goals were determined: were they established through a planning process involving the faculty or do they reflect the goals of the current chair or higher administrators? Wise candidates will also ask about future infrastructure improvements as construction may impact available resources and research space for some period of time. If renovations to existing space are expected, asking about support for non-tenured faculty for conducting research would be important. You will have time to ask about policies regarding research, teaching and service. While there will be an effort to minimize the amount of service you will be expected to provide in your first two years, some service will be expected. The chair can provide examples of typical service performed by new faculty. The chair can also provide information on any anticipated changes to student demographics or to governance processes.

The chair is the individual to ask for information about official promotion and tenure requirements as well as specific information about teaching loads and assignments for the first one or two years. The chair can provide information about university structure, how the department interacts as a whole with other departments in the college, and how the department is supported by the college.

The chair will ask about your equipment needs and start-up costs so it would be useful to have approximate answers to such questions. At our institution, instrumentation that is used for teaching can also be used for research outside of regularly scheduled classes. At other institutions research instrumentation is separate from teaching instrumentation. Useful questions are to determine what the policies are for accessing instrumentation obtained by a specific faculty member and to determine the procedures for using equipment employed for teaching courses. You should be able to discuss how specialized instrumentation you need for research could benefit the instructional needs of the department.

If you are a dual career couple and a position for your spouse is an important factor in your decision-making process, let the chair know. Indicating that a curriculum vita for your spouse is readily available would also be beneficial. A decision to extend an offer will not be affected by your spouse's career needs but in some institutions, finding a suitable position requires time. Advance notice to the chair may be the key difference in offering an appointment to both you and your spouse. Your spouse may accompany you on the interview trip (probably at your expense) but should not be involved in any of your on-campus interviews.

Meeting with the Dean

The interview with the dean is the first opportunity for a salary discussion to occur. Do note that the final salary may be different depending on your negotiation of the contract offer. Discuss with the dean if you are interested in credit toward tenure for a prior academic appointment including how publications at that position will be counted in a tenure decision. The dean can provide information about college policies supporting research and teaching, and about benefits such as released time and parental leave. Generally the dean does not vote on whether to extend an offer but the dean is the one with whom you will negotiate a contract. At some institutions, such as ours, this responsibility may be delegated to the chair of the department.

Meetings with Other Non-Chemistry Faculty or Administrators (Optional)

Some institutions will arrange for you to meet with the director of external grants or a grants officer. This individual may also indicate what internal grants are available to support your research expenses and/or undergraduates who may conduct research for you. The process for obtaining external grants including information about potential granting agencies may be described. If your research is interdisciplinary, a meeting with potential faculty collaborators may also be arranged (see above). Individuals outside of the department may be contacted for their views on your candidacy but their views will generally be advisory only. An interview with important support staff may also be part of your on-campus visit. These staff members may include the laboratory supervisor who can describe support for teaching laboratories and a head of instrumentation services if the department is sufficiently large.

On-Campus Interview Follow-Up

Send the search committee chair a thank-you email that can be forwarded to the rest of the search committee or to the department faculty. You can include statements like "looking forward to hearing from you." You may also include questions that arose after your interview was concluded.

Conclusion of the Search

When all the on-campus interviews are completed, the search committee will meet to rank the candidates. In this ranking, the committee members will consider feedback and opinions of faculty, students and all others who met with you. The search committee will present an overview of the search process and its ranking to the faculty of the department who will then approve and rank the candidates. The department chair may then contact you informally to indicate the remaining steps in the process and the approximate timeline. At our institution, any offer must be approved by the executive committee of the college. Upon obtaining this approval, the dean will send you an official contract. Before the final offer is made, you will negotiate, generally with the chair or the dean, the details of the offer, including start-up costs, moving expenses, commitments of office and research space, length of initial contract (one to three years), credit for previous appointments and any other appointment details. The dean will send the official letter or contract. There is usually a limited time for you to accept the contract. The length of time for the final steps of the search can take anywhere from two to four weeks. Contact the chair immediately if you have a competing offer.

General Advice

You should always communicate in correct grammatical English in all phases of the search, from the initial application through the on-campus interview and in negotiations of an offer. This point cannot be stressed enough. Do not relax at any time you are in contact with the search committee chair, the search committee or anyone you meet in the on-campus interview. All those you communicate with will be able to share their opinions of your appropriateness for the position. This particularly applies to meals, even informal ones with students. Having a drink with an evening meal is acceptable but you are urged to use caution with alcohol.

You will be asked the same or similar questions by many throughout the search process. It is important to be consistent in your answers. Inconsistent responses suggest that you are tailoring your responses to a specific individual or that you have not carefully considered the question. Either situation is a red flag for the search committee. You will meet a diverse range of faculty and students in terms of personalities, teaching and research interests. Be prepared to communicate with all of those you meet.

Some questions, such as specific faculty salaries, should not be asked and you may refuse to answer questions that you find offensive. As indicated on the Equal Opportunity Employment Commission's website (*6*), a general rule is that information obtained and requested through the posting and interviews should be limited to those essential for determining if a candidate is qualified for the position. For a faculty position at a public institution, this means that information regarding race, sex, national origin, age, disability and religion are irrelevant and questions about these should not be asked nor should you feel compelled to provide answers. It is important that you feel comfortable in politely declining to answer questions that are forbidden by law or that you find offensive.

Note that requests for demographic data may be made for the purpose of completion of equal employment/affirmative action forms according to federal or state regulations. These requests are voluntary but important as most public institutions seek to diversify their faculty. At our institution, this information is sought by our human resource division and is not shared with the search committee.

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Chapter 8

How To Avoid Common Mistakes When Searching for a Faculty Position

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This chapter describes both the process of applying for an academic position and common mistakes people make when searching for an academic position. The following elements of an application are discussed: (1) the cover letter, (2) transcripts, (3) the CV, (4) the summary of research interests, and (5) the statement of teaching philosophy. The chapter concludes with a brief look at what to do (and not do) during a telephone interview or an on-site interview. The perspective being brought to this chapter is one the author developed working with many graduate students who have gone on to successful academic careers as well as the insight into the hiring process he gained on the basis of serving on faculty search committees in chemistry, education and engineering. His perspective on the search for an academic position is therefore described as a first-person narrative.

Deciding Where To Apply

It has been more than 40 years since I first started to look for a faculty position at the college/university level. All that I knew, at the time, was that the application had to contain a cover letter and a CV, but I had precious little information about what these should contain. Nor did I have a rational strategy for finding positions for which I should apply. So I took the first step toward the development of a motto that captures the essence of the first few years of an academic career: *Tenure is the point in time when graduate students, post-docs, and young faculty first start opening C&EN from the front*. Early in my career, whenever my copy of C&EN arrived, I — like so many of my peers —would start by looking at the advertisements at the back to see if there was a position for which I could apply, and only then peruse the contents of that issue. Reflecting on that time in my career, I will admit that I sent in applications that were totally inappropriate because they were for positions for which I was not qualified. And, several times, I received letters back from the head of the search committee informing me of how inappropriate my application had been.

Over the years, I have learned that my behavior was not unique; it has been exhibited by many others seeking jobs at the beginning of their academic career. Several years ago, I served on a search committee for the dean of one of the three colleges in which I hold academic rank at Purdue. Two applications were "memorable," to say the least. One applicant noted in his cover letter that he had one year of experience teaching at an institution that would be classified as a "predominantly undergraduate institution" (PUI), but he was ready to take on the responsibilities of a dean at a research-intensive institution because, as he said it, "I work really hard!" Another applicant had two years of experience at a community college, but considered himself ready to be a dean.

The first step in deciding whether to apply for a particular position involves a careful reading of the description of the position written by the department or institution. The position description often provides important cues about the qualifications they expect candidates to have and the level at which the institution seeks to hire someone, e.g., someone at the beginning of their career, or a senior-level hire. The individual who reviewed the first draft of this chapter made an important point. The position description might note that they expect the individual who is hired to do many things, including teaching introductory courses, mentoring undergraduate research students, working with colleagues in other departments or programs, while, at the same time, bringing in external funding. As the reviewer noted, a potential candidate might believe they can do each of these things, without realizing that "… the job is asking them to do ALL of these things."

Once they have checked the position description to make sure that they have appropriate qualifications, the readers of this chapter have a distinct advantage that I couldn't have dreamt about having when I started my academic career — access to the Internet. Time and time again, I have served on search committees for both faculty and administrators and noted that the candidates who seemed to rise to the top were those who knew the most about the institution, and how they would fit in, i.e., those that had spent the time to learn about the institution.

There are many questions that can now be answered before you decide whether to apply for a position at a given institution to see how you might fit in. How big is the student body? Does the institution enroll 2000, 10,000, 20,000, or 40,000 students? How many chemistry faculty are there? Is there someone on the faculty whose skills or expertise strongly overlap with your own, or would you bring something new to the department? What is the distribution of assistant to associate to full professors? (i.e., has the department been hiring faculty in recent years?) Where did the faculty who were hired in previous years come from? What does the department brag about on their home page? Is this consistent with your own values about what is important? In essence, the basic question is: Is this someplace where I feel I can fit in; where I can contribute?

It has been more than 30 years since I read an article on midlife crisis; something about which I knew virtually nothing, at the time. A comment made by one of the individuals interviewed for that article has stayed with me ever since, and has been used repeatedly in discussions with people who have come to me for advice about careers: "Some son-of-a-bitch decided when he was 18 years old, that I would be a dentist." In other words, this individual made a decision about his career path when he was young, and never questioned it again, only to find that he was now in his 40's and didn't enjoy doing what he had spent a lifetime preparing himself to do. I hope that those reading this chapter have been asking themselves the basic question: "What do I want to be *if* I grow up?" It is not the time to start asking questions of this nature when deciding what positions to apply for; hopefully, you have considered your values and beliefs before you reach this point.

The Cover Letter

The phrase "one size fits all" is seldom true. The same can be said of the cover letter that serves as the foundation of an application for an academic position.

The take-home message conveyed by the cover letter should revolve around answers to two questions: "Why are you interested in this particular position?" And: "Why do you feel you are an appropriate candidate?" The cover letter is your first chance to convey to the search committee that you have taken the time to learn something about them before you ask them to invest time in learning about you.

In order to answer these questions you may need to modify your cover letter to suit a particular institution and/or position. The classic mistake that has been made by so many applicants, so many times, is to make it seem as if you are sending the same letter for any position; doing nothing more than printing out another copy of a standard letter, addressing the envelope, and putting it in the mail.

There are many websites that offer advice about the content of a cover letter when applying for a *job*. But that is not what you are doing; you are writing a cover letter for a *career*. Not a job you want to take for a few months or maybe a couple of years, until you can gain enough experience to move on to another job, with a different employer. But a career at an institution that might last for 30 or 40 years.

The Purdue Online Writing Lab (OWL) website (*1*) notes that "…the cover letter is your first chance to make a strong impression as a promising researcher and teacher." Unlike letters sent when applying for a job, "… a cover letter for an academic position should be long enough to highlight in some detail your accomplishments during your graduate education in research, teaching, departmental service, and so on. The typical letter is thus usually one and a half to two pages long …"

Your Transcript

At one time, transcripts did not play an important role in the academic hiring process; in fact, they played no role whatever. But that is no longer true. The source of the problem is simple: There have been too many well-publicized cases in recent years of individuals who have submitted résumé's or CV's that claimed degrees that had not been awarded (*2*). The transcript, however, does much more than indicate whether a particular degree program has been completed because it lists the courses that individual has taken. It can therefore provide insight into the best "fit" between the individual's education and the needs of the Department. For many years, I have advised graduate students to think carefully about the courses they take (or do not take) because that information will be available to potential employers. This is why transcripts are requested from individuals who have not yet completed their degree. As those who are still completing their degree proceed along the path toward a job offer, there is likely to be a phone call from the Department Head to the student's major advisor asking: "Do you expect this student to graduate by August (or September, or whatever time the new position would start)."

What Is a Curriculum Vitae (CV)?

Everyone who writes about CV's starts by noting the same thing: "A CV is not a résumé." But, if you are like most people applying for a job for the first time, this isn't particularly useful advice because you may not understand the characteristics of either of these documents. So let's start by describing a résumé: A one-page document that *briefly* summarizes your education, employment history, experiences, and skills. It is a concise document, often using bulleted lists, that describes the position you want — e.g., a position as a synthetic organic chemist working on natural product synthesis in the pharmaceutical industry — and the skills or expertise you would bring to the job.

A CV starts with the individual's name, birthplace, and a summary of their college- or university-level education, listed in chronological order. The title of the M.S. thesis and/or Ph.D. dissertation is usually written on the line under the institution, and the major professor's name is given next to the title.

Once these details have been entered, the CV becomes a living, dynamic document. This can best be illustrated by noting that the next section lists professional experiences in chronological order, a section that will continue to develop throughout one's career. This section in my CV, for example, starts by listing the fact that I held both NSF and NASA predoctoral fellowships, identifies the graduate school, and lists the years during which I held these fellowships. It then notes that I was a visiting assistant professor at the University of Illinois at Urbana-Champaign; a member of the faculty at Stephens College; and then an assistant professor at Purdue, with the years at each institution. It then summarizes stages in my career as I was promoted to associate professor, professor, and then distinguished professor. It also lists the opportunities I have had to take temporary positions elsewhere, such as the time I spent as a lecturer in computer science at Xi'an Jiaotung University, in 1985, and my time as a distinguished professor at Transylvania University (the one in Kentucky). Because they are examples of "professional experience," this section in my CV also lists the four journals for which I have been an associate editor and the years in which I served in that capacity.

The next section in many CV's lists professional societies of which you have been a member. In my case, I joined the ACS as a student affiliate in my freshman year and have been a member of the Society continually since I received my B.S. degree. I am also a member of the Royal Society of Chemistry, the American Association for the Advancement of Science (AAAS), and the National Association for Research in Science Teaching (NARST). This section is important because it provides some evidence that you have take advantage of opportunities to network with others in your field. The following statement undoubtedly reflects my personal bias: I can't see how a chemistry department could recommend to the dean the hiring of someone for a faculty position in chemistry who is not both a member of the ACS and a member of the ACS division that focuses on the research that individual did for their Ph.D.

The next section in the CV would list any honors or awards that are relevant to the position for which you are applying, e.g., recognition of excellence in undergraduate or graduate teaching or research.

Documenting Research, Teaching, and Service

The primary goal of the CV is to document your development as a professional within three domains: research, teaching, and service. Or, as these categories are sometimes known today: discovery, learning and engagement. Many institutions ask their faculty to organize this dynamic portion of the CV into a series of well-defined sections. One of these sections would include books and/or book chapters for which you have been the author or co-author. A friend of mine, for example, lists a book written for elementary school children in this section as evidence of her long-standing commitment to teaching at all levels.

The next section is the list of publications. I recommend listing them in chronological order — with your first publication at the top of the list and your most recent publication at the bottom — because there will come a time when the list is long enough to be numbered, and it is much easier to update the CV by adding a new publication at the end of the list without having to renumber them each time. This list should provide the names of the authors, the title of the paper, the name of the journal, and the date and page numbers, e.g., Bodner, G. M. "Constructivism: A Theory of Knowledge," *J. Chem. Ed.*, **1986**, *63*, 873-878. I would recommend basing the list on the format outlined in the ACS Style Guide (*3*) because this is a format with which the search committee members are likely to be familiar.

There is some debate about whether to list papers that have not yet appeared. I have recommended to my students that they list both papers that have been accepted for publication and submitted papers because this provides the search committee with a more accurate view of the sum total of the work they have done. But. it should be clearly indicated whether a paper has been published, been accepted (i.e., is "in press"), or submitted for publication. I do not recommend listing papers "to be submitted" because this category too often turns out to be wishful speculation on what might happen in the future.

The list of publications is followed by a list of presentations at technical meetings. This list provides the search committee with an indication of the extent to which you have been participating in technical meetings. This section is sometimes accompanied by a list of technical meetings the individual has attended. When I am asked to write a letter for someone coming up for promotion, I sometimes note that I will forgive a graduate student or a young faculty member for not presenting a paper at a technical meeting at which one would expect them to participate, but I will never forgive them for not attending these meetings to learn what others are doing so that they can implement this work in their own teaching or research.

As the living document that constitutes the CV develops, sections are added that list the students with whom one has worked, the various teaching assignments one has taken on, summaries of student evaluation (both quantitative and qualitative), and a list of research support. Search committees fully understand that these sections may not be found in the original version of the CV submitted when the individual first applied for a position at the institution.

Statement of Research Interests

Let's assume, for the moment that you are interested in a position as an assistant professor of chemistry at a research-oriented institution, such as, for the sake of argument, Purdue University. It should not be surprising that a statement of research interests would play an important role in the search committee's evaluation of your candidacy. There are many questions to which this document would provide answers. Does your research align with the position that was advertised? Would you bring additional expertise to the Department in an area in which it is already strong? Or would you bring new skills to the Department in an area where it needs to improve?

I might have an unusual perspective on the way search committees look at statements of research interests because search committees in my department include representatives from each of the content domains. Over a period of almost 40 years, I have therefore served on search committees in all of the major subdisciplines of chemistry.

What kinds of mistakes have candidates made in their research proposals? All too often, the proposals describe individual experiments (or studies), rather than themes of research activity that will continue for years. Candidates often propose work that is a continuation of research being done by their major professor, rather than original work of their own. Your proposal obviously needs to build on the research experience you have had, but it should describe a new direction in which your research can build on work being done in your area of expertise. Your proposal also needs to tread the thin line between too much "jargon" that would not be familiar to anyone except those working in your area and not enough "jargon" to demonstrate mastery of the field to those who are familiar with it.

When thinking about research proposals, I would recommend considering the advice I received from a friend and mentor — John Bailar — when I was a young faculty member at UIUC: "There is a difference between research that *can* be done and research that *should* be done." The best proposals are those that clearly link the work being outlined with a problem that people outside your field might recognize as needing to be solved. Your research proposal should be something that many members of the Department would find interesting, not just the one individual who is working in the same field.

By now, many readers are undoubtedly asking themselves: "What does this section have to do with *my* job application? I'm trying to get a position in an institution that values teaching!" Contrary to popular belief, we *all* value teaching. But, at many institutions, excellence in the classroom is not enough; it is something that is expected of the faculty we hire. What are you doing outside the classroom, in terms of research or other forms of scholarly activity? And what are you doing in terms of service or engagement?

I raise these questions because there has been a general trend in recent years toward expecting at least some scholarly activity at institutions where this had not been done in the past. One of the driving forces is the perceived importance of research experience for undergraduates (REU) programs. When I taught the sophomore seminar course for chemistry majors, at Purdue, I asked the students: "Do you want to be a chemistry major or a chemist, when you graduate?" There is nothing wrong with getting a chemistry degree on the way to a career in a wide variety of fields. But, I argued that students who do not do undergraduate research are chemistry majors, not chemists. Because of the shared perception that undergraduate research is a valuable experience (*4*), many colleges and universities that would be considered "predominantly undergraduate institutions" seek to hire individuals who can provide an appropriate REU experience for their undergraduates. As a result, statements of research interests are being solicited by an ever-increasing fraction of search committees for faculty positions in chemistry. Even when an explicit summary of research interests is not requested, applicants can chose to share their ideas with the department.

Research programs at institutions that are not research-intensive are very different from the experience most graduate students have while pursuing their Ph.D. Mid-sized programs, with perhaps 10-20 faculty, are often happy with research programs that generate a paper every two or three years. Smaller institutions are often happy if their faculty are publishing, at all.

So what are the tricks involved in writing a research proposal for a PUI? First, be realistic about what infrastructure is available. I spent several years at a liberal arts college where I had the students in my organic chemistry course develop and execute a synthesis of one of a series of simple compounds that I could use in my research. Then, every couple of months, I would drive back to UIUC and run the NMR spectra I needed. I have many friends at PUI's who have built a nice research program by interacting with someone in a nearby research-oriented department. This path, however, means that one has to spend some time thinking about the proposals being submitted so that they fit the geographic realities involved in doing collaborative research. Many of the faculty I know who teach at PUI's focus their research on local problems, which are often environmental issues. This is something that can be done by creative organic and inorganic chemists, not just those with a background in analytical chemistry.

I am grateful to the reviewer who suggested that one way in which someone can tailor a statement of research interests to different institutions is to describe the portion of the work that could be carried out by undergraduates as opposed to work that would be more appropriate for a graduate student or a post-doc.

This section raises the obvious question: Where does one get ideas about research that is suitable for a PUI? I would suggest looking at the titles of papers presented by undergraduates at Regional ACS Meetings, or walking through the poster session at Sci-Mix at a national meeting.

Statement of Teaching Philosophy

From my perspective, I have saved the best for last — the statement of teaching philosophy (SoTP). Let me start by describing the classic mistake: *Writing something you don't really understand*. I can't tell you what it is that indicates to people who read a SoTP that this is happening, but so many of my colleagues in academics laugh when I ask them whether they've seen examples of this phenomenon. Paraphrasing a famous statement of a Supreme Court justice, *We know it when we see it*.

Now let's consider what can be done to strengthen a statement of teaching philosophy. I will admit I am biased, but I'll argue if your statement is one page, or a page and a half, you might as well not send it in. The people who will be reading this document have developed their own teaching philosophy through the process John Dewey's theory described as *reflective thought and action* (*5*). And they expect people who want to devote their careers to teaching to have taken at least some steps toward developing a tacit teaching philosophy of their own.

I am in an unusual position, having spent 40 years studying the issues of teaching and learning chemistry and having had 67 graduate students work toward degrees in my research group that would prepare them for academic positions. I have also been "blessed" by serving on countless committees that have looked at statements of teaching philosophy for faculty at all levels of academics. So what do I look for, when reading someone's SoTP?

I don't want to see someone write: "I believe in active learning," without including some definition of what that term means to them. In much the same way that I would not support hiring a faculty member whose research proposals did not contain references to the relevant literature, I get annoyed when someone who claims to want to devote their life to teaching chemistry doesn't include at least a handful of references to the literature on teaching and learning in their statement of teaching philosophy.

Discursive Writing

Literally hundreds (if not thousands) of websites can be found that contain more or less the same definition of the term *discursive writing*: "Passing aimlessly from one subject to another; digressive; rambling." If you were going to write a paper for *JACS* it would contain various sections divided by section heads such as: Introduction, Results and Discussion, and so on. You wouldn't (I hope!) submit a paper that contained a number of paragraphs that followed each other in a "digressive" manner. And yet that is exactly what so many SoTP's look like. You might therefore want to think about a piece of advice I was given almost 40 years ago that has made writing less of a burden than it would have been in its absence: *When you can't find a natural way to connect one paragraph with another, insert a heading between the two paragraphs that informs the reader that they are not connected.*

For the sake of argument, let's assume that your SoTP starts with an introduction. This could be followed by a heading that reads: "Statements of beliefs about teaching and learning in general." We'll get back to the contents of that section, in a few moments, but let's think about other section headings you might use. I would hope that you have certain beliefs about the discipline within the field of chemistry that you want to teach; why not have a section dedicated to that? How about a section that deals with your beliefs about expectations for the instructor? And, of course, a section on your beliefs about expectations for the students? Do you have any ideas about appropriate ways of assessing learning? Why should students be required to take your course? Another section might describe your beliefs about the role of instructional technology, or this topic might be integrated into one of the other sections.

What is the role of the laboratory in your course? Consider the following scenario I have used with my graduate students for many years: The Dean comes to your office and says that they want to close the lab associated with your course because it is too expensive. (Not because of the cost of chemicals, or even the cost of waste disposal, but because of the enormous cost of paying an instructor to teach a 3-hour or 4-hour lab.) How would you justify the existence of the lab? (And I refuse to accept the answer: "Well, everybody else does it!") What are your beliefs about the value of the lab in your course that makes it worth the "expense"? (Most of my graduate students have had difficulty with this scenario until they thought about it for some time. Many faculty with whom I have shared the question do not have tacit answers. But you might.) In conjunction with statements about the role of the laboratory, you might want a section that deals with the function of the undergraduate research experience.

Beliefs about Teaching and Learning in General

It is more than 25 years since I wrote a paper (*6*) on the constructivist theory of knowledge in which the first paragraph offered the following hypothesis: "*Teaching and learning are not synonymous; we can teach — and teach well — without having the students learn*." Ever since then, I have been collecting examples of this phenomenon that help me illustrate some of my beliefs about the difference between "teaching" and "learning.". Consider an example from a study we did of students enrolled in an organic chemistry course for chemistry and chemical engineering majors (*7*). There was no doubt that the curved-arrow/electron-pushing formalism was an integral part of the lecture, lab and textbook for this course. So we know what was taught.

So what was learned? An example created by a student who was on the A/B border in a rigorous course for chemistry majors is shown in Figure 1.

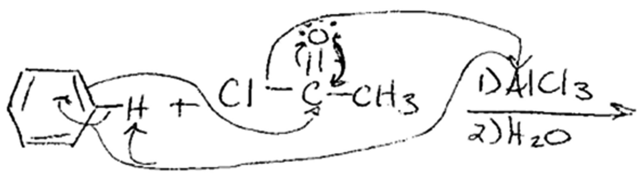

Figure 1. The arrow-pushing formalism a student used to describe the mechanism for the Friedel-Crafts acylation of benzene.

Contrary to popular belief among organic chemists, there is nothing inherently "wrong" with what the student did. But it is not what she had been "taught."

Beliefs about Teaching and Learning Chemistry

I have given a seminar for many years based on a series of statements I refer to as Eternal Verities. These are statements derived from research on teaching and learning for which there is so much evidence we can assume they will be true until the end of time. The list was started by my colleague, Dudley Herron, 35 years ago, but has been growing in number ever since.

It should come as no surprise that I use these statements to introduce or organize sections of my SoTP. In one of these statements, for example, I argue: "Teaching is something that has historically been done *to students*; not *with students*." As evidence of this, consider the classroom environment in so many of the chemistry departments I have visited. The students' seats are locked in place, facing the front of the classroom, or else, God forbid, they might interact with each other during "lecture." I then quote the introduction to the Ph.D. dissertation written by one of my first graduate students, Patricia Metz. She started her dissertation (*8*) by reflecting on some of the graduate courses she took. One course was described as:

> …. The most frustrating of all. . . . My frustration as a teacher started to mount when a student asked some questions on a point he did not understand. The professor responded to the first [of these questions], then said he could not answer other questions because he had material to cover and had limited time to do so. ... Several days later when this same student raised his hand, he was ignored. No one ever again attempted to ask a question.

She then noted: "The next point of frustration was the lecture notes," and concluded with a statement that should be etched above the portal of every chemistry classroom in the U.S.: "At times I felt the professor's notes became my notes without passing through either of our minds." Perhaps it is not surprising that her dissertation focused on a study of differences in both the cognitive and affective domain of bringing a form of active learning into the lecture classroom to produce a classroom environment where the instructor seldom lectured but often brought "problems" into the class on which students worked in groups. Although far less material was "covered" in this classroom, the students were far more likely to believe that enough material was covered to prepare them for exams (*9*).

Statements of Beliefs about the Role of the Instructor

I have had more than 50,000 students enroll in chemistry courses I have "taught." It is not surprising that, in my SoTP, I include the following Eternal Verity: "I have abundant evidence that I cannot teach chemistry. What I can do is facilitate learning." Let me give you an example based on my own experiences as both a student and a professor of chemistry. I can clearly remember having my high-school chemistry teacher tell me that equal volumes of different gases at the same temperature and pressure contain the same number of molecules. Until I took physics, this was the dumbest thing I had ever heard.

The problem of course was an error in my mental model of a gas. I accepted the idea that there was empty space in a gas, but seriously underestimated the amount of space that was empty. Thus, I concluded that a given volume of gas could obviously hold more small particles than it could if you tried to pack in much larger particles. I knew how to play what has been called "the game of school" (*10*), and I am fairly sure that I would have been able to repeat Avogadro's hypothesis if I had been asked to state it on an exam. But there was no way I would have been able to apply it to solving a problem because I didn't believe it was true. Over the years, I've learned that resistance to this idea is shared by a significant fraction of the students who have enrolled in my general chemistry course.

So what do I do to overcome this common misconception? I use an approach I learned from Talesnick's book (*11*) that uses the two pieces of lecture demonstration equipment shown in Figure 2.

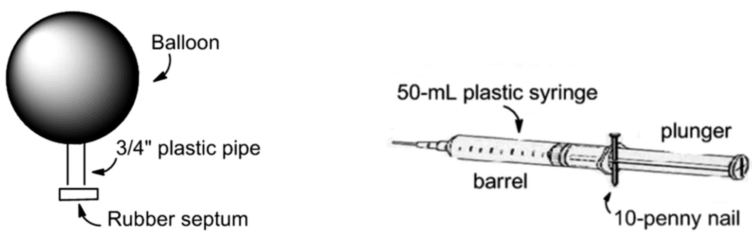

Figure 2. Apparatus need to prepare samples of different gases to determine the number of particles in a 50-mL sample of each gas.

The simplest way to handle gases for lecture demonstrations uses balloons, syringes, and rubber septums. The balloon is filled from a compressed gas cylinder and a ¾" plastic pipe sealed at one end with a rubber septum is inserted into the mouth of the balloon. The other piece of apparatus is based on a 50-mL Leur-lok plastic syringe with a hole in the plunger at the 50-mL mark that can hold a 10-penny nail. Start with the plunger inserted as far as possible into the syringe and seal the syringe with a plastic syringe cap (Becton-Dickenson #8531) so that no air can enter the syringe. Pull back the plunger until you can insert the nail through the hole in the plunger, as shown in illustration above. Weigh this "empty" syringe on a balance to ±1 mg. Now fill the syringe with 50-mL samples of various gases and measure the weight of the syringe filled with each gas sample. Assign different groups of students the task of using the weight of 50-mL of one the gases and the known weight of a mole of the gas to calculate the number of gas particles in the sample. Next day, assemble the results. A typical set of results is shown in Table 1.

Students may not like the results of this demonstration, but it clearly confronts the erroneous mental model they have of a gas. One can then convince students that the vast majority (99.9%) of the volume of a gas is empty space by asking them to compare the densities of common substances that can be found in both the liquid and gaseous states at different temperatures. Consider the following data, for example, in Table 2 .

Instead of wasting time trying to "teach" students the concept of Avogadro's hypothesis, this approach in which students are active participants facilitates their construction of this concept.

Table 1. Results of calculations of the number of gas particles in a 50-mL sample of different gases

Compound	*Weight of 50 mL of gas*	*Number of gas particles*
H_2	0.005 g	1×10^{21}
He	0.009 g	1×10^{21}
CH_4	0.041 g	1.5×10^{21}
N_2	0.055 g	1.2×10^{21}
air	0.056 g	1.2×10^{21}
O_2	0.061 g	1.2×10^{21}
Ar	0.081 g	1.2×10^{21}
CO_2	0.088 g	1.2×10^{21}
C_4H_{10}	0.111 g	1.15×10^{21}
Cl_2	0.131 g	1.11×10^{21}
CCl_2F_2	0.228 g	1.14×10^{21}

Table 2. Densities of common substances in the gas and liquid phases

	Liquid (g/cm³)	*Gas (g/cm³)*
Ar	1.40	0.001784
O_2	1.149	0.001429
N_2	0.8081	0.001251

Statements about the Role of the Instructor

It must be enjoyable to poke fun at instructors who act as lecturers because so many people are doing it. They talk about "the sage on the stage," or make fun of "chalk and talk." And each of us probably has memories (if not nightmares) of having an instructor drone on seemingly for hours at a time. But that says more about the individual's ability to command a classroom environment than about an inherent problem with the lecture, itself. Paraphrasing the work of McKeachie in his many editions of *Teaching Tips*, (*12*) there are three sets of conditions for which research has shown that the lecture is the most efficient mode of instruction.

One of these conditions traces back to the mode of instruction in medieval universities, where someone who had read the 10 or so books in the field lectured to students who did not have direct access to these books. Does that ever occur today? Of course it does. Let's assume I was teaching a graduate-level physical organic course and decided to discuss gas-phase basicity. It would be absurd to expect the students to read the hundreds of research papers on this subject with which I might be familiar. I would *lecture* on their content, and provide the students with key references in case they wanted to go back to the original literature for their own research. This is not the case, however, in most undergraduate courses where there is a textbook (for better or worse) for students to use.

Another situation where the lecture might be the best approach is in a course where the content must be memorized, rather than understood. A course in gross anatomy or certain courses in pharmacognosy come immediately to mind. This is not the case in the introductory chemistry curriculum, however, where a conceptual understanding of certain so-called "threshold concepts" (*13*) is vital toward building an understanding of the field.

The third situation for which the lecture is the most efficient mode of instruction is when your job is to "preach." And I will argue that there are times in our teaching when we are literally trying to do nothing more than convert the beliefs our students have about the nature of science or its product to what we believe is a more appropriate world view.

Effective teachers bring a mixture of skills to the classroom. They need to be able *to lecture*, when it is appropriate; *to ask questions* to get their students involved in what is happening in the classroom; and *to listen* in order to pick up signals about when their students understand the topic and when they do not.

Let's look at a classic example from my own evolution as an instructor (*14*) that I use in my seminar on Eternal Verities. When I teach general chemistry, I invariably spend time on the structure of solids because this is an important topic for the science and engineering students in my course. I set the basis for one of the important ideas about the structure of ionic compounds by reminding the students that monatomic negative ions are larger than the neutral atoms from which they form, whereas monatomic positive ions are smaller then the neutral atoms. I therefore note that simple ionic compounds often crystallize in a structure in which the relatively large negative ions pack in a *closest-packed (or closely packed) array*. I then note that the relatively small positive ions pack in holes *between planes of negative ions.*

I then introduce the traditional diagram for this structure shown in Figure 3 and note the existence of two kinds of holes, marked with "x"'s and "●"'s. I ask the students to assume that the solid circles represented one plane of closely packed negative ions, and the dashed circles represent negative ions in a plane above the plane of the solid circles. I then ask them to imagine that there was a plane *below* the solid circles that was identical to the plane *above* the solid circles. In other words, I ask them to envision a "hexagonal closest-packed" (*ABABAB* …) structure.

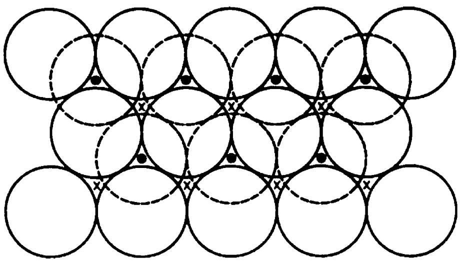

Figure 3. Traditional drawing of the stacking of hexagonal closest-packed arrays.

When I first taught this material, I used to tell the students that the holes marked by the solid "●'s" were given a name I will not share with the reader, for the moment, and that positive ions that packed in these holes were assumed to have a coordination number that will also be described in a subsequent paragraph. And I was happy doing this, feeling good about my ability to "teach" this material to students.

Thirty years ago, having studied the constructivist theory and having written a paper on this topic, I thought to myself: I wonder what would happen if I asked each of the lecture sections of about 450 first-year science and engineering majors to respond by voting on possible answers? I asked them to think about what would happen if they were a positive ion in one of the holes marked with a solid "●". (A classic anthropomorphic activity.) How many negative ions would they touch? I started by asking the students if any of them thought the answer was "three"? (A few did.) How about "four"? (A few did.) "Five"? (This turned out to be, by far, the most popular answer.) "Six"? (A few chose this answer).

When I first asked this question, I couldn't imagine how anyone could possibly get an answer of "five." But it was the clear favorite, being preferred by perhaps two-thirds to three-quarters of the students who responded. I told that class what the right answer was, finished the rest of the lecture, and went to lunch. While eating lunch, I suddenly realized what the students had done to get the answer of "five." They had put the positive ion in the same plane as three negative ions (in spite of my having emphasized the fact that the positive ions were in holes *between the planes of negative ions*) and then expected the positive ion to touch a negative ion in the plane above and another in the plane below in the hexagonal closest-packed array. In other words, they constructed a hole in which the positive ion would touch a total of five negative ions arranged toward the vertices of a trigonal bipyramid. So I knew what to do when I taught the second lecture section that day. And I have been doing the same thing for almost 30 years.

Each year, I ask the same question and get the same answer: "Five." I then show the students a pair of photos. The first photo shows a model formed by packing three styrofoam balls as close to each other as possible with a small macramé bead (representing the positive ion) placed in the hole above the styrofoam balls. The next photo shows what happens when a fourth styrofoam ball is placed on top to form a tetrahedron. When I ask the students if they want to change their vote, they laugh and "four" becomes the most popular answer because they realize that when you pack positive ions in the holes *between the planes of negative ions* in a closely-packed array marked with solid "●'s" in the diagram in Figure 3, they occupy *tetrahedral holes* in which they touch *four* neighboring negative ions.

Without ever using clickers, I have been using examples such as this to take advantage of my belief that "active students learn more than passive students." And I have been doing this for more than 30 years in courses at all levels from general chemistry through graduate courses.

Statements about the Role of Instructional Technology

There are many reasons for using various forms instructional technology in your classroom. While writing this section, I am watching the clock because I need to get back to preparing for class tomorrow. I am teaching a course in biophysical chemistry that enrolls 76 undergraduate students majoring in biochemistry, biological sciences, or pharmacy. I will use images I located using Bing at various times in the lecture, and I believe my students respond favorably to their use. But I've asked them: Which element would you want me to keep using in this class if I made you choose between images projected on the screen using the computer projector or the lecture demonstrations that I do more or less every lecture? There is an almost unanimous preference for the demonstrations.

Recently, as chair of our Teaching Academy, I've been participating in new faculty orientation workshops organized by our Center for Instructional Excellence. I have repeatedly listened to people talk about clickers as if they were the best thing since sliced bread. (Maybe even better.) They've talked about how clickers help students become more active in class. How clickers provide the instructor with feedback on what the students understand, and, more importantly, what they don't understand. How clickers allow students to respond anonymously. If you agree with these ideas, you might want to comment on how the use of instructional technology, including clickers or PowerPoint, would allow you to be a better instructor. If you've been convinced by those who want to "flip the classroom," explain what this means and why you want to do it.

But I'm getting close to retirement. (Some would argue, not close enough,) So I am allowed — if not necessarily expected — to be a curmudgeon. Thirty years ago, in a symposium on the state-of-the-art in chemical education, we argued: *Nothing will ever replace a dedicated teacher* (*15*). From this perspective, I am allowed to ask questions such as this: Who said that providing students with the ability to be anonymous when they are answering a question is a good thing? I teach science and engineering students, and have done so for most of my career. I remind these students that they are not going to be allowed to offer anonymous opinions when they are practicing scientists or engineers. I tell my engineers there is no partial credit for almost getting a bridge to cross a river, and tell my pre-med students that there is no partial credit for almost keeping a patient alive. I don't want them to be anonymous; I want them to commit themselves to an answer, whether it turns out to be right or wrong.

As we have noted elsewhere (*16*), "Arguments for the use of clickers are almost invariably based on the inadequacies of the traditional approach to large-lecture section instruction." Furthermore, we noted that: "There is general agreement in the literature on personal response systems that ... students have a positive attitude towards the technology" (*17*). Our experience over an almost 30-year period of using active learning in the classroom, however, is consistent with Carl Wieman's advice (*18*). *It is not the clickers that improve instruction. What improves instruction is creating an environment in which clickers could be used.* In my experience, I have found that I don't need to know the distribution of student responses among four or five alternatives to three significant figures. All I needed to know in the example taken from my discussion of the structure of simple ionic crystals was that the vast majority of the students had an answer — five — that was inconsistent with what the community of practice of crystallographers thought was the correct answer. And I then needed to find ways to confront the students' predictions that made them laugh and change their mind.

For more details on how to implement a non-clicker based approach to interactive teaching, you might look into the POE (predict, observe, explain) model proposed by White and Gunstone (*19*). In brief, you ask the students to commit themselves to an answer to a conceptual question, provide them with an opportunity to observe what happens, and then force them to explain either why there prediction was correct, or what was wrong with their prediction.

As a simple example of this technique, put equal sized beakers on a hot plate with equal amounts of vegetable oil in one beaker and water in the other. Support a thermometer in each beaker and turn on the hot plate. Ask the students to predict whether the temperature of the oil will be hotter than, cooler than, or the same as the temperature of the water when it starts to boil. It is not until students have an operating mental image of the concept of heat capacity that they can explain why the temperature of the vegetable oil is so much larger than the water when it starts to boil. Alternatively, put ice cubes of approximately equal size on pieces of aluminum and styrofoam that are roughly the same dimensions (*20*). Students will almost invariably assume that the ice will melt faster on the styrofoam block because it feels "warmer" to the touch than the aluminum block, whereas the opposite is clearly observed.

Statements about the Role of Your Discipline

I could expand about the following idea for pages: "The content of the general chemistry course is vital to the education — as opposed to the "training" — of students entering STEM careers." And even more on the idea that: "General chemistry is the context we can use to generate transferrable skills —such as problem-solving skills — that are essential for success in STEM careers as well as careers in so many other areas." What do you believe is a characteristic role of your discipline in the education of chemistry students and/or chemistry majors?

Statement about Why Your Course Is (or Should Be) a Required Course

As an example of a philosophical statement about why physical chemistry should be a required course for certain majors, consider the following statement:

> Physical chemistry helps students understand the difference between the term 'model' when it is used as a *noun* to describe ideal gases or the kinetic molecular theory and its use as a *verb* to describe how chemists create and evaluate such models. Whereas the 1st- and 2nd-year chemistry courses use models (from Boyle's law to Saytzeff's rule), they seldom evaluate the validity of these models, or introduce students to 'modeling' in the sense of building models of one particular portion of the universe, or provide students with the ability to estimate the magnitude of so many of the effects they have memorized in previous courses.

Statements about the Role of the Students in Your Course

In the early 1970's, I was hired at UIUC to teach general chemistry. One afternoon, the chair of the biochemistry program asked me if I would be willing to teach a biochemistry lab course, that summer, even though he knew I had never taken a biochemistry course. His argument was that I was a pretty good chemist and a respected teacher with a strong set of lab skills and I could pick up what I needed to know while teaching the course. Having survived that experience, he asked me to teach the lecture course the next summer.

All I can say is that the summer teaching the biochemistry lecture course for the first time provided me with all of the evidence I need to support the notion: "No-one in the classroom learns as much as the individual teaching the course for the first time." If you believe this particular example of our Eternal Verities, then you need to create an environment in which students teach each other. Whether it is through group work using some form of the Process Oriented Guided Inquiry Learning (POGIL) format or some adaptation of the peer-led team learning (PLTL) approach that have been so successful at so many institutions (*21*), or some alternative such as "flipping the classroom", is less important than creating an environment in which students routinely teach each other.

The Phone Interview

Search committees at institutions across the spectrum from research-oriented universities to predominantly undergraduate institutes routinely use phone interviews as the basis upon which they decide which candidates to invite to campus for an on-site interview. As might be expected, there are multiple sites on the Internet for advice on even such seemingly arcane ideas as preparing for the academic job phone interview. The advice they give is cogent, but let's pull out a couple of ideas. First, be prepared. Spend time on the department's website. You should be able to recognize the names of anyone in the department who participates in the call; you might be able to remember their specialty (e.g., synthetic organic, theoretical chemistry, and so on); and you might even know something about their research interests or recent publications. Second, be prepared. You should have a list of a few points that you want to make at some time during the interview, but don't go so far as to have a dozen rehearsed answers that are given regardless of what questions are asked. Make sure that you give concise answers to the questions that are asked. In other words, listen carefully! But that doesn't mean that you won't have a few ideas of your own that you would like to inject into the conversation when appropriate. Third, be prepared. Be able to talk succinctly about the research you have done as a graduate student, the courses you would be interested in teaching, your research interests for the future, and so on. Finally, be prepared. I am willing to cover all bets of as much as 25¢ apiece that someone on the search committee is likely to ask toward the end of the interview: "Do you have any questions you would like to ask us?" And, if there is any doubt in the reader's mind, let's repeat: Be prepared. Spend time with the job description prepared by the institution advertising the job. The authors of this document spent a considerable amount of time drafting it, so it can be a useful starting point for thinking about the questions you are going to ask the committee.

So You Made It to the On-Site Interview

For many years, the symbol for Purdue University consisted of a Griffin mounted above a shield divided into three segments, which was surrounded by the name of the institution.

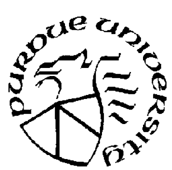

Figure 4. Traditional symbol for Purdue University.

Although very few people know this, the three segments of the shield were supposed to represent the three aspects of a faculty member's role: *research*, *teaching*, and *service*. The balance between time spent teaching and that spent doing research (or some other form of scholarly activity) will vary considerably from one institution to another, and even from one department to another within the same college or university. But it seems reasonable to expect that faculty will not only be willing to do both, but should want to do some mixture of both.

Those of us in academics have a fantastic job. Studies have shown that academics who do not yet have tenure have similar levels of job satisfaction as those who are not in academics, but those who do have tenure have substantially greater job satisfaction than those who are not in academics (*22*).

The best metaphor for the on-site interview is that of the first date. A successful interview is one where both sides feel comfortable about continuing the relationship; where the department feels that you are a viable candidate, and, at the same time, the department convinced you during your visit that the job is one that you would take if it is offered.

At some point during the on-site interview you might be asked: What would your start-up package look like, and what would it cost? If you are not asked this question during the on-campus interview, it would surely come up during any negotiations that would surround a job offer. At Purdue, candidates often come to the on-campus interview with detailed lists of what they would need to build their lab and estimates of what this equipment would cost. Sometimes, they have even considered what they would need during the first year and what could be delayed until a subsequent year. If you accept the idea that the statement of research interest has to be tailored to the institution you should be willing to accept that this is even more true of your start-up package. You may not be able to put together a detailed list of what you will need before you visit a department, but you should be ready to discuss this in at least general terms if you are asked about it during the interview. The best source of information is your network of peers who have taken similar jobs in recent years. Your research advisor should also be able to help because your advisor has had to worry about external funding to support your work while you may have been blissfully unaware of these costs as a grad student or post-doc who can focus on doing research.

Classic mistakes during the on-campus interview can be found on both extremes of the affective domain. I have watched candidates spend two days at Purdue who could only be characterized by the label "depressed affect." There was so little response from the candidate that members of the search committee were asking themselves: "Why did he (and it has always been a 'he') accept the interview trip?" But I can also remember being a member of the search committee when a candidate arrived who wanted this position so much that he (and, once again, it was a "he") was tongue-tied, constantly thinking: "What do they want me to say?" The middle ground between these extremes is the obvious place to be, and there is plenty of room between these extremes. As a candidate, you should demonstrate that you are interested in the position, if it turns out to be appropriate, without appearing desperate.

Let's return, for a moment, to the first-date metaphor. I have watched several candidates interview for a position wearing jeans, a lumberjack shirt, and tennis shoes. You might not be surprised to find that they never seemed to make it to the top of the list of candidates. I will admit, however, that I have never seen anyone interview in a tuxedo. Dress appropriately. If you are not sure what that means, ask for advice from someone who does.

An interesting phenomenon can be observed when candidates visit campus for an on-site interview. Some of them are good listeners, carefully listening to questions that are asked either during or after their seminar, and then responding to these questions. But others can't seem to do this; they don't listen carefully and therefore don't respond to the question. The individuals who can't seem to respond to questions are seldom hired. This can be understood, perhaps, by thinking about the nature of a department as it operates. You have been chosen to be a candidate because people believe you have something to bring to the department that they don't already have. During the day-to-day interactions among faculty in a department, or between departments, faculty are expected to share their expertise and therefore value those who can listen and then respond appropriately.

Every once in a while, a candidate makes a mistake during their visit that can only be described as terminal. One of my favorite examples from personal experience was an analytical chemistry faculty candidate who showed correlation coefficients on slide after slide that were reported to four decimal places for data that contained so much scatter that they deserved perhaps two decimal places. It wasn't surprising to hear members of the search committee question hiring someone to teach analytical chemistry who didn't seem to understand the concept of significant figures. My favorite example as reported by an ex-student at a PUI was the answer to the question: "Why do you want a job at this institution rather than in a research-intensive department?" According to my student, candidates would repeatedly respond: "Because I don't want to work that hard." It should not be surprising to find that none of these individuals were hired.

In a previous section, I invoked some of the advice I was given by John Bailar when I was teaching general chemistry at UIUC. Let me build some advice about the on-site interview on the foundation of two observations I made about this remarkable man: I never heard him say anything bad about another person and I have never heard anyone say anything bad about him. Think about how *you* would respond to candidates you were interviewing at some point in the future who spoke negatively about the people they worked with, or the institution from which they were coming. Or even worse, spoke negatively about someone at the institution at which they are interviewing. I suspect you might ask yourself: I wonder what this individual will say about us if we hired them?

Conclusion

A famous quotation falsely attributed to Thomas Jefferson states: "I am a great believer in luck, and I find the harder I work, the more I have of it." Even though this quote actually traces back to a collection of sayings entitled "Listen to This" published in 1922 by Coleman Cox it is still a valid observation. Securing an academic position takes time and effort, but it is well worth the effort when it is successful. Pessimists will tell you that the job market in academics is not what it used to be. They will tell you that the salary doesn't compare with what you could make elsewhere. They complain that the percentage of faculty in tenure-track positions has decreased. And, of course, conventional wisdom suggests that today's students are not as good as they were "when I went to school."

Realists will respond that there was only a short period of time, perhaps in the mid-60's, when the demand for faculty exceeded the supply. They are likely to tell you that if the starting salary is an important factor in selecting how you are going to spend your life, academics might not be the best place for you. Although the shift from tenure-track to non-tenured instruction is worrisome for people concerned about the future of our higher education system, it is important to remember that people with whom I have worked have sometimes deliberately switched from tenure-track to non-tenured career paths for a variety of reasons. By the way, when the curmudgeons tell you that today's students are not as good as they used to be, agree with them. They're right; today's students are much better than used to be. This is a phenomenon known as the Flynn effect — a significant and long-sustained increase in performance on standardized tests from the 1930's to the present time (*23*, *24*).

The good news is that there are, in fact, academic jobs out there for people with the right set of skills. The good news is that content knowledge may be necessary, but it is by no means sufficient. The jobs are being filled by those with good "people skills," who can listen to and work with others, who are motivated to teach for the right reasons, and who can make valuable contributions to a department and thereby make their colleagues more productive. In other words, people who have what accreditation boards call "soft skills," i.e., the skills that are by far the hardest to teach.

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Chapter 9

Academic Leadership

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This chapter compares leadership in academia and knowledge-based companies with leadership in manufacturing companies and traditional hierarchical organizations like the military. As explained by Machiavelli 500 years ago, traditional hierarchical organizations are best led through the negative emotion of fear. However, it is counterproductive to lead in academe or knowledge-based companies with fear. Rather, such organizations are best led by virtuous servant leaders whose authority comes from the respect they engender rather than from positional authority. In academia, this respect comes from exceptional performance as a scholar as well as from behavior that is consistently courageous, reverent, temperate, just, and wise, i.e., virtuous.

Academic Leadership

Leadership is critical to the success and vitality of both the teaching and research missions of any academic institution. However, the title of this chapter, “Academic Leadership,” is as much of an oxymoron as “military intelligence” because the roles, responsibilities, and authority of University Presidents, Provosts, and Deans are completely different from those of their counterparts in most of corporate America.

Essential Features of Traditional and Academic Leadership

Figure 1 was drawn for Marc Donohue by William Richardson, former President of Johns Hopkins University (*1*). In the left-hand panel, the company president is at the top of the pyramid and the factory assembly line workers are at the bottom of the pyramid. Vice presidents, division directors, and shift supervisors occupy the levels in between. Actually, most large companies have even more levels between the president and the workers, but their titles and the nuances of their authority vary widely from company to company.

Regardless of the structural details of any single organization, in a corporate hierarchy, the people who are on higher levels tell those below what to do. And those at the lower levels accept those orders (i.e., they *defer* to the authority of those above) because they know that if they do not there can be negative consequences. These negative consequences can vary from being chastised (either privately or in public), being given a negative performance evaluation, or being fired. The reality is that in our current litigious society, few people are fired for a single infraction. Nonetheless, the sequence of events from failure to follow the instructions (orders) of a superior to dismissal is clear to everyone who works in such an environment. In such traditional organizations, workers defer (i.e., follow the orders of those above them in the corporate hierarchy) because they *fear* the potential negative consequences.

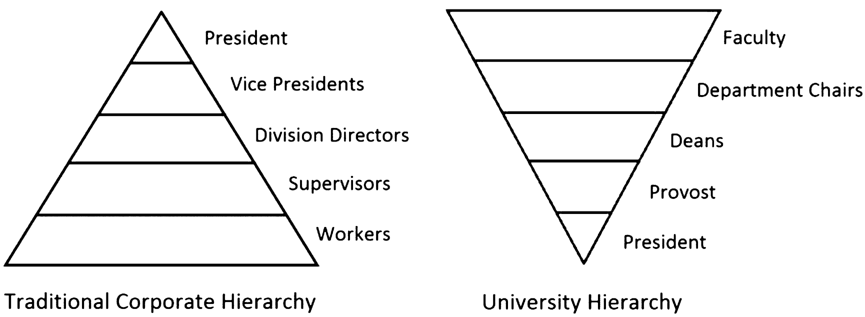

Figure 1. A comparison of a traditional corporate hierarchy and a university hierarchy.

The right-hand side of Figure 1 shows the hierarchy in research universities in the United States. The pyramid is inverted from that of a corporation and has the faculty at the top and the university president at the bottom. While there are some aspects of academic life that resemble the left-hand pyramid (in the setting of raises, for example), most of academic life is depicted by the upside-down pyramid on the right. Yes, department chairs do make teaching assignments and have a say in their colleagues' raises, but they rarely dictate what research their faculty do or how they teach their classes. Rather, the main role of the department chair is to help his or her faculty members be successful. Hence, the department chair really is working for the faculty. Similarly, deans typically do not tell department chairs what to do; rather, the Dean's primary job is to help department chairs do their jobs. The same is true in the relationship between the president and provost with the deans. Hence, academia is (or should be) the paradigm of an organization in which there is "servant leadership" (*2*).

It is the existence of this inverted pyramid that gives rise to the often-used cliché that leading faculty is like herding cats. A more precise characterization is that research universities are a conglomerate of independent divisions, each of which is its own cost center; i.e., the faculty members in research universities are each independent entrepreneurs running their own small research organization. To a great extent, each faculty member operates independently of the others and each is responsible for finding the financial, staffing, and other physical resources required to support their own research activities (read business enterprise).

Table I provides a listing of some typical negative managerial actions and the associated emotional reactions experienced by subordinates who are the targets of such interventions. It illustrates that when managers attempt to provide feedback and guide the performance of those under them the hierarchy is created and sustained through fear. Five hundred years ago, Niccolò Machiavelli (*3*) in his classic primer on leadership, *The Prince*, asked the question whether it is better for a leader to be loved or feared. He went on to answer that it would be best to be both loved and feared, but this is very difficult to achieve. To be sure, there are some notable U.S. political and military leaders who, with the passage of time, seem to have accomplished this, including General George Washington, General George Patton, and General Dwight Eisenhower. However, as noted above, leading by instilling both love and fear is very difficult to accomplish. Therefore, Machiavelli suggested that, if one must choose, it is best for a leader to be feared because subordinates will tend to continue to follow individuals they fear even in times of stress because of the adverse consequences of disobedience or defection. He also believed that people tend to abandon beloved leaders at such times, and that a leader should avoid being hated at all costs.

As an example, consider a worker on an automobile assembly line. Most people view this as a mind-numbing job in which the only relief is for the workers to chat or daydream. However, this is far from the case on an assembly line. To keep pace, assembly line workers must concentrate intently on what they are doing. It turns out that fear and other negative emotions are significant motivators for people working under such conditions (*4*). Fear focuses one's attention on the immediate task at hand; it narrows the mind's ability to respond creatively though activities like daydreaming. It serves to defend individuals both emotionally and physically. Hence, while fear may be a historically useful way to lead soldiers in battle and people who are doing manual labor, according to Fredrickson (*4*), this narrowing of the mind's thought repertoires prevents people from being open to new possibilities, building effective, collaborative relationships with others, and performing virtually any creative task at the highest possible levels. Therefore, it would appear to be the last method a leader would want to employ with the faculty in a university or the employees in any organization that earns its profits from the creativity and intellectual property of its workers.

Table I. Potential Emotional Consequences of Negative Managerial Actions

Negative Managerial Actions	*Potential Emotional Consequences (Inner Fears)*
Being chastised for doing something wrong	Embarrassment Humiliation Loss of self-esteem Loss of respect of boss and/or coworkers
Poor performance evaluation	Poor raise or even salary cut Inability to increase standard of living Potential decrease in standard of living Not being able to provide as much for one's family as one would like
Being fired	Loss of self-esteem that comes from working Separation from coworkers who are friends Loss of income Inability to provide for your family Your spouse and children may go hungry Inability to make your car payments Inability to pay rent or house payments Your family may become homeless Your spouse and children may lose respect for you

So, if academic leaders cannot resort primarily to fear and other negative emotions to motivate faculty and staff and direct their organizations, how should executives manage a university or other knowledge-based organization? The answer sounds simple, but actually is not. Organizations that require creativity from their workers must be led through respect. Respect, like fear, creates deference and deference is required for any organization to have a hierarchical structure that is capable of sustained productivity. So, what is respect? While everyone has an intuitive understanding of respect, we define it here as perceived or experienced virtue. Aristotle, in his Nicomachean Ethics, defines two types of virtue, intellectual and moral. Today, we would refer to intellectual virtue as one's creative ability or scholarly accomplishments. Aristotle believed that one can learn intellectual virtue. He also believed that moral virtue is different in that we all have to potential to be morally virtuous, but we must train ourselves to behave in the right way by practice. We will discuss moral virtues in more detail in the next section.

Fear is a visceral (instinctual) emotion that is manifest through the sympathetic nervous system. While there is a fundamental difference between the fear of being chastised, the fear of losing one's job, and the fear of death during a firefight in war, it does not take fear beyond the loss of a job to make or sustain a hierarchy in a corporate setting. However, respect is based on the cognitive attribution of virtue and virtue, like respect, is multifaceted. It is possible to be respected for some aspects of your performance or personality, but disrespected for others. For example, we all know and respect colleagues because they are excellent teachers but only so-so in research, and others who are excellent researchers who are mediocre (or worse) teachers. While many believe the adage that the best researchers are the best teachers, good researchers are not always good teachers and vice versa. Similarly, there may be faculty you respect for their research productivity (intellectual virtue), but who you disrespect for their character because they may be back-stabbing, narcissists, or dishonest. We contend that for an academic leader to be truly effective, s/he must be respected *both* for their intellectual virtue (academic accomplishments) and for their moral virtue (character).

Before exploring the importance of virtuous behavior, we would like to briefly discuss two related questions. The first is, "What happens if a leader in a university or other knowledge-based organization is not respected for either their accomplishments or for their character?" The answer to this is quite simple and very important to keep in mind when choosing department chairs and deans. When a leader is not respected, either because s/he is not respected as a scholar or because s/he is not respected for their character, the only way s/he can produce the appropriate levels of deference in subordinates is to lead through fear and other negative emotions. This brings up the second question, i.e., "What happens when a university leader resorts to using fear, intimidation, and other negative emotions to lead or maintain control?" The answer to this also is quite simple and equally important. When a university leader tries to use fear to motivate or control an organization, that leader tends to decrease or destroy the creativity of the workers (faculty) and therefore does severe damage to the productivity of the organization overall.

This relationship between respect and creativity is important at all levels of university leadership. While we have been talking primarily about the university hierarchy in terms of faculty, chairs, deans, etc., this is equally true for the interactions of faculty with students. If a faculty member uses fear or intimidation as the primary way to motivate either his/her research group or classes, that faculty member thwarts the creativity of students and research staff. This is fine if the goal is to have students learn through rote memorization; however, if a faculty member wants to establish an environment where the students unleash their creative abilities to solve highly complex problems and discover new knowledge, then the only way to do this is by creating an environment in which the students respect but do not fear or feel unnecessarily intimidated by the faculty.

Because faculty give students assignments, grades, and recommendations, there inevitably must be some tension in the faculty/student relationship. However, because faculty are at the university to teach students (i.e., the university's clients), Greenleaf's servant leadership model (*2*) suggests that students are above faculty in a university's hierarchy, as shown in Figure 2. We also would like to note that undergraduate and graduate students spend years in their universities and most often work very closely with faculty in apprenticeship models of professional development. These methods and aspects of university culture only strengthen and deepen the requirement for deference hierarchies built on mutual respect.

While it is commonly believed that students attend universities to learn and the faculty are there to teach them, we contend that this is an antiquated picture of these institutions. Instead, we believe that faculty are at research universities to learn (i.e., to discover new knowledge that is important to the advancement of society) and students (at least graduate students) are at the university to learn how to think for themselves and do research (i.e., they are at the university to learn how to learn). We firmly believe this can only be done in an intellectual environment that is not based on fear, intimidation, and other negative emotions. Hence, faculty have an obligation to treat their students (particularly, but not only, their graduate students) in a way that is virtuous. And university leaders have similar responsibilities to create organizational environments, processes, and cultures that rest on foundations of positive character traits and behaviors (*4*).

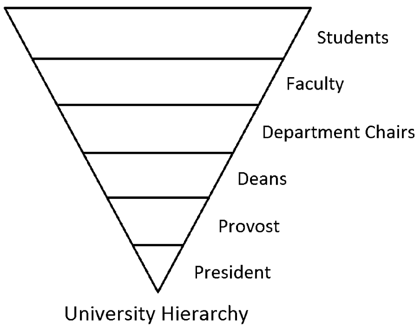

Figure 2. A respect-driven university hierarchy.

Virtuous Leadership as the Means to Success in Academic Careers and Organizations

Figure 3 illustrates Kilburg's (*8*) model of leadership performance. This model emphasizes three major domains of activity: discernment, decision making, and action as the core of what executives do on a daily basis. This triad is linked via feedback loops based on experience and learning that contribute to the development of "virtuous leadership." Discernment involves intuitive and rational perception that can be either virtuous or corrupt. Similarly, Decision Making involves intuitive and rational analysis and choices which can be either virtuous or corrupt; Action involves intuitive and rational execution of choices that can be carried out in either a virtuous or corrupt way. The incorporation of virtues of courage, temperance, justice, reverence and wisdom should be called upon in the processes of discernment, decision making, and action. However, when he notes the corresponding vices of cowardice, intemperance, injustice, irreverence, and stupidity are used, the resulting organization may be productive, but the workers in the organization will be incapable of truly creative thought.

The model depicts the practice of leadership and management. We argue, by analogy, that faculty performance is also a continuous process of engaging in these three interacting domains of behavior which are guided by the character of the individual and whether s/he is under the influence of human virtue or vice. Therefore, faculty performance and academic organizations can be improved through the development of leadership and managerial knowledge, skills, abilities, and experience. Thus, teaching, research, and university leadership activities can be thought of as being structured around the core processes of discerning what is happening, deciding what to do, and taking effective action based on virtuous choices. We suggest that faculty members and other leaders in academic institutions who do so are far more likely to build deference hierarchies that will support and nurture creativity and higher levels of performance. Following this argument, if these three processes are conducted under the influence of the five core virtues, the individual using them is likely to perform more effectively. For example, a faculty member facing a complex problem in the area of research ethics and who decides what to do based on his/her judgment using courage, temperance, justice, reverence, and wisdom seems more likely to produce a better result than one facing the same or a similar challenge whose decisions and actions are more influenced by cowardice, intemperance, injustice, irreverence, and stupidity.

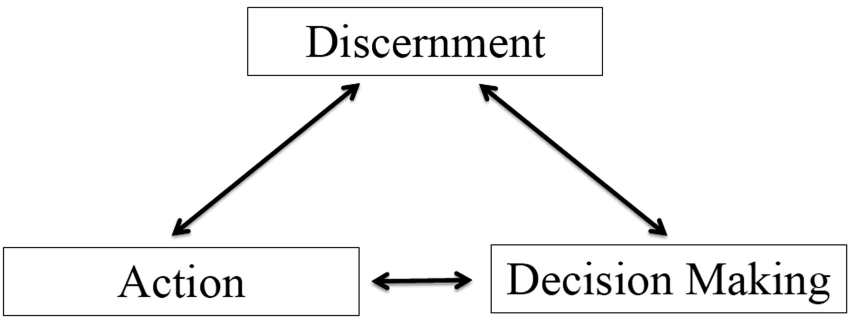

Figure 3. Kilburg's (8) model of leadership performance. Virtuous leadership results in organizations that can be both creative and productive. However, if there is corrupt leadership, the resulting organization can be productive, but its workers will be incapable of truly creative thought.

Kilburg (*8–10*) also emphasized that in every domain of human performance studied to date, two major findings have discriminated between what one can think of as experts versus amateurs (*11*). The two activities that systematically improve human performance over time are structured practice — many deliberate, learning focused repetitions over years — and timely, effective, expert coaching by individuals with very high levels of knowledge, skill, ability, and experience in the skill or capacity under development (becoming a musician, mathematician, athlete, leader, faculty member, etc.). Based on these models and research findings, we argue that the structured and well-coached practice of virtuous leadership by faculty members in pursuing their careers is far more likely to lead to consistently successful outcomes. Let's dive a little deeper into these five essential virtues.

Courage is the will to do what is right despite political opposition or potential personal harm. One example in academia is when a Dean (or Provost) decides not to recommend tenure for an assistant professor who is an outstanding teacher but a poor researcher or, alternatively, an outstanding researcher but an abysmal teacher. In either case, there will be cries that the candidate's strengths should be weighted more heavily than their deficiencies.

Peterson and Seligman (*12*) defined courage as "emotional strengths that involve the exercise of will to accomplish goals in the face of opposition, external or internal." Kilburg (*8*) elaborated on this definition by recognizing that acting with courage does not always involve attacking one's adversaries. Though this is one way to deal with opposition, good leaders also can act courageously by retreating, resisting, or engaging the opposition. He also provided a set of frameworks and exercises to further develop the ability to act courageously.

Anyone familiar with the challenges of being a university faculty member appreciates that they are called to act courageously on almost a daily basis. Enforcing expectations for high performance for students, speaking out on matters of organizational and academic importance, and knowing when, how, and with whom to engage and negotiate on issues involving standards, organizational and programmatic boundaries, and the allocation of resources are constant challenges. And everyone knows someone who has acted in a cowardly fashion with adverse consequences for themselves or others. For example, in many academic settings (particularly those which have a rotating chair), it is not uncommon for a department chair to be afraid to stand up to senior colleagues who are basing their votes on whether or not to tenure an assistant professor who is both a better teacher and researcher but who doesn't show his senior colleagues the deference they feel they deserve. Similarly, a significant fraction of the grade inflation that has occurred over the last twenty years in universities has happened because many faculty believe that their teaching evaluations will be better if their courses are an "easy A."

Temperance is the ability to control one's interactions with others, particularly one's responses to criticism. In Goleman's model of Emotional Intelligence he defines a similar concept, self regulation, as the ability to control or redirect one's disruptive emotions and impulses. However, as Kilburg (*8*) notes, leadership temperance goes beyond "holding one's temper"; rather, it is "a disposition or pre-dispositional intention and capacity engrained in a leader's character to respond to people and the world around him/her through the ability to strategically express or restrain thoughts, feelings, and behaviors based on the judgment on what would be most courageous, just, and wise in a given situation." Thus, temperance involves conscious decisions about what is virtuous. A faculty member's temperance (or intemperance) is on display in virtually every exchange that faculty member has with other people. Most faculty know (and respect) colleagues who have the ability to gracefully respond to inappropriate provocation by others. Simultaneously, we all know colleagues who seem totally incapable of effective verbal or non-verbal restraint in virtually any situation. We would advocate that faculty members who demonstrate the capacity to routinely behave in strategically temperate ways will be more successful throughout their careers and will help to build more positive and creative organizations in which others thrive.

Reverence conjures up images of God and piety in a religious setting. However, in the context of leadership, "reverence is the virtue that keeps human beings from trying to act like gods (*13*)" and from becoming tyrants. The Dean who recognizes that there is wisdom in groups and therefore takes the advice of the department chairs and faculty committees shows reverence. The dean who is convinced that he knows more than all the faculty in his school combined does not. Kilburg (*8*) defined leadership reverence as “a disposition or pre-dispositional intention and capacity engrained in a leader’s character to respond to people and the world around him/her through the ability to feel and strategically enact or express respect, shame, and awe based on the judgment of what would be most courageous, just, and wise in a given situation.” Since being a faculty member in a research university involves regular negative feedback in the form of proposal reviews, paper reviews, and teaching evaluations, it is necessary to have a strong ego to survive. However, a strong ego and irreverent behavior do not go hand in hand. In fact, it is our experience that the most successful faculty usually are those who are most reverent, and it is the less successful faculty who often become irreverent. Nonetheless, acting with reverence can be learned. Kilburg (*8*) suggests a variety of activities leaders can pursue to improve their ability to express this virtue. Simple acts of reflection on when and how one does or should feel respect, shame, and awe can lead any individual to improve in this arena. For faculty members deeply enmeshed in worlds of interpersonal complexity, they would do well to engage in such reflective exercises routinely as an avenue to improve their performance with their colleagues, students, and superiors. We argue that faculty who behave reverently each day significantly increase the likelihood that their classes and research group will run smoothly and will produce positive results.

Justice is the ability of faculty members to engage in superior moral reasoning, demonstrate ethical behavior across all their responsibilities, and respond to others in a just fashion. Department chairs who treat all their faculty based on their performance and productivity regardless of how much the chair personally likes them are acting justly. However, a dean who makes all his decisions regarding what faculty initiatives to support (financially or otherwise) based on whether the faculty member is a friend or enemy is not behaving justly. However, we know a dean who, when approached with an initiative, would support the initiative (no matter how meritorious) at the level requested if the faculty member was a friend and would decline to provide any support (again, regardless of merit) if the person was an enemy. And for those who were neither friends nor enemies, he would give them exactly half of what they asked for.

Moral development and reasoning and organizational justice have been extensively studied over many centuries. A profoundly rich and deep literature awaits anyone who becomes curious about or is forced to consider these types of issues. Kilburg (*8*) suggested that developing a formal, moral point of view and elaborating a personal, moral compass would enrich anyone faced with professional and leadership challenges in the area of justice. We contend that faculty members who pursue their careers with a character structure based on injustice and poor moral reasoning are very likely to experience increased risks of derailment and the associated organizational cultures will not foster productivity or creativity. The recent history of higher education and scientific research is replete with examples of unjust behavior that has ended the academic lives of faculty and severely damaging their parent institutions.

Wisdom is the ability to apply knowledge and the common sense gained from experience in a way that is consistent with one’s ethical beliefs; it often requires suppressing one's emotions to provide sincere and direct advice. Wisdom is not the same as intelligence, education, or being either shrewd or articulate. Rather, it is a common sense about social and interpersonal relationships that develops with age. It is knowing which battles to fight, when to compromise, and when to acquiesce. It also involves the ability to find the non-obvious win-win outcomes. Kilburg (*10*) described executive wisdom as "an expert system in the fundamental pragmatics of organized human life" through which leaders "discover or create the right thing to do; do the right thing in the right way; and do it against the right time frame." In his overview of the extensive literature on wisdom, Kilburg (*10*) emphasized that Socrates, Confucius, and others have long considered this to be the master virtue that regulates the development and especially the deployment of all of the others. Tichy and Bennis (*14*) took a similar stance in their exploration of executive judgment. They expounded three primary principles of judgment:

- Making judgment calls is the essential job of a leader — in the end, little else but good judgment matters;
- Long term success is the sole marker of good judgment — leaders do the important things right; and
- Leaders make the calls and see to their execution — they work through and in key relationships to get things done.

We could hardly find better and more concise principles upon which to base and engage wisdom in a faculty career. Every day, faculty members are challenged to be as wise as possible in every domain of their complex lives. Every day, their judgment is called upon and often called into question. And every day, in and through the hundreds of decisions they make and often the dozens, even hundreds of relationships that mediate their lives, their performance is graded by students, colleagues, and superiors based upon how wise they are in their judgment and in the behavioral manifestations of their virtues and vices.

Respect and Fear: Finally, as noted above, Machiavelli (*3*) advocated that it is best for a leader to be both loved and feared but that it takes a truly gifted person to accomplish this. There is an analogous question that can be asked, i.e., "Is it better for an academic leader/faculty member to be respected or to be both respected and feared?" The answer to this question is actually much more complex than it is for love and fear. Both fear and respect tend to increase the organizational strength of a hierarchy. So, for example, Generals like Washington and Patton, who were both feared and respected, were more effective than their counterparts who only were feared. However, as noted above, fear narrows people's thought repertoires and therefore decreases or destroys creativity (*4*). Therefore, even though it strengthens their authority, faculty, department chairs, and deans should not use fear or other negative emotions to motivate others. However, because faculty must give grades for students and department chairs and deans must give performance appraisals and make promotion and tenure decisions for assistant/associate professors, we believe there always will be some amount of fear in both the faculty/student relationship and in the dean and department chair/junior professor relationships. However, it is important to both graduate students and assistant/associate professors that this fear be outweighed significantly by the respect they have for their teachers, research mentors, and department chairs respectively. Therefore, both faculty mentors and department chairs should be extremely cautious about using fear-inducing language and other behaviors in their interactions with subordinates. It goes without saying that both should be conscientious about being virtuous. We believe that academic leadership teams that understand the need to build cultures and deference hierarchies that are based on virtue will be far more likely to sustain superior overall performance and thus retain their ability to attract the most gifted students and faculty members.

Management of Academic Careers

In the first part of this chapter, we introduced you to the essential tasks of academic leaders and faculty members and provided a variety of insights and ideas about what we believe is perhaps the most important way of conceptualizing the nature of successful academic leadership and faculty performance — building deference hierarchies based on servant leadership and virtuous behavior. In this section, we endeavor to expand on two key ideas that the vast majority of faculty members never truly contemplate. The first is the fact that every person is in essence conceptualizing and running a business that is their career. Kilburg (*5*) made this argument writing about careers in psychology.

Management science and practice have been pursued informally by humans since they first banded together in groups to hunt and then into communities to farm. The scientific study of the related fields began in the mid-nineteenth century and continues at a furious pace. We do not have the space in this chapter to provide anything but a few chosen ideas. Below are a few key concepts that are elaborated on in the references cited.

A wide variety of definitions of management are readily available. Kreitner (*6*) stated that it is "the process of working with and through others to achieve organizational objectives in a challenging environment." For faculty members, their organizational objective is to be successful in research and teaching and they must work with and through their students to accomplish this. Because a faculty member's career can be viewed as a business, the entire domain of management theory, science, and art can more or less be applied to faculty life. The following examples should help to make this point.

Henry Mintzberg (*7*) has been one of the leading scholars focusing on the practice of management for more than four decades. He has approached the subject with unyielding practicality. What follows are a couple of his main ideas. First, his research has demonstrated that there is a formal set of roles that leaders play as they manage their enterprises. In general terms, managers frame and schedule work. In other words, they decide both strategically and tactically what is to be done and then they decide when, how, and by whom it will be accomplished. At a minimum, every faculty member is making these choices with regard to time, their most precious and important asset. We would suggest that a more detailed set of roles can be applied to any faculty member who is managing his/her career. These roles are as follows:

Interpersonal Roles:
Figurehead
Leader
Liaison
Coach

Informational Roles:
Monitor (quality control)
Disseminator
Spokesperson

Decision Roles:
Entrepreneur
Disturbance Handler
Resource Allocator
Negotiator

According to Mintzberg, in the interpersonal roles, the manager (read faculty member) engages with others as the person seen as the head of the business unit (his/her research group, teaching, and career in daily practice). In the informational roles, s/he gathers and disseminates information critical to the success of the enterprise (the faculty member's career) and speaks out in strategic, coherent, and effective ways to represent the views and ideas most central to that performance. Finally, in the decision roles, the faculty member decides what directions to take, allocates essential resources (time, money, and attention) manages conflict and other disturbances when they arise, and negotiates with all other actors in the relevant environments that contribute to his/her work performance/career.

An enormous range of behavioral competencies that contribute to managerial success are embedded in these roles. Over the course of the past several decades, a variety of leadership and managerial competency models have been created by academics, individual organizations, and commercial enterprises selling management development services. Mintzberg (*7*) offered his own set of managerial competencies following his model of roles. These include:

Personal Competencies:
Managing self internally
Managing self externally
Life-long learning
Scheduling

Interpersonal Competencies:
Leading individuals
Leading groups
Leading the organizational unit
Administering
Coaching

Linking the organization/unit

Informational Competencies:
Communicating verbally
Communicating nonverbally
Analyzing

Actional Competencies:
Designing
Mobilizing

More detailed descriptions of these competencies are provided by Mintzberg (*7*). Kilburg (*8*) discussed this issue in somewhat more detail and provided general overviews of three other widely disseminated leadership competency models. He stated that managers "being evaluated in the competency paradigm are being asked to address the questions, 'what do you do?' and 'how do those actions make your performance effective as judged by others?' "

In summary, the first key idea that may contribute to improving the ability of any faculty member to succeed at the various components of his/her work is that it is extremely helpful to conceptualize these activities as managing the business of an academic career. In this context, the knowledge, skills, abilities, science, and practice of leadership and management can be accessed and applied to anything s/he does. And through such applications, faculty members and other academic leaders are increasingly likely to co-create productive deference hierarchies that are based on effective performance rather than the establishment and maintenance of environments built on and sustained by negative emotion.

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Chapter 10

Missing Components of Training in the Chemical Sciences

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As noted in a recent ACS Presidential Commission report and elsewhere training in the chemical sciences in the U.S. is, at best, inadequate and perhaps inappropriate. Industry is unable to find suitably-trained applicants for available positions and is petitioning Congress to relax immigration laws so that larger numbers of international candidates will be available. At the same time, unemployment among those trained in the chemical sciences is at an all-time high. Clearly, there is a disconnect between what universities are doing and what the country and the world needs. It is incumbent upon any program of training in the chemical sciences that it turn out not only degree holders but functional graduates. If the U.S. is to remain competitive in the area of science and technology, training in the chemical sciences must be redirected and improved. Most programs continue to be quite traditional in approach and slow to adapt to changing needs. The demarcation between fields of chemistry, and even among disciplines, is blurring. The base of the chemical sciences is broadening. This requires more integration in the training of students – more focus needs to be placed on the program rather than a set of courses. There are several areas in which inadequate training is provided. Perhaps most prominent is polymeric materials. These materials are essential for a high standard of living and most industrial chemists work in a polymer or polymer-related area, yet training in this area is often neglected. Every program should include a course in industrial chemistry which treats the actual chemistry of industry, the technology of industry (how the chemistry is utilized to produce

items required by the consuming public) and the chemical environment (interrelationships, capital generation, a common business cycle, intellectual property/trade secrets, marketing, reporting, job performance, education, etc.). Students should complete a meaningful research project focused on a real societal problem and, if possible, an industrial internship.

Introduction

There is growing evidence that training in the chemical sciences in the United States may not be adequately preparing graduates to assume a meaningful place in the professional world. Perhaps most telling is that at a time when unemployment among chemists is at an all-time high (albeit at a much lower level than for the population as a whole) industry is unable to find suitably-trained applicants for available positions and is petitioning Congress to relax immigration laws so that larger numbers of international candidates will be available. Most chemistry graduates at any level (B.S., M.S., Ph.D.) work in industry. Yet the training received by these individuals often does not prepare them well for this role. In fact, training is often much narrower than potential employees find desirable. As a consequence, up to two years of costs (overhead, salary, etc.) may be required to bring new employees up to speed. This situation is now being recognized and proposals for change put forth (*1*). It has been suggested that training should lead to the generation of functional graduates that would be fully equipped to assume an industrial position. Why has this taken so long? Much of the problem has been inertia. Change is usually accepted with reluctance and occurs slowly. As noted in a recent publication, "Universities have been especially slow to act… in improving the quality of undergraduate education" (*2*). So the problem is pervasive – from undergraduate through graduate programs in which focused rather than broad training is the norm. Some fairly dramatic changes in research funding have been proposed to respond to this situation (*1*). If research funding went directly to graduate students rather than to individual principal investigators, students might be able to work with two, three or more professors during their graduate career. In this way, much broader experience could be achieved. This proposal has not been received with overwhelming enthusiasm. As has been noted, "The key to educational reform lies in gathering evidence that will convince faculty that current teaching methods are not accomplishing the results that professors assume are taking place" (*2*).

Some initial efforts to address the situation are occurring. As a consequence of the Scientific and Advanced Technology Act of 1992, the National Science Foundation sponsors thirty-nine centers across the country (*3*). These are industry, academic and government agency partnerships that promote innovation in technological education. The centers have been effective in recruiting under-represented groups into STEM areas and enhancing the skills of STEM technicians educated at community colleges.

Perhaps, more importantly, several chemical companies are partnering with universities to sponsor research that will address "real world" problems and provide broader training for graduate students, and, in some cases, industrial experience (*4*). Some notable examples include the BASF interaction with Harvard, BASF with MIT and UMass-Amherst, Dow Chemical with UC Berkeley, Penn State and others and BP with UC Berkeley, Lawrence Berkeley National Laboratory and the University of Illinois, Urbana-Champaign. Perhaps most notable is the interactional of Eastman Chemical with North Carolina State University. Eastman has established the Eastman Innovation Center on campus and Eastman scientists regularly interact with university faculty. Such an arrangement should not only produce useful research results but should provide excellent training for graduate students.

An effort to provide more meaningful training in the chemical sciences is more advanced in the U.K. Government funding is being provided to develop seventeen new Centers for Doctoral Training which will place emphasis on "skills development" (*5*).

There are numerous reasons for the inadequacies in the current training in the chemical sciences. Some of these are listed below.

- Inertia
- Tradition
- Training requirements
  − ACS Committee on Professional Training
- Broadening nature of chemistry
- Funding models
- Lack of understanding of the function/operation of the modern chemical industry

As noted earlier, change does not come easily to any institution. For many departments, there is a pattern for how things are done, which seems to work and there is little incentive to make alterations that will require significant effort and may cause some disruption. The requirements for training in the chemical sciences are neither uniform nor adequate. The ACS Committee on Professional Training (CPT) sets the standards for ACS-approved B.S. programs in chemistry. Despite the importance of polymeric materials to the well-being of society and their central presence in the chemical industry, current CPT guidelines contain no requirement for a polymer chemistry course. At the graduate level, the background required may be less broad and is often highly dependent on the area of interest of the research advisor. This is compounded by the fact that "chemistry" is increasingly broad and includes many areas that were excluded by that term only a decade or so ago. The divisions within chemistry have almost been obliterated. Independent of the formal area of training, chemists often work across all these areas. Current practitioners must be more widely knowledgeable and skilled than ever before. The way in which support for chemistry training and chemical research is provided often mitigates against meaningful reform. At many smaller or mid-level institutions, chemistry departments receive institutional funding based on the number of student-credit hours generated. This leads to a focus on high-enrollment service courses rather than on a high-quality majors program. As noted previously, the practice of federal research funding flowing to individual faculty members rather than to graduate students fosters excellent training in a particular area but a lack of breadth in training (*1*). All of this is compounded by the fact that most university faculty lack detailed knowledge of the chemical industry, have no industrial experience, and are not involved in industry-sponsored research.

- Obviously, any program must provide solid training in the chemical sciences, but that is not enough. Students must gain some understanding and ability in several other areas.
- Communication (ability to write well and speak effectively)
- Basic economics
- Intellectual property
- Basic computer skills/statistics
- Characteristics of the chemical and allied products industries
- Aspects of polymer science
- Engineering concepts

Discussion

Initial understanding of chemical concepts is gained, more or less effectively, in an undergraduate program (Figure 1).

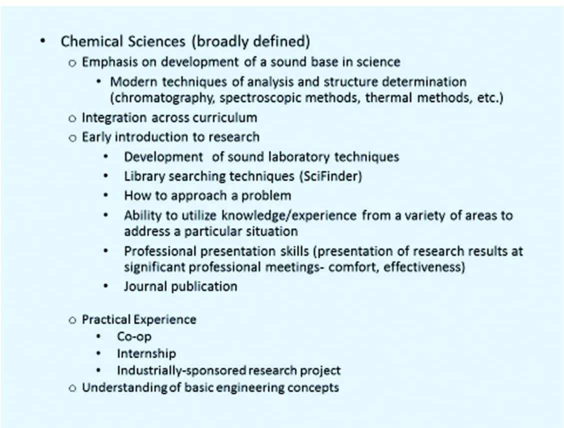

Figure 1. Basic Skills to be Acquired in an Undergraduate Program in the Chemical Sciences.

Participation in a quality program of undergraduate research (see CPT guidelines) is essential for training at the B.S. level. Students tend to treat courses as packets which can be ignored as soon as successfully completed. When confronted with a research problem of their own they must rely upon knowledge independent of its origin, across all courses. They learn to plan, to evaluate critically, to address the chemical literature, to search effectively, to generate and evaluate data, to write reports in ACS style and to present results in a professional manner. The most significant development as an undergraduate usually comes about as a consequence of participation in meaningful undergraduate research. Performance in undergraduate research is perhaps the best predictor of success in graduate school and beyond.

Participation in a co-op program or an industrial internship can provide valuable experience and some appreciation for an industrial environment. Some of this can be achieved by participation in a research project that is sponsored by a chemical company.

Good communication skills are required for any position (Figure 2). Arguments and results must be presented well for projects to be funded and progress to be demonstrated.

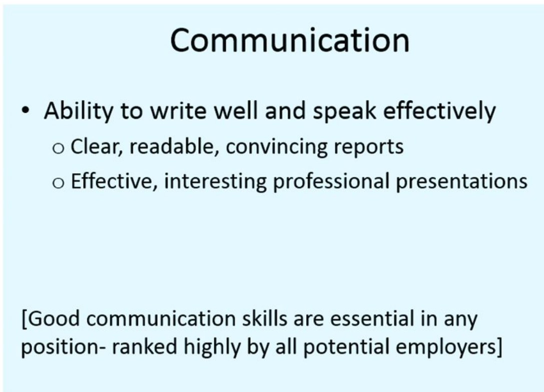

Figure 2. Essential Communication Skills.

Elements of basic economics that a functional graduate will need are listed in Figure 3.

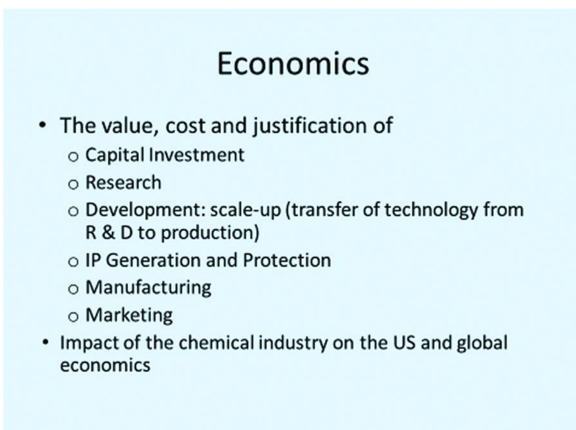

Figure 3. Components of Basic Economics Necessary for Functional Chemistry Graduates.

Most graduates have little understanding of how research results get converted to salable products – what the process is, what the costs are, or what a reasonable product life cycle might be.

The development, protection and utilization of intellectual property is the life blood of the chemical industry. Some elements to be included in the background of any student of chemistry are listed in Figure 4.

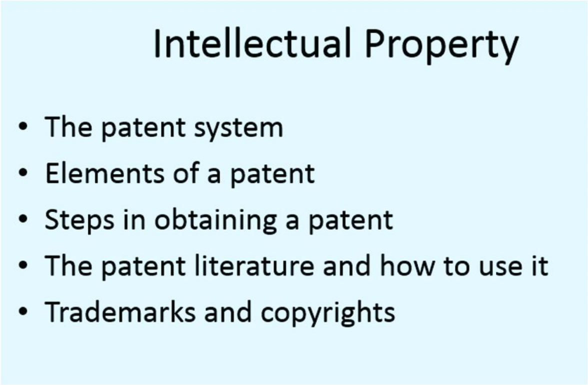

Figure 4. Intellectual Property Background for Chemistry Graduates.

Most current chemistry students, at all levels, have good computer skills. Some fundamental capabiltiies are listen in Figure 5.

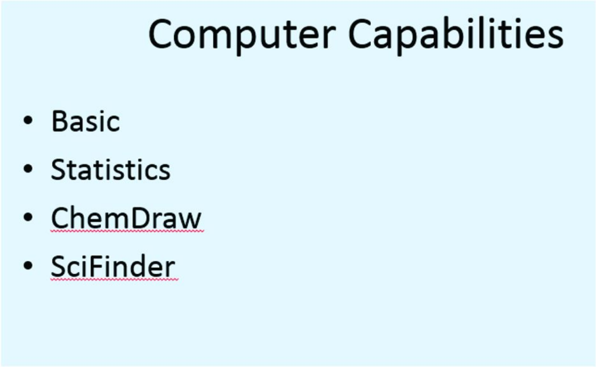

Figure 5. Fundamental Computer Skills to be Acquired by Chemistry Students.

An area in which many students lack any understanding is the interrelationships among segments of the chemical industry (Figure 6). This can be most readily taught using case studies. A simple example is Posed in Figure 6. How does an increase in the price of electricity at Niagara Falls impact the producer of vinyl siding in Georgia? The student must be aware that chlorine and caustic are produced by electrolysis of brine using electricity produced at generation units at the Falls. Chlorine is used for the chlorination of ethylene. This followed by dehydrochlorination generates vinyl chloride monomer from which poly(vinyl chloride) [PVC] is produced. An increase in the cost of electricity at Niagara Falls will drive up the cost of chlorine, vinyl chloride and the resin coming to the producer of vinyl siding in Georgia. His margin will be reduced. He may have to increase the price of siding to customers, or barring that, to accept smaller profit or reduce the level of operation with consequent job loss, etc. These are the kind of things that most students of the chemical sciences never really think about but are critical to an understanding of industry and their potential role in it. Some background in this area should be provided by all chemistry programs.

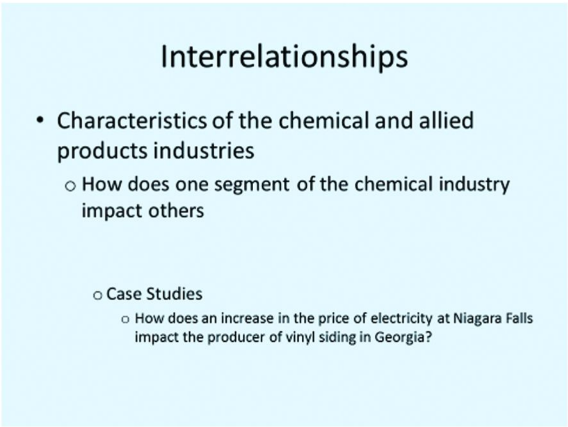

Figure 6. Interrelationships Among Segments of the Chemical Industry.

The Need for Inclusion of a Treatment of Polymeric Materials in Chemical Education

An area in which most chemistry programs are woefully inadequate is the treatment of polymer science. Not only do most chemistry graduates work in a polymer or polymer-related area but the high standard of living enjoyed by citizens of the developed world would simply not be possible without polymeric materials (Figure 7).

Some polymer concepts that all students should be familiar with are listed in Figure 8. Because of the increasing interest in "green" materials and issues of sustainability some introduction to biopolymers (Figure 9) is also warranted.

How can missing components be incorporated into the chemistry curriculum? A simple approach would be to include them at appropriate places in existing courses and distribute them across the curriculum. This requires a commitment of all members of the faculty to include concepts as appropriate and do it in a meaningful way. This can be quite effective but, for a variety of reasons, may not be the better approach. Certainly, these concepts can be introduced via a course in Industrial Chemistry (Figure 10).

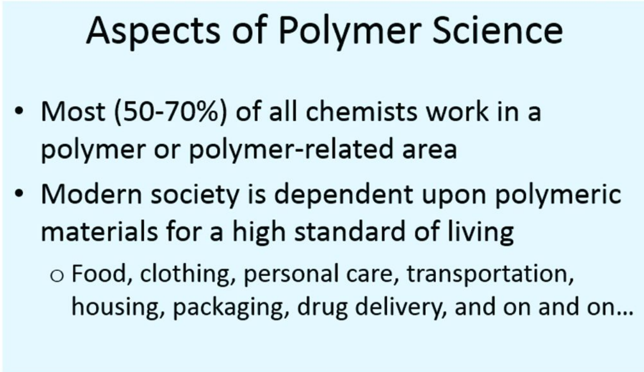

Figure 7. Importance of Polymeric Materials to Society and the Chemical Industry.

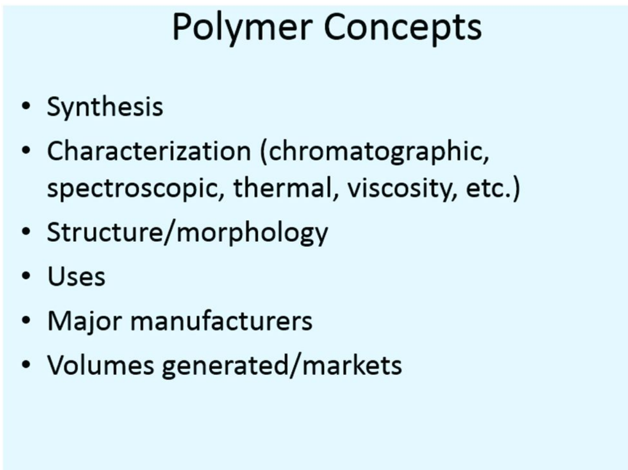

Figure 8. Basic Polymer Concepts to be Included in Chemistry Curricula.

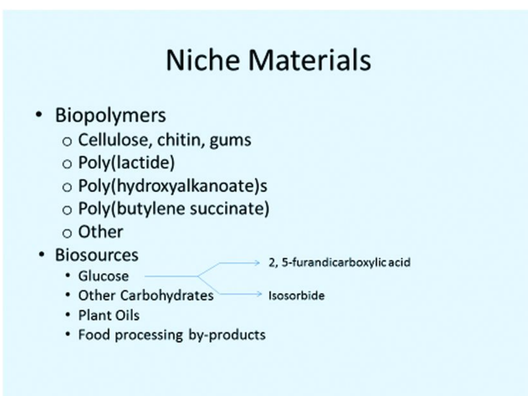

Figure 9. Representative Biopolymers and Sources.

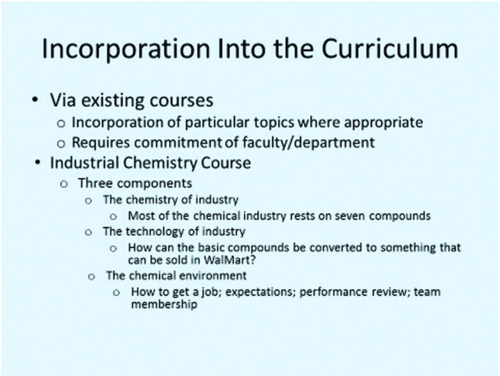

Figure 10. Incorporation of Industrially-important Concepts into the Chemistry Curriculum.

Industrial Chemistry

A course in Industrial Chemistry may be subdivided into three approximately equal segments: 1.) the actual chemistry of industry, 2.) the technology of industry and 3.) the chemical environment. The chemistry of industry component (Figure 11) examines the sources of the basic compounds on which the industry rests and processes by which they are formed and converted into other materials.

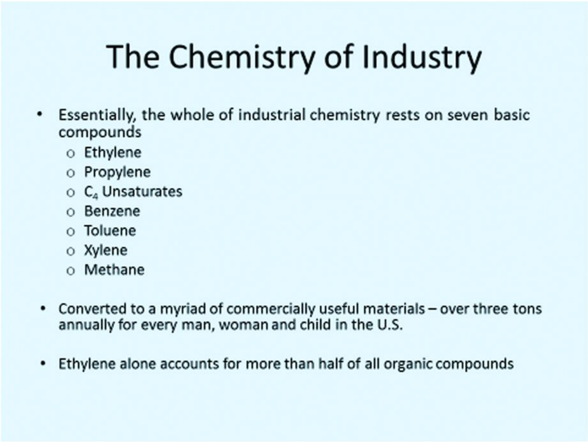

Figure 11. Basic Compounds of Industrial Chemistry.

These basic compounds, except for methane, are currently derived from petroleum (Figure 12). In the immediate future the small olefins will come from cracking natural gas components in the U.S. This is possible because of the current relative abundance of natural gas from hydraulic fracturing of gas-bearing shale deposits.

The technology of industry (Figure 13) has as a focus the conversion of the basic chemicals of industry to goods that may be used in manufacturing or for sale to the consuming public, i.e., to items that can be sold in WalMart.

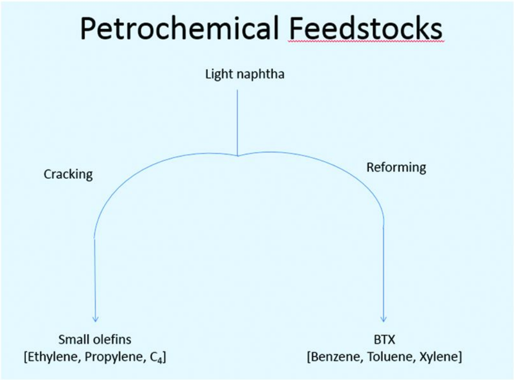

Figure 12. Basic Componds for Petroleum.

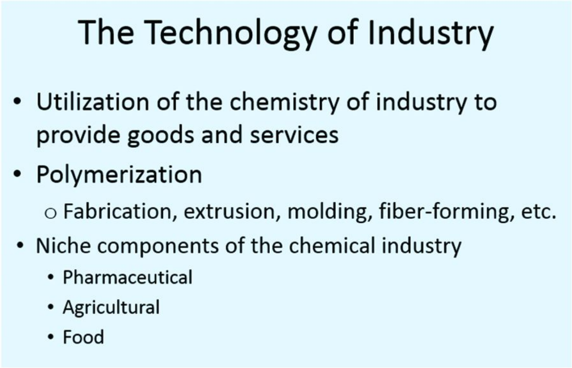

Figure 13. Conversion of Basic Chemicals to Goods and Services.

The third segment of the course, "the chemical environment" (Figure 14) deals with how a chemistry graduate might go about seeking employment, what to expect during the process, how evaluations will occur after employment is achieved, expectations for safeguarding proprietary information, and several other aspects of industrial employment.

Case studies, short reviews, oral presentations and major papers may be used throughout to enhance analytical thinking and to hone both oral and written communication skills. Two excellent textbooks are available for use in a course of this kind (*6*, *7*). The Wittcoff text generally focuses on the US chemical industry while Weissermel/Arpe treats European industry. However, in most regards, the two are quite similar and either will serve well as a base for the course.

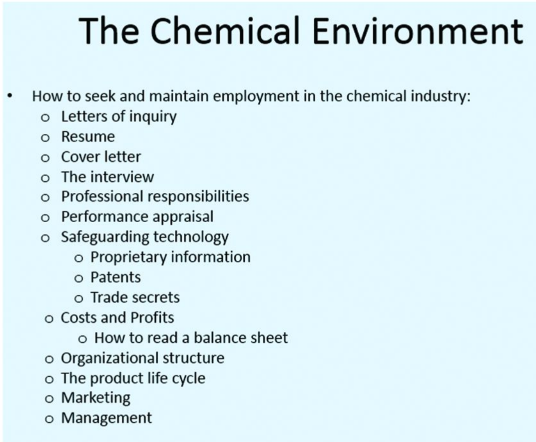

Figure 14. Aspects of the Chemical Environment.

Conclusions

Current training in the chemical sciences lacks several essential components. For the U.S. to remain technologically competitive this needs to be corrected. This requires greater attention to the needs of potential employers. This may be most readily done (without great effort or undue cost) by incorporation of polymeric materials into the foundational chemistry courses, problem-based research, and introduction of an industrial chemistry course.

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Chapter 11

Don't Know Much about Pedagogy: Your First Job in Chemical Academe

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In Sam Cooke's inimitable rendition of "Wonderful World" from 1960, he states "Don't know much about history, don't know much biology." Much like Mr. Cooke's simple lament about a lost chance at love, modern scientific training is just now, in the 2010s, waking up to its lack of emphasis on pedagogy and the short/long term ramifications of such thinking. Arguably, the most pronounced effect of this neglect is, ironically, in the world of learning and teaching. Since many chemical scientists decide to enter academia with their advanced degrees, this can be viewed as downright paradoxical. This work aims to detail the growing number of ways that pedagogical methods themselves enter into the pedagogy of training future and new scientists and suggests ways for integrating these techniques into the instruction of every scientist headed for or new to academia.

Introduction

Speaking broadly, the life of the modern graduate student in chemistry has always been based on contributing knowledge to the world through empirical or applied research. Even these turns of phrase are almost always meant to assume laboratory work and the reading/writing that goes along with it. For many, the teaching aspect of graduate school, like teaching assistantships, are hurdles to be overcome to expedite lab work and not much else. Considering the proportion of graduates aiming for academic life, the lack of training in the areas of teaching and learning is regrettable. A "you'll pick it up when you need it" attitude that pervades all higher education of future faculty members (not just chemical science) is outdated at best and dangerous at worst. Not too far from this thinking is the fact that those charged with the education of today's students have received little to no training in the area of pedagogy and good teaching/learning methods. The majority of Ph.D.s hired to faculty positions from graduate school or lab research postdocs directly speaks to this lack of training quantitatively – since the 1950s, this practice is the norm.

We are learning more about what we don't know much about though, and the last 25 years have taught us much about the cost of this type of instruction. Elementary teachers, the "front lines" of education, can foster student interest in STEM, but what are we doing at the secondary, undergraduate and graduate level? If elementary students' interest in STEM (science, technology, engineering and math) careers continues to drop precipitously, does this mean there is little hope that the United States may again be at the forefront of innovation and cutting-edge thinking many years hence? At the same time, however, we have learned much about learning and the time could not be better for integrating understood methods into modern instruction. In short, a great hunger has emerged for those interested in the modes of learning appropriate at all levels of schooling, especially at the graduate level. The rise of the PUI (Primarily Undergraduate Institution) has made substantial undergraduate lab research a possibility for many. Postdoctoral teaching positions have emerged as true on-the-job training for academics interested in joining the professoriate. And that old adage about the types of jobs our students will be getting not even existing at the time of their instruction? A growing American industry of pedagogical support tools for college, high school and elementary school instruction are employing more and more Ph.D. scientists in their ranks. The American Chemical Society Presidential Commission Report titled "Advancing Graduate Education in the Chemical Sciences" summarizes these sentiments plainly:

> "Current educational opportunities for graduate students, viewed on balance as a system, do not provide sufficient preparation for their careers after graduate school (*1*)."

This report was mandated for many reasons, but one of its findings is that pedagogy cannot change as a culture until current models of cognitive/behavioral understanding about learning are combined with modern graduate instruction. If successful, future educators would take this instruction with them to their own academic careers and spread the word not just about chemistry, but about the concept of life–long learning. This chapter will highlight many of the contemporary ways of thinking with regard to instruction in pedagogy including: the role of a professional learner, planning for your own instruction in pedagogy, assessment/learning outcome culture, and feedback from students and colleagues.

The Role of a Professional Learner

Defining the problem of lack of pedagogical training from the top down, one might ask the following: Is a faculty member a teacher? A student? An educator? An instructor? To some, these words are just that – terms with interchangeable meanings. Psychological research suggests that when students view the professor as a team member on a journey of learning alongside them, better attitudes toward learning result. Also reasonable to ask is the role students play in an academic's learning. Should faculty not have more frequent incidents where we learn as much from students as they do from us? Placed together, these two point to the role in which we wish our students to perceive us, both from the start and through our daily and weekly actions. Many in the field have centered in on the role of the faculty as professional learners present for the goal of instilling good attitudes toward learning and productive learning methods in their students.

When future faculty considered these questions and began to formulate where their own attitudes toward learning arose from, some fairly shocking facts came to light. According to an article published in 2013, research clearly indicates that when polled, students perceive the vast majority of their learning taking place not in school but outside of the classroom (*2*)! What is even more interesting is the number of professional academics who agree with these statements on first principles – that afternoon with grandpa fishing or a trip to the zoo with your mother were far more formative experiences for you than the 4th grade, at least in retrospect. Why? The article states that cognitive research continues to build on a body of knowledge that points to a concept called "emotional learning." In other words, the "flash" of a quick understanding is fun (indeed many educators cite the "light going on" for students as a main impetus for going into education), but science tells us that lasting learning takes place by means of gradual awakening. This process is heavily tied to the way we feel and therefore, good learners know one must stoke the fires of emotion for any real learning to take place. As chemical academics, we are primarily motivators and we have only just begun to use the beauty of the struggle of learning to cement in our students a true love of chemistry.

The bottom line to these methods is a priming of the mind to engage directly in metacognition, the act of thinking about the way one thinks. Research shows that students who are taught how to learn perform better, retain better and have healthier attitudes toward their education (*3*). Since a significant investment of time and patience is always involved in any worthwhile activity, faculty can model their pedagogy after their own experiences setting and achieving study goals.

Planning for Your Own Instruction in Pedagogy

Traditional wisdom for newly–hired faculty members contemplating the courses they will teach almost exclusively relied on their knowledge of their own, previous instruction. After all, one just needs a place to start and then over the years, small changes will result in a personal, unique teaching style. The errors in this way of thinking are numerous, but primary among them – Don't modern faculty spend much of their time explaining their disdain for students who cram for exams? Why is this method okay for first-time faculty with little to no exposure to the world of pedagogical research?

"Crash–coursing," once the way of the past, has now been replaced by measured planning for those aiming to join the ranks of chemical academe. Like any other research field, individuals simply need to know where the best information can be found to begin to prepare for this rather daunting, first–time task. Persuasive data to this end can be found in the flagship ACS journal for the study of pedagogy, *The Journal of Chemical Education*. Not only has the *Journal* been absorbed into the ACS Publications house (seen as a formal legitimization of the work published), but in the last 25 years, the journal has seen a marked increase in the number of articles published concerning chemical education research, as well as laboratory experiments, demonstration suggestions and theory explanations. And this publication is only the beginning. The *Journal of College Science Teaching, The Chemical Educator,* and myriad other representative journals await those beginning to strategize about their teaching style, methods and objectives (*4*, *5*). The classroom, after all, is as much a place for experimentation as a flask is in the lab! Researchers publish to let readers know what works, what doesn't, and what is yet to be explored. Growing questions about pedagogy function in the same way, and are as serious, as any chemical laboratory project. Entire symposia and conferences have been dedicated to the sharing of such data.

Emulation of colleagues is also a place where many start their pedagogical planning, but what many new academics miss is how their colleagues outside of chemistry and STEM fields make for excellent pedagogical fodder, too. Our students, undergraduates for example, are switching gears constantly among their courses: science, liberal arts, fine arts, math, health professions, etc. Engaging the "moving target" of student interest and effort is a badge shared by all professionals in education, and it is a common mistake that new academics make by not reaching beyond the boundaries of their discipline for ideas. In planning one's own instruction in pedagogy, sometimes simple classroom observation, review of syllabi, or a new set of eyes for review can make all the difference as faculty try to decide what risks are worth taking. An excellent and most salient example of this kind of pedagogical planning can be seen in hybrid or fully online courses. Much like the old grad school adage, "An hour in the library can save you a month in the lab and vice versa," learning about how students learn in these types of courses can forestall major problems and help new faculty see the interconnectedness of their students' learning. One need not be from the same specific discipline to impart such experience. With a little forethought and time, new faculty can begin the process of improving their pedagogy from a very high starting level.

Assessment and Learning Outcome Culture

Chief among the changes of the last 25 years in every level of education is a migration toward a culture of learning outcome assessment. Some educators have misinterpreted both the meaning and aim of the principles behind this recasting of educational theory. To some, "assessment" has become a dirty word, while for many it is an idea whose time has come. Who is right and what bearing does this have on your first job in chemical academia?

First, it is reasonable to describe the growing culture of assessment as the scientific method applied to teaching and learning. Looked at in this way, chemical scientists should have no problem adopting the same approach they give their laboratory work to their pedagogical methods. Research in behavioral science has concluded that without purposeful design, learning can go into unintended or dark places or perhaps, never move at all. Assessment refers to the numerous methods by which student learning can be measured and how the resulting data is used to improve instruction. While the terminology seems new to many, assessment culture is neither a fad nor a true innovation – it is a new way of thinking about what academics want for their students. In addition, the economics of "bottom lines" that has pervaded recent discussions of the future of higher education may mean that assessment culture is here to stay. This should not be a primary motivator for new educators, though – assessment, by its very nature, shows a careful consideration for the pedagogy aimed at our students and their resultant learning.

The easiest way to cast the assessment process is to "start at the end." Learning outcomes occur at every possible chronological level – topic, task, quiz, test, exam, course, degree program, university core curriculum. Faculty familiar with this method start by asking: What do I want my students to be able to do at the end of a specific instruction unit? Once this is determined, the depth of the stated learning outcome can be mapped against similar or dissimilar outcomes within the unit. A common outcome mapping technique involves using Bloom's Taxonomy in the cognitive domain (*6*). In efforts to gather outcomes toward an overarching goal of critical thinking, Bloom's classification states that every item in the classroom has the ability to ask students to remember, understand, apply, analyze, evaluate and create. The complexity of the task at hand increases along the continuum of these terms, left to right. In addition, there is a circular Bloom's classification map that helps educators realize that students engage multiple learning outcomes at different levels simultaneously. The intent of such categorization is twofold: in the short term, most important is the betterment of the educator's pedagogical skill set. Thinking of the very last day of class – a final exam, a term paper or a lab practical – will help focus the pedagogy that comes in the weeks before. In fact, there have been whole books written about visual representation of learning outcome mapping for distribution to students (*7*). Secondly, tracking of learning outcome achievement is mandatory to many institutions' overall and professional degree accreditation, where chemistry plays a huge role in the instruction of engineers, nurses and other degree programs. Faculty are often asked to measure the effectiveness of learning through measureable outcomes, which means the design of the outcomes and metrics by which they will be measured falls in the hands of the course instructor. All in all, assessment is a process wherein learning can be predicted, measured and modified to fit the ever–changing needs of students. In many ways, such practices are second nature to trained laboratory scientists.

Feedback from Colleagues and Students

A professional from almost any field will say that focused feedback from a "coach" is essential to growth in that field, and the same applies to pedagogy. Of course, there is always fear that comes with allowing someone to purposefully judge us, but this is the same fear our students have of us! Truthfully, this could be reason enough to engage in this very healthy habit. What many newer educators ignore are the criteria by which the best feedback can be attained and utilized. To start, a good rule of thumb for feedback is that if it does not make the requester happy, it will make no one happy.

No 50 minute lecture observation is going to bring about a massive overhaul of one's teaching style, but it may lay the groundwork for future evolution by starting the conversation. Asking for feedback is the first step. Some institutions have formalized faculty mentoring programs where junior and senior teachers are paired up from the start of one's career, but many do not. Asking is the all important groundbreaking that allows the rest of the feedback process to unfold. Just as the students who leave questions unasked are bemoaned by faculty, the same applies to faculty who do not take advantage of their colleagues' experience. In the same vein, the timing of feedback is also imperative. This applies to the timing within the reviewee's career, as well as in the academic year. Earlier feedback from colleagues may result in immediately applicable changes, while later feedback can be more reflective on a larger scale. Conversing ahead of time about the kind of feedback sought can make the process rewarding for both parties involved. At this stage, one can also discuss the kind of report desired – compiled written observations are common, but course material reviews and open conversations can also be appropriate. The use of the feedback generated is the final stage of the feedback cycle. While it might seem obvious to some to embrace positive practices and improve negative ones, the tracking of such data is very often a cornerstone of tenure and promotion dossiers. In addition, open conversations about individual lectures, topics and courses can lead to reform at the level of degree programs, as previously described in this chapter.

The ultimate goal of a faculty member asking for a colleague's feedback is to preen the development of their own students through the feedback the faculty member supplies those students. Helping students interpret the feedback presented to them helps them, in turn, make positive changes in their own self–teaching. Students can learn how to give better feedback to each other and the professor when faculty know the best timing, kind, and use of good feedback. Since modern cognitive research suggests that students with more, varied, and timely feedback succeed in achieving critical thinking learning outcomes, it only makes sense that faculty should adopt such practices to get the best work from their students (*8*). Educators can mirror the type of feedback mechanisms that are the best kind of learning for students.

Summary

There are many ways that prospective faculty can prepare for their future pedagogy today. As discussed in this chapter, they can view themselves as professional students, they can plan for their own pedagogical training, they can design learning outcomes and assessment with student goals in mind, and they can engage in colleague/student feedback cycles that are productive and model professional behavior. Starting from the baseline of what was and is important to their own personal learning, faculty can begin to shape their teaching methods as early as their undergraduate and graduate years. All academics are certainly products of the old way of thinking about pedagogy in some way, but have we ever considered that we succeeded in spite of this way of thinking? Chemists have a duty to explore all facets of the laboratory, and this includes the experiments we perform in the classroom as well as at the lab bench.

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Chapter 12

What You Need To Start an Academic Career as a Chemical Educator

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The nontraditional field of university chemical education offers a wonderful and exciting career, and the purpose of this chapter is to offer helpful information to those who wish to begin as a faculty member in a M.S-. or Ph.D.- degree granting institution. Such faculty may be chemical educators who have formal training in the discipline, while others may belong to a specialty area such as organic chemistry, but who contribute to chemical education research. The chapter begins by discussing the types of chemical educators, and the need for them. Next, advice on job selection, including how to write CVs and teaching philosophy statements is provided. After discussing demographics and diversity, considerations pertaining to research, teaching, and service are discussed in detail, as are tenure and promotion. The chapter ends by describing online scientific networking sites.

I. Introduction

The unique but nontraditional field of university chemical education offers a wonderful and exciting career, but why is chemical education so important, and why is work in this discipline so interesting and satisfying? The purpose of this chapter is to answer these questions by explaining how the discipline of chemical education differs from other educational and chemistry professions. The comments in this chapter are either informational or reflections based on the author's experience.

Another reason for writing this chapter is informative in scope. It's for those who might be interested in a career in university chemical education, or for those who just want to learn about it. Non-chemical educators will pick up some tips as well, for example, on publishing and pedagogy. The writer hopes to cover material that newcomers to the field might not have thought about or expected, allowing them to successfully prepare for a career in academia.

Navigating and experiencing the world of chemical education in graduate school, though daunting enough, is still very different from the world of the academy for the new Assistant Professor. In this chapter, the author will describe what one can expect to encounter when making the quantum leap from graduate school to academia, as a chemical educator. However, the material in this chapter would also be useful to any new Ph.D. candidate starting out in a first job.

The chapter begins by considering what a chemical educator is, and why there is a need. Then it delves into identifying job opportunities and provides important tips that the reader may not have thought about. The demographics of the career are then covered, along with a few informative notes regarding diversity. The section on teaching, research, and service includes pitfalls to be avoided, as well as preparatory advice on tenure and advancement in rank that is not published or provided by any tenure committee. Indispensable considerations pertaining to where and how to publish research, and references to a list of chemical education journals to consider, are given. Last of all, social networking is addressed because it has become essential as a multi-faceted professional development tool. Information in this chapter, much of it derived from experience, is what the writer wished he had known before starting out.

What Is a Chemical Education?

Simply defined, chemical education is a field in which chemists help others learn chemistry content knowledge (*1*). It is an interdisciplinary field at the junction of chemistry and education that targets the research, pedagogy, and instruction of chemistry at all levels, in both the cognitive and laboratory domains. The work of chemical educators (CEs) includes teaching, research, and service. The primary focus of this paper will be to target CEs who work as faculty members in university chemistry departments.

Chemical education research (CER) includes traditional areas derived from science education, and also newer, developing fields. Using the traditional approach, CEs use both qualitative and quantitative methods to establish best practices by developing and testing new approaches to teaching, administering programs offering an endorsement in secondary education, performing theoretical work in cognitive psychology, studying diversity, assessment, or concentrating on a specific discipline such as physical or analytical chemistry. This latter group of chemistry discipline specialists, for example, organic or physical chemists, contribute to the field through improving teaching and learning in their respective disciplines, through, for example, developing new laboratory experiments. In a more recently developed field, chemical educator researchers study the metacognitive aspects of instruction through analysis and reflection on their own teaching in the Scholarship of Teaching and Learning (*2*). The only commonality between chemical educators is that they advance their field through analysis of the art and science of teaching.

Although any chemistry instructor is a chemical educator, the field has evolved to a point at which key specializations (*1*) can be clearly defined. From surveying job functions of chemical educators, it is obvious that chemical educators can be classified as one of two types, those who specialize in either research or practice. Research specialists are of two types: those who have received formal training in the discipline (Type I), and those who haven't (Type II). On the other hand, practitioners, the second main group of chemical educators, generally do not perform research, and most, by far, own the primary duty of classroom instruction. These classifications are delineated in Table 1, in terms of job function, training, and place of employment.

In the narrative that follows, the above-designated types of chemical educators will be referenced using the acronyms defined in Table 1. Hence, when referring to an analytical chemist who publishes a new chemical education experiment in electrochemistry, the term Type II CE will be used. On the other hand, when referring to a researcher belonging to a chemical education research group, the term Type I CE will be used. However, much of this narrative pertains to Type 1 chemical educators who practice their art and science in graduate schools, and are generally regarded as scholars who have received formal training, generally speaking, by a earning a Ph.D. or a D.Ed. through a science education program in a College of Education (COE). Through working in higher education, chemical educators can greatly influence curricula, and have a lasting impact on many generations of students to come. Because of their background in pedagogy, Type I chemical educators are uniquely prepared to be both effective chemistry researchers and teachers.

National Awards in Chemical Education

What better way to study chemical education than to examine some of the most accomplished people in the field, as honored by national awards? The American Chemical Society (ACS) sponsors the George C. Pimentel Award in Chemical Education, given to a nominee who has made outstanding contributions to chemical education, encompassing, for example, research, teaching, administration, or professional training. On the other hand, the Northeastern Section of the American Chemical Society sponsors the James Flack Norris Award, given each year for Outstanding Achievement in the Teaching of Chemistry. A list of recipients (*3*, *4*) of these two top chemical educator national awards since 2000 and an attempted classification according to chemical educator type, are given in Table 2 below. Of the research chemical educators listed, many are Type II CEs. For example, Harry B. Gray and Richard Zare are primarily Type II CEs, researchers in a non-chemical education field. On the other hand, Zafra Lerman was a practitioner, primarily a CEI.

Table 1. Classification of chemical educators

Researchers	
Generally speaking, these are faculty members employed in Chemistry Departments that have graduate degree programs, although a few may work in professional societies, science education, or government. They are generally listed in the ACS Directory of Graduate Research, hold Ph.D., or D.Ed. degrees, and usually have postdoctoral experience.	
Type I	Chemical Education Research Faculty
Individuals in this discipline have formal training or background in chemical education, and are listed in the ACS Directory of Graduate Research as having a chemical education specialization. Type Is investigate methods, curriculum, and assessment using human subjects through the application of quantitative and qualitative methods. Some Type Is may manage the chemistry side of elementary, middle, and secondary teacher preservice teaching programs. The newer area, called The Scholarship of Teaching and Learning or SoTL, is a specialization wherein faculty investigate their own teaching and the teaching of others through research and reflection.	
Type II	Research Faculty in non-Chem. Ed. disciplines who perform chemical education research.
They are listed in the ACS Directory of Graduate Research as having a non-chemical education specialization, but contribute to the chemical education field by publishing research articles. These individuals may have little or no formal training or background in chemical education.	
Practitioners	
CEI	Chemical Education Instructors
These are instructors who specialize in classroom teaching. They are employed at four-year institutions, community colleges, high schools, or middle schools. They generally hold M.S. degrees or have chemistry teaching endorsements. This is the largest group of chemical educators in the country. Research production is not a primary duty.	
CEP	Chemical Education Professionals
These individuals are employed in professional societies, government, private industry such as publishing, online teaching, government, or in science museums. Classroom teaching is not their primary function.	

Table 2. List of CEs receiving national awards since 2000

	George C. Pimental Award	*Type*	*James Flack Norris Award*	*Type*
2013	Conrad L. Stanitski	I	Melanie M. Cooper	I
2012	Diane M. Bunce	I	Vicente Talanquer	I & II
2011	William R. Robinson	I & II	Peter Mahaffy	I
2010	Zafra J. Margolin	CEI	George M. Bodner	I
2009	Henry W. Heikkinen	I	William F. Polik	II
2008	Richard N. Zare	I	David K. Gosser, Jr. Jack A. Kampmeier Pratiba Varma-Nelson	I & II I & II I
2007	A. Truman Schwartz	I & II	Diane Bunce	I
2006	F. Albert Cotton	II	Brian P. Coppola	I
2005	James N. Spencer	II	Morton Z. Hoffman	II
2004	Nicholas J. Turro	II	Richard N. Zare	II
2003	George M. Bodner	I	David N. Harpp	II
2002	Michael P. Doyle	II	Zafra Lerman	CEI
2001	Harry B. Gray	II	Dennis G. Peters	II
2000	Jerry A. Bell	CEI	Billy Joe Evans	II

In addition to the above awards, the ACS Division of Chemical Education (CHED) sponsors three awards (*5*): (a) Outstanding Service to the Division, (b) The Dorothy and Moses Passer Education Fund, and (c) Travel Awards. Last of all, NSTA offers an impressive number of science educator awards (*6*).

The Need for Chemical Educators

According to the U.S. Department of Education Report titled *Education for Global Leadership* (*7*), America's dominance in STEM fields is threatened because, while STEM jobs are projected to increase by 14% from 2010—2020, fewer than 20% percent of American high school seniors are interested in a STEM career. Moreover, this same report indicates that most high school students are not prepared to enter STEM fields because they are not proficient in mathematics. Several organizations (*8*, *9*) have indicated that U.S. students are not prepared, not interested in, and not going into science at the same rate as students in other countries.

All types of chemical educators should keep current with trends in public education, and understand how public policy (*10*) affects their field. By understanding the educational landscape, both Type I and II CES can better help prepare U.S. STEM students and teachers for the 21st century global STEM workforce.

An indicator of America's declining performance in STEM education is its performance in the Program for International Assessment, or PISA (*11*). PISA results provide a measure of how U.S. students compare to students around the globe in STEM knowledge. With regard to PISA testing, in 2009, for example, 17 OECD (Organization for Economic Cooperation and Development) countries had significantly higher scores than the U.S. in mathematical literacy. Fast forwarding to 2012: after seeing the recently released 2012 U.S. PISA scores, U.S Secretary of Education Arne Duncan (*12*) reportedly commented that America's performance in the 2012 PISA results are "…straightforward and stark: It is a picture of educational stagnation …" that "must serve as a wake-up call against educational complacency and low expectations." Such concerns echo the findings of a National Science Board Report (*13*) which recommends ensuring that students are taught by well-prepared and highly effective CEIs.

To address K-12 STEM education, many states are raising the bar for public CEIs, by implementing both tougher entrance standards and teacher competency testing. Moreover, new accountability mechanisms are in place, especially, for example, in Michigan, with the establishment of the Educational Achievement Authority (EAA) that oversees the lowest performing school districts such as Detroit Public Schools, which Dan Rather (*14*) studied in his documentary titled "A National Disgrace."

Not only is the quality of STEM preparation of secondary students criticized, but more specifically, the chemical industry would like to see better-trained chemistry graduates who are prepared to enter industry, especially in polymer science, where the ranks of qualified scientists are being depleted through retirement. The chemical industry wants its new employees to be better able to step in to industry and immediately produce, rather than spend a year in training. Perhaps industrialists and academicians alike share common ground — that the U.S. STEM educational system is providing neither enough practical experience, nor enough highly trained professionals. The above factors have created a wonderful opportunity for all chemical educators to improve the quality and effectiveness of STEM educational programs.

II. Preparing for Employment

Career Hunting

This section pertains to Type I and II CEs, although the information may be somewhat helpful to anyone. First and foremost, job searching should be more about finding a full and satisfying career than about just finding employment. Two primary sources for job listings in chemical education are: (a) Chemical and Engineering News and (b) The Chronicle of Higher Education. Other sources include The ACS Division of Chemical Education, other professional societies, social networking sites, and university websites. Since an abundance of information is available on career search websites such as those of the American Chemical Society, and in books, such as two well-known texts, (*15*, *16*), this section's narrative will be kept to a minimum, addressing helpful job hunting preparedness hints that one may not have thought about.

The career progression of a Type I chemical educator can be divided into three phases. Phase 1 is the uncertain time before tenure, marked by intense activity as indicated by the establishment of a research program, and solidification of teaching, and course and curricular design. Phase 2 is the tenured time, which encompasses the next 30 years or so. The security of phase 2 allows the CE to develop professionally and become better known in the field but, most of all, it should be a time of fulfillment. Phase 3 is the period close to retirement, during which one might focus more on administration and service, perhaps by helping along the next generation of CEs new to the department. After retirement, a Type I CE may continue to work in a Chemistry Department, perform service activity, or even start a new career as a high school teacher.

One approach to job hunting is the just-in-time job application, where the job seeker targets teaching jobs that become available at certain times of the year; if one surveys the field and wisely chooses good matches, then one has a better chance of being hired. A hard-pressed candidate might consider job hunting between Fall and Winter terms because when such vacancies arise, there is an urgent need to have them filled. This approach also requires less work, and better control over where one's curriculum vitae (CV) is disseminated.

Applicants should keep in mind that each job opportunity is unique, and that they must tailor their application, and preparation for each position in different ways. When one applies for that unique position, although these may vary across institutions, the standard items that search committees want are: a cover letter, CV, teaching philosophy statement, research proposal, and good references.

The CV

A CV differs greatly from a resume. A resume is a brief summary (one-two pages) listing career goals, education, skills, experience, and references, while a CV is much more detailed, and may be many pages longer (from two to four). A CV should include: education, professional employment, membership in professional organizations, awards, presentations, publications, grants, and service. Help in writing a CV is available (*17*). Moreover, one can often find CVs online, as, for example, can be obtained for Professor Thomas Greenbowe, a distinguished Type I chemical educator at Iowa State University (*18*). CVs have also been published in the *Journal of Physical Chemistry* (*19*). However, for a newcomer to the profession, it may be disadvantageous to post one's CV across the internet, because one's personal information may find its way into a public database.

The Teaching Philosophy Statement

The teaching philosophy statement, or TPS (*20–23*) elaborates on one's unique teaching beliefs, and explains how they are translated into classroom practice. It demonstrate one's personal commitment to students, the department, and the profession. The TPS solely reflects the beliefs of the applicant, and in order to impress the search committee with the applicant's sincerity, and the authenticity of his/her beliefs, it is therefore written in the first-person using the present tense. Teaching philosophy statements should be tailored to meet the specific missions of the chemistry department and university applied to. Therefore, different statements would be written for Research-1 versus small college departments. The TPS fits in very nicely with the Scholarship of Teaching and Learning, for it is an act of metacognition about one's beliefs, and self-reflection on classroom practice.

The TPS submitted by a Type I CE would be different from that of a Type II CE who will be doing content teaching in a discipline like analytical chemistry. Three major differences are that a Type I CE would submit a much lengthier statement, provide more detailed information, and offer evidence-based statements with citations to the chemical education peer-reviewed literature. Moreover, the Type I CE would be expected to demonstrate detailed pedagogical content knowledge. Sometimes the search committee specifies a certain number of pages for the TPS, and if that is the case, then writers should keep within that limit.

Once candidates complete the belief section of the TPS, they must explain how their specific beliefs translate into classroom practice, remembering to adapt their statements to the unique position for which they are applying. In this regard, applicants explain how they plan, organize, and run their classrooms on a day-to-day basis. In doing so, they might address their use of mathematics, technology, online course shells, and even demonstrations. They should address specific pedagogies like active and group learning, collaboration, discussions, and the flipped classroom. They should explain how they promote problem solving, critical-thinking skills, how they correct student misconceptions, and how they make their lectures relevant to the lives of their students. If applicants want to show that they have managed inclusive and student-centered classrooms, then they explain how they have done so, for example, by addressing diversity, learning styles, ability, background, the nontraditional student, rank (freshman versus senior), and major. Applicants cite specific examples of how they mentored and helped students succeed. The TPS should also take into account whether applicants will be teaching large or small classes, and explain how they will accomplish this, especially if they haven't. One key idea is that, since experience is lacking for the new Type I and II CEs, it is more important to clearly articulate a vision of beliefs and practice than to just reiterate courses taught.

Last of all, the field of chemistry has achieved a reputation for excellence, and so the applicant should address how to promote and maintain standards of excellence while meeting student needs. Hence, modes of student assessment, namely quizzes and examinations, are also included in the teaching philosophy statement. In addition, an author might, for example, explain the advantages of using problem-solving examinations rather than multiple choice questions.

The Interview

Sometimes search committees request a phone interview before inviting candidates to campus, and so it is important to project oneself well through speaking. After being invited to campus, one should be prepared for up to two long days of interviewing. When answering questions posed by interviewers, one could impress the interviewer by giving answers that, when appropriate, are literature-based. When invited to campus, it is important that interviewees project a positive image, be dressed appropriately, and be knowledgeable about the institution where they are interviewing. One should communicate clearly, and answer tough questions with composure, avoiding small talk. Behavior is important, so interviewees should be friendly and personable, and painstakingly avoid being condescending, arrogant, or impatient. During the interview, it is important to discuss the nature and amount of start-up support, and gauge whether what is offered fits in with one's needs.

Naturally, a well-prepared lecture with slides is mandatory. Sometimes audio-projection systems or computers malfunction, so one should avoid videos and the web, and come prepared with the talk in multiple formats. Candidates must remember to remain calm if these problems arise, handle such problems gracefully, and proactively request adequate set-up time. Students will be invited to attend and rate one's talk, so candidates should make their presentation relevant to student lives, refer to research students they have mentored, and consider what attributes the student audience likes or dislikes. A candidate's talk may even be videotaped. If the search committee asks for a teaching talk, then a talk that mainly emphasizes research is unacceptable. Running over the allotted time won't be well received by some faculty, so the talk should undergo a test-run beforehand. Last of all, one must be sure to incorporate a research plan during the seminar.

The ACS Employment Dashboard

The ACS Employment Dashboard (*24*) and Salary Comparator (*25*) provide a way for academic and non-academic ACS members alike to evaluate a job offer by viewing the results of ACS employment surveys that provide demographic and regional information on base salaries as a function of many factors including job experience, degree, professional specialty, job duties, types of employers, and geographic region. For example, Figure 1 below shows Salary Comparator input and output boxes for a Type I CE seeking a university position involving more teaching than research at a large university in the northeast central region of the U.S.

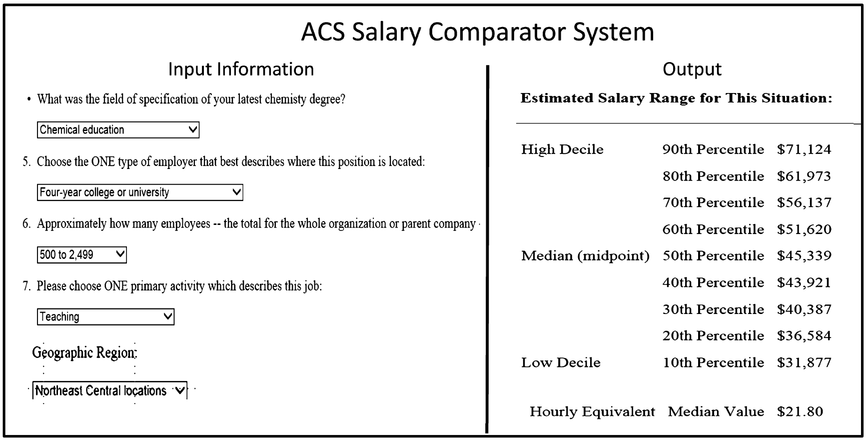

Figure 1. Projecting salary in chemical education.

III. Demographics

The field of chemical education is broad, and includes those who teach in the K-12 system, in community colleges, universities, and also those who work in professional societies, profit or nonprofit companies, foundations, museums, and government. CEIs, mainly K-12 teachers, make up the largest segment of chemical educators. According to a 2013 NSTA membership demographics report (*26*), there are 15,240 CEIs out of 160,663 members, or about 9.5%. However, there isn't a way of knowing how many CEIs are employed by private industry, or by private or public museums, science organizations, public policy, or those who work out of the field, for example in Science Education Departments or administration. Since this chapter mainly pertains to what Type I and II CEs need to know for their first job, this narrative cannot do justice to the many other chemical educators who do such fine work in our K-12 system; they will be respectfully acknowledged but not delineated.

The American Chemical Society provides DGRweb (*27*), a searchable online version of the ACS Directory of Graduate Research, which it claims is the most comprehensive source of information on chemical research and researchers at universities in North America. DGRweb allows users to search for: institutions, faculty by rank and gender, and research specialties. According to the 2013 ACS-DGR, compared to other areas of specialization, there are very few Type I CEs. This conclusion is based on the data shown in Figure 2 below, where the number of Type I CEs, compared to those in other chemistry disciplines, is three to five times lower. Figure 3 shows that few Chemistry Departments have more than two Type I CEs.

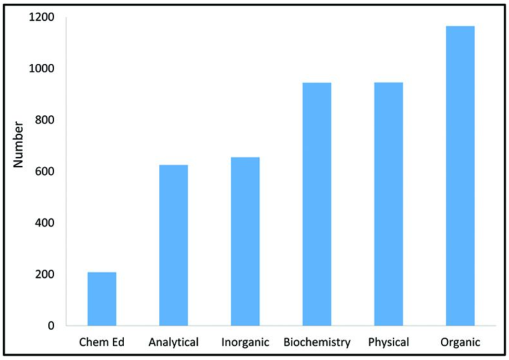

Figure 2. Comparison of Type I CEs to other disciplines.

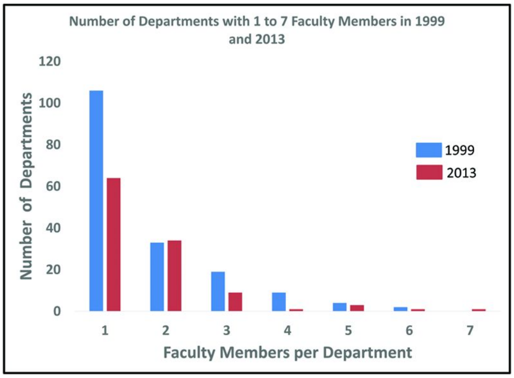

Figure 3. Number of Departments with 1 to 7 Type I CEs.

Isolation within the Discipline

Although there are many chemical educators whose work spans the K-12 system, higher education, and government, from the above discussion, it is painfully obvious there are very few Type I CEs working in university chemistry education. Out of an estimated 6000 graduate school faculty listed in the 2013 ACS-DGR, there are only about 200 chemical educators, or less than 3% of the total! Part of the reason for this is that many CEs are of the Type II variety, and specialize in one of the traditional research fields, for example, organic chemistry, and so do not appear in the grand total count of Type I CEs. It may not be that Type 1 chemical educators are declining in numbers, but instead list themselves in another specialty area. However, the small numbers of Type I CEs may lead them to feel isolated within their departments, where, for example, an organic chemistry group may have 10 or more members. This isolation may even extend across the broader field of academia. Since most chemistry professors perform laboratory work, one's colleagues may under-value and under-appreciate the chemical education discipline. One way to overcome isolation is to join Faculty Development Groups, or chemical education groups, such as the Division of Chemical Education, or even local groups such as the Michigan College Chemistry Teachers Association (MCCTA). This situation presents a challenge that may well become an opportunity when a Type I CE crosses discipline boundaries, to collaborate with others, who may request guidance when they see the value of chemical education as a discipline. One positive side of this is that when working alone, one has more control over course design.

Employment of Type I CEs by Gender and Age

This section pertains to chemical educators of the first type, namely Type Is who are listed in the ACS Directory of Graduate Research as chemical educators. An individual entering this field may be interested in demographic information regarding age and sex, and this information is provided in Table 3 over the period 1999—2013, the data being obtained from the ACS Directory of Graduate Research (ACS-webDGR). Using the ACS web tool, one can select a year, and extract a set of faculty who list chemical education as their specialty. The data from the year 2005 appears to be an anomaly, being inconsistent compared to other years, so it wasn't included in further data analysis. The data shows two trends since 1999: (a) the number of Type I CEs has decreased by 40%, and (b) average age has increased.

Table 3. Type I CE Demographics; N = number, F = female, and M = male

Year	*N*	*N (F)*	*N (M)*	*Mean Age All*	*Mean Age (F)*	*Mean Age (M)*
2013	181	59	122	55.4 ± 12	50.5± 10	57.8± 12
2011	212	68	143	58.0 ± 12	53.0± 11	60.3± 11
2009	221	67	154	60.2 ± 12	55.0± 11	62.5± 11
2007	217	65	150	61.1 ± 11	55.9± 11	63.6± 11
2005	167	46	121	62.7 ± 11	58.1± 10	64.5± 10
2003	242	53	189	66.5 ± 10	62.6 ± 9	67.6 ± 9
2001	297	65	231	66.5 ± 10	61.9± 10	67.8± 10
1999	301	53	239	68.1 ± 10	63.8± 10	69.1± 10

Consider a data analysis of employment by sex. From 1999 to 2013, the ratio of males to females dropped from 4.5 to 2.1, but the 2013 data shows that still only 37% of faculty are female. Figure 4 shows the employment distribution with regard to gender as a function of year.

The data was modeled by linear least squares, the statistical parameters of which are summarized in Table 4.

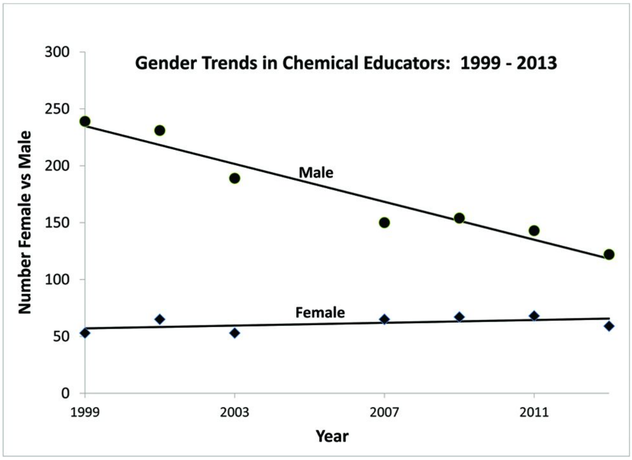

Figure 4. Female/Male Type I CEs from 1999 – 2013.

Table 4. Linear regression parameters

	Females		*Males*	
Variance	0.254		0.939	
Slope and Standard Error	0.615	0.47	-8.33	0.95
Y intercept and Standard Error	57.0	4.1	235	8.2

The linearity of the plot showing number of males versus time is strong, approaching that of physical science data, since its Pearson Correlation Coefficient is -0.967. On the other hand, for women, the slope has a high uncertainty, such that the relationship is interpreted as flat with noise. Using these models, the numbers of men and women are predicted to be the same in 2019, when 68 of each are employed. These trends have no discernable rationale. Perhaps males are retiring at a faster rate than they are being replaced. Perhaps Type I CEs simply choose to list themselves under another chemical specialization, or are instead working in Colleges of Education.

IV. Diversity

This section on diversity applies to both Type I and II CEs, but it would also be useful to anyone considering a professional career in the chemical sciences. Professionals should be both happy to, and willing to look upon interacting with diverse groups as both an opportunity and an obligation.

Under-Represented Minorities

With regard to under-represented minority groups, the ACS Committee on Minority Affairs, or CMA (*28*), focuses on increasing participation within ACS and the chemical industry. Some organizations advocating on their behalf appear are shown in Table 5 below.

Table 5. Advocacy groups for under-represented minorities

NOBCChE	The National Organization for the Professional Advancement of Black Chemists and Chemical Engineers
SACNAS	Society for Advancement of Chicanos and Native Americans in Science

The National Organization for the Professional Advancement of Black Chemists and Chemical Engineers (*29*) advocates for scientific careers across the K-12, college, and post-graduate educational spectrum. On the other hand, SACNAS (*30*) is a society of scientists focusing on the professional and educational success of Hispanic, Chicano, and Native American scientists.

Women

Although women do not have the same representation as men on Type I CE faculty, several advocacy organizations exist, some of which are listed in Table 5 below. Some of these organizations, such as AAUW (*31*) and AWIS (*32*), go beyond providing professional services, and instead are social and/or political in nature. Each group listed in Table 6 will be described below.

Table 6. Some advocacy groups for women in STEM

ACS WCC	American Chemical Society Women Chemists Committee
	ACS Women of Color
AAUW	American Association of University Women
AWIS	Association for Women in Science
Scientista	The Network of Women in Science and Engineering)
SWE	Society of Women Engineers
NSTA	National Science Teachers Association

The American Association of University Women, or AAUW, makes recommendations to universities on tenure decisions, and maintains a Legal Advocacy Fund in order to supplement the many laws and programs already in place. It has sub-chapters on most university campuses. Although AAUW recognizes that women have made significant gains, it feels that women remain under-represented at the rank of tenured professor.

The Association for Women in Science, or AWIS, promotes a feminist social and political action agenda in Congress on behalf of its seven million members. It seeks to advance women in all STEM areas.

Within the American Chemical Society, the Women Chemists Committee, or WCC (*33*), attracts, develops, promotes, and advocates for the participation and retention of women in the chemical sciences. It also sponsors Rising Star Awards, which recognize exceptional early- to midcareer women chemists across all areas of chemistry on a national level. The American Chemical Society also sponsors an award for Encouraging Women into Careers in the Chemical Sciences (*34*).

The ACS Women Chemists of Color Program (*35*) desires to empower women chemists of color to maximize their opportunities in the chemical profession while cultivating an environment that fully engages its members.

Although limited to a small number of campuses, *Scientista* (*36*) provides helpful networking and assistance to female undergraduates applying for graduate school, and for those who just want to plan and advance in their careers.

Although the NSTA (*37*) is not a gender-oriented organization, it sponsors and provides many programs specifically oriented toward women, and hence should not be overlooked, especially by Type I and II CEs.

The Society of Women Engineers, or SWE (*38*), has about 20,000 members in over 400 sections. It is both an educational and service organization that promotes engineering as a career aspiration for women.

V. Rank and Tenure

Once an applicant acquires a job as a Type I or II CE, a plan must be prepared for the triad of teaching, research, and service, and beyond that, for advancement in rank and tenure. This section addresses such academic requirements for Type I and II CEs. *One key point of this section is that the new Assistant Professor must plan to meet the evaluation criteria at her specific institution from the very first day*, since no universal template exists. A visual representation of the three major job functions of Type 1 and II CEs, namely research, teaching, and service are shown in Figure 5 below. When one considers how to distribute time between these primary contractual obligations, a rule of thumb is: Research > Teaching >> Service. This rule reflects the fact that the most important criterion for promotion is research, and it is also the most time-consuming task of the three. In Figure 5 below, the dot marks the spot indicating a heavy teaching component for a Type I CE at a non-research-1 university (70% teaching, 20% research, 10% service). For this situation, even though the teaching component is much larger than at a Research-1 university, research, because of its time-consuming nature, it should still be the first priority. However, for a Type I CE at a Research-1 university, the research load would be typically heavier, and the dot in Figure 5 would translate to the right by about 60 percentage points. Schwartz (*39*) calls Figure 5 the "Academic Phase Diagram."

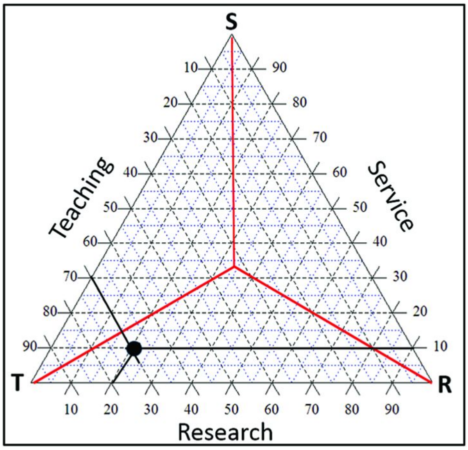

Figure 5. Primary duties of Type I and II CEs.

The Path to Tenure

In 2008 (*40*) a chemical education task force published a report on hiring and promotion in chemical education. The report provides both candidate and department guidelines related to professor candidates, their hiring, and promotion. It also offers departments a list of procedures to use when hiring. Among the topics addressed were: a definition of chemical education research, a definition of scholarship, and the evaluation of candidates for promotion and tenure.

When it comes to tenure, the most important rule is that Type I/II CEs must understand the very specific requirements of rank and tenure advancement at *their* institution of employment, because no general professional review document exists. Therefore, new Type I/II CEs must have a reference copy of their employment contract at hand. Their preparation and action plan should document in real time how they are meeting specific criteria, and allow for self-reflection and corrective action if they are not. Van Note Chism (*41*) delineates the essential facts about peer reviewed teaching.

The first year is also a good time for Type I/II CEs to develop a good reputation among students and faculty by displaying sensitivity and collegiality with their peers. Generally speaking, in year one, Type I/II CEs should concentrate on setting up research and classroom teaching. Generally speaking, anything that distracts from these goals should be avoided. *Hence intensive committee and service activities, and new course designs, should be avoided in year one*

One's specific tenure action plan prepares the candidate for a summative evaluation, perhaps five years away, that will decide whether tenure and advancement in rank are granted. New faculty should immediately begin collecting relevant documents pertaining to their institution along the way, both electronically and as hard copies, assembling an impressive portfolio covering the areas of teaching, research, and service. Based on the portfolio, the author writes a narrative of self-evaluation, showing one's progress, and summarizing activities and accomplishments. The Department, the Chair, and a Personnel

Committee first evaluate the document, and then the Dean. Assistance with writing the narrative may be provided by the Faculty Development Center, union representative, and colleagues who may be willing to mentor or help by sharing their advice, and even their tenure reports. New faculty should meet with the personnel committee early on, read the contract, and take notes as to what is required of them. Last of all, one should develop collegial relationships with a number of individuals across disciplines (see "Networking" below).

Not all faculty receive tenure, and in some cases, while departments advise tenure, the administration does not agree. Sometimes these cases become grievances and are taken up by the AAUP, which publishes them on its website, as, for example, happened in a case at New Mexico Highlands University in 2006 (*42*). Again, in summary, any tenure promotion plan must meet the specific criteria published at the specific institution where employment occurs. One superlative book written as a resource book for aspiring chemistry professors is Schwartz's "And Gladly Teach" (*38*). There are many other excellent books that provide in depth information on the rigors and demands of academic life (*43–48*).

VI. Research

Even at non-Research-1 universities, where teaching is the central role, some research is required, and early on, when it comes to teaching versus research, it is wiser to spend more time on the latter. It is never a good idea to try and fit research into a teaching schedule; instead, a research agenda should be the priority. General information and advice is available in "Nuts and Bolts of Chemical Education Research," edited by Bunce and Cole (*49*).

The research agenda during the first year should include attending grant-writing workshops, usually available for free or at low-cost through universities, the NSF, or ACS. Institutions generally provide start-up grants, and ACS PRF Grants (*50*) provide seed money to fund investigations in new directions, by new investigators, while ACS Doctoral New Investigator Grants or DNI (*51*) pertain to new Assistant Professors in their first three years of academic appointment.

Another first year priority is to recruit and supervise research students who should, in the future, present at conferences. During the second year, one commences research and begins writing research papers. The candidate should always be on the lookout to engage in collaborations with other scientists.

Having the proper infrastructure, meaning physical facilities, funds, and support personnel, will stimulate research productivity. Therefore Type I and II CEs must be concerned with infrastructure before they are hired. The basic physical facilities are generally already in place, and therefore, candidates will need to adapt their needs to whatever spaces exist. If the right amount of physical space isn't present, or if the facilities are dilapidated, then one should ask if plans are being made to update them. Toward that end, job candidates should enter into discussion with their department. One should keep in mind that new space is generally difficult to acquire and if the minimum infrastructure is not available, then candidates should consider not accepting the position. Type II CEs, who specialize in a traditional area of laboratory work like physical chemistry, will probably be able to use their research lab for CER projects. With regard to Type I CEs, space to work with human subjects is also required. For example, there may be a need for rooms where audio and video recordings of human subjects performing think-alouds can take place. An important consideration is to have a secure room where human subjects-data can be stored and readily accessed. For Type I CEs who teach methods classes, having a specially designed laboratory and classroom that mimics a real K-12 setting will promote the teaching and training of preservice teachers. A seminar room where students can practice oral presentations is also helpful. Research students also need to collaborate, and a tiny work cubicle won't do. Other requirements pertain to revenue for technology used in teaching and research. Perhaps a College of Education would consent to providing space. Last of all, having support personnel like statisticians and grant experts available for consultation are crucial for success. All of the above infrastructure requirements are expensive, often difficult to come by, and so must be dealt with immediately.

Where To Publish in Chemical Education

Generally speaking, to be counted for tenure, research must be published in peer-reviewed journals, and, so the sooner one gets started, the better. Although writing can be a challenge, it can also be fun and satisfying. There are many factors to consider when publishing, including the journal's reputation, acceptance rate, and the length of time it takes to review a paper. Some journals decline to accept good papers, and some refereeing is erratic at best. Submitted papers always require a cover letter. Most journals require that papers not be submitted to other journals while under review. In chemistry, textbooks do not count the same as journal publications. Towns (*52*) has discussed guidelines for chemical education research.

Towns and Kraft (*53*) published a ranking of the top chemical education journals in the world. Important and respected peer-reviewed chemical education journals (for an English-speaking readership) are listed in the references section of this chapter for the areas of: primary research (*54–62*), K-12 teaching (*63–67*), history and philosophy (*68–72*), physics (*73*, *74*), and several other miscellaneous categories (*75*, *76*). Naturally, one can publish in a wide array of education and technology journals, not listed below, as well. For example, one might publish in the *Journal of Rehabilitation* when researching how to promote disabled chemists in the classroom and workplace (*77*).

An author has the choice to submit and publish manuscripts in open-access or non-open-access (traditional) journals. The best journals in the field of chemical education are currently of the traditional, non-open-access variety, meaning that they can be generally accessed only through university websites, by membership in professional societies, or by paying a subscription fee. One major advantage is that non-open access journals do not require authors who submit papers to pay a fee, and submission is open to anyone, regardless of whether they own membership in any organization. Another advantage of traditional journals is their reputation for excellence. For example, membership in the American Chemical Society allows its users access to some of the best journals in the world. Obviously, Type I and II CEs in academia would generally have access to scholarly works through university libraries, and therefore access would generally not be a problem, except when library budgets are a concern. In such cases, one should check whether one's library partners with that of another institution.

In the last 10 years, more and more open-access journals, where scholarly articles can be viewed for free on the internet, have proliferated. Arguments, both pro and con, have been presented by Moore (*78*) and Erickson (*79*). Advantages of open-access publishing are that they don't require membership in any organization, and published research can be freely viewed. However, open-access journals, sometimes require authors to pay article-processing fees. While the open-access publishing model does have several advantages over the traditional route, especially for authors in developing countries, since most Chemistry Departments stipulate in contracts that only publications in peer-reviewed or referred journals of high reputation will count toward tenure and advancement in rank, then it is wise for new authors, for the time being, to take the safe route, and consider only the traditional route of publication on the way to tenure. The field of open-access publishing is evolving, and perhaps a journal devoted to chemical education is on the horizon. Furthermore, another important point is that some tenure committees won't divulge whether they will count publication in open-access journals—in essence tabling the issue until the summative review is initiated. Until open-access publishing becomes mainstream, publishing in internationally respected peer-reviewed journals is the realistic choice for prospective authors.

Another item to consider is that some departments may require, but not count, conference presentations, and so one might consider limiting one's number of conference presentations each year. On the other hand, since the training of new chemists is an important mission of any chemistry department, tenure review committees may grant credit for student advisees presenting conference papers. Again, it must be emphasized that each appointment has different requirements, and the new hire must understand her unique institutional requirements from day one.

VII. Teaching

This section addresses many considerations relevant to teaching for both Type I and II CEs, including a comparison of their preparedness to teach in the first year of their contracts. Published articles on creative teaching in the curriculum are also provided. For the classroom, creative teaching strategies discussed include: lecturing, constructivism, learning cycles, Johnstone's MPS model, the Scholarship of Teaching and Learning, and student ratings.

Dedication to the art of student-centered teaching, the advancement of chemistry as the central science, and commitment to the profession are important reasons for becoming a Type I/II chemistry educator. But entering the academic arena for the first time puts serious demands on instructors, who in many instances, are told by their personnel committees that they must maintain course rigor, proven by a wide grade distribution, while attaining standards of excellence in teaching shown by dynamic delivery of well-planned lectures, and good student evaluations. Personnel Committees generally provide little guidance or encouragement in these matters, and leave it up to the individual to work through whatever situations arise.

The sordid history of student performance in general, and organic chemistry at the university level, not only demonstrates the need for more effective collegiate instruction, through both curricular and pedagogical reform, but also the need for better mathematical and science preparation at the secondary level. Although student success has often been linked to ACT scores, the major reason for student problems is that the academic chemists adhere to high standards. Indeed, the manual *ACS Undergraduate Professional Education in Chemistry* (*80*) establishes standards for undergraduate programs.

Type I versus Type II CEs

The first year of teaching is very different for a Type II CE than for a Type I CE, because a Type II CE will have had few if any courses related to pedagogy and curriculum, and, moreover, comparatively little teaching experience, except, for example, in graduate school laboratories and recitation sections. Whereas Type II CE instructors strive to promote the best-trained professionals by emphasizing content knowledge, Type I CEs are more likely to understand, value, and implement teaching strategies emphasizing both pedagogical and metacognitive content knowledge.

In STEM, the primary goal is to prepare better-trained, and more knowledgeable students who can assume productive careers, and this fact of life begs the question: “Is it wise for Type I/II CEs to invest their initial time in course development?” Although the rule of thumb is to avoid anything that detracts from research productivity, the CE must take into account whether his/her specific contract rewards such efforts, and whether the personnel committee shows enthusiasm. For a Type II CE, it may be wise to discourage course design efforts, but for a Type I CE, where pedagogical content knowledge is a driving force in the initial hire, it may actually be advantageous for a creative and energetic worker to perform class improvement and curricular work. Type I CEs may be able to help new non-CE chemistry instructors and teaching assistants who have never been exposed to pedagogy, and thereby strengthen department instruction, perhaps through team teaching. Type I CEs can also direct novice non-chemical education professors to the literature where they can find helpful strategies that will promote deep student learning.

Attempts to impart improved teaching skills to Type II CEs have been reported. Pierce (*81*) provided advice to entry level graduate assistants, because, in general, graduate assistant programs provide scant training in pedagogy, and as a result, teaching assistants are not only unprepared to instruct but, moreover, Pierce found that they feel unprepared as well. Not having learned to teach in graduate school, new Type II CEs then enter the academic profession not fully trained to teach. In order to correct this situation, the Pew Charitable Foundation, the Council of Graduate Schools, and Association of American Colleges and

Universities funded a *Preparing Future Faculty Program,* or PFF. Using the PFF model, seminar courses and colloquia were successfully integrated into the graduate curriculum over several semesters (*82*, *83*). In addition, a three-credit course devoted to successful class strategies in teaching was implemented at the University of Nebraska (*84*).

One purpose of this section on teaching is to provide information on what new Type I and II CEs need to know in order to survive teaching. Several excellent books provide the new instructor with a wealth of indispensable information. *The Survival Handbook for the New Chemistry Instructor* (*85*) contains valuable information on syllabi, classroom instruction, assessment, and careers. Volumes I and II of *The Chemist's Guide to Effective Teaching* (*86*, *87*) cover cognition, pedagogy, group learning, technology, and visualization. *Theoretical Frameworks for Research in Chemistry/Science Education* (*88*) deal with educational frameworks in constructivism, hermeneutics, and critical theory.

Bunce and Muzzi's *Survival Handbook for the New Chemistry Instructor* (ibid, (*85*)) is an invaluable and carefully written resource that addresses many of the teaching concerns that a new Type I/II chemistry instructor might have. It has one chapter devoted to finding an academic job, but it also addresses professional development and expectations. The handbook is mainly devoted to teaching general chemistry, and offers a chapter suggesting how to go about teaching such a course, including good advice on using group learning. It also contains reflective writings from several faculty members. Syllabi and use of textbooks, and detailed information on assessment are also provided.

Considering more specific studies that may be helpful to Type I and II CEs, Arnaud (*89*) has described a "boot camp" for new professors that was designed to impart classroom skills that will help them become successful instructors. On the other hand, Zielinski (*90*) discussed the issue of time management from both teacher and student perspectives. How to survive the beginning professorship is also discussed through their shared experiences in articles written by Wilkinson (*91*) and Zurer (*92*). Another published report describes a well-received seminar-style class (*93*) with invited speakers who discuss, among other topics, becoming a professor; the class having been implemented for both undergraduates and graduate students. Ladage and Samant devoted a book to pedagogy, perspective, and curriculum (*94*).

Creativity in the Curriculum

The purpose of this section is to describe examples of creative teaching. With regard to curriculum reform, several published articles have addressed creative ideas. For example, a general study of chemical education reform was published in 2013 (*95*). Another investigation (*96*) proposed a model of data-driven general chemistry curriculum reform that takes into account prior knowledge and assessment of students, the selection and sequence of specific content knowledge topics, and materials required. Reforming the general chemistry curriculum through an Atoms-First approach (*97*) designed to emphasize chemistry from the microscopic rather than macroscopic perspective showed that instructor training is important in promoting student success, which was not observed until the second year. Revising the chemistry curriculum using the theme of structure, reactivity, and quantitation has also been proposed (*98*). Changing the graduate organic chemistry curriculum (*99*) has also been reported. Cummings (*100*) and Fisher (*101*) have addressed a green curriculum while others (*102*, *103*) have investigated a sustainable curriculum. Moreover, three ACS Symposium books addressed creative teaching in physical chemistry (*104*), nanotechnology (*105*), and green chemistry (*106*).

Another class of creative teaching ideas modify the chemistry curriculum, by involving collaboration. Service Learning (*107*), Peer-Led Team Learning (*108*), Cooperative Learning (*109*), and Collaborative Learning (*110*, *111*), are newer group methods that have been employed successfully. Moreover, Process Oriented Guided inquiry Learning, or POGIL, has been in use across many disciplines of chemistry (*112–115*).

Creativity in the Classroom

Within the classroom, many innovative teaching strategies have been advanced (*116*). This section will cover some useful teaching methodology. Table 7 summarizes some pedagogy pertaining to the classroom. Traditional lecturing uses an expository approach (*117*) in which the student audience is passed information; instructors then generally help students apply their knowledge by working example problems with them, while recitations are devoted to answering student questions (*118*). The flipped classroom is a newer approach (*119*) that substitutes videos viewed outside of class for lectures, and instead uses class time for homework. The Just-In-Time teaching strategy was introduced in 1999 (*120*, *121*). A student-centered technique, it engages students in completing specific content-oriented activities on the internet before a lecture. Results showed that just-in-time teaching promoted student learning. The constructivist model will be discussed below. Naturally, a Type I CE would be expected to utilize such strategies in the first year.

Other teaching methods not described in the above table are now discussed. In active learning classroom environments, students engage content matter through numerous modes such as open discussion, white boards, case studies and class discussions (*122*, *123*). Hinde and Kovac (*124*) found that students responded positively to active learning using guided inquiry with computer-based cooperative exercises in a physical chemistry course.

Since each individual in the student audience engages and processes delivered content using their very own learning style. Felder and Solomon (*125*, *126*) published a learning style model that can be implemented using an online inventory (*127*). In the Fielder-Solomon model, there are four basic learning styles, each of which has a dichotomy: (a) active versus reflective, (b) sensing versus intuitive, (c) visual versus verbal, and (d) sequential versus global. Instructors should use a variety of instructional delivery strategies to match student learning styles.

Table 7. Lecture styles

Type	*Description*
Expository	A teacher-centered, direct method of instruction in which the student has the passive role of receiving information, through, for example, note-taking.
Recitation	A student-centered session that supplements a scheduled lecture. It is designed to answer student questions, provide problem-solving help, and generally promote student understanding of lecture material.
Flipped classroom	A student-centered teaching method in which students view online lecture videos outside of class, and then use lecture time like a recitation section.
Just-In-Time Teaching	Student-centered. Prelecture activities required.
Constructivist	A student-centered method in which students construct their own knowledge by using their senses to actively interact with the external world. Students then use reasoning skills to generate a cognitive model to explain what they observed.

In the case when a new Type I CE cannot critically examine new pedagogies before implementation in the classroom, they can turn to proven tools such as Khan Academy (*128*), Panopto (*129*), or they can post their own online videos in a course shell.

Constructivism and Learning Cycles

Constructivism is one of the most important learning theories that has positively impacted science teaching. It is the basis of inquiry learning (*130*). One disadvantage of using it is that it requires instructor training and takes time to implement effectively. George Bodner (*131*, *132*) summed up constructivism by writing, "Knowledge is constructed in the mind of the learner." Bretz (*133*) delineated the theory by relating it to Novak's theory of knowledge, while Shiland (*134*) adapted the theory to laboratory teaching. Turro (*135*) applied Constructivism to technology.

Two science learning models that utilize constructivism, namely MPS and the 5E learning cycle, will now be examined. Learning Cycles were introduced by Atkin and Karplus in 1962 (*136*). The Learning Cycle (*137–139*), which is also a student-centered pedagogy, also involves inquiry. The learning cycle represents the fact that learning is not a one-way sequential event with beginning and end, but instead, a continual process that advances through successive iterations.

One well-known Learning Cycle is the 5E (*140*), which is divided into five phases as shown in Table 8 below.

Table 8. The 5E Learning Cycle

Phase		*Instructor and Student Roles*
1	Engage	The instructor selects a topic and presents an instructor-centered activity or demonstration, perhaps involving a discrepant event, to pique the interest and motivation of students. Students mainly observe, but are hopefully engaged.
2	Explore	A student-centered hands-on activity or experiment is performed in which students use science process skills to investigate an assigned problem. Teacher involvement is minimized to Socratic questioning and general guidance.
3	Explain	Using information from the Explore Phase, students construct knowledge to solve their assigned problem by inventing or proposing explanations, through social interaction, which they present in discussion. The instructor intervenes to correct misconceptions and consolidate learning.
4	Elaborate	Students apply or transfer knowledge gained in the Explore/Explain Phases to a new problem. Elaboration revisits the Explore Phase and students construct and reinforce knowledge without instructor intervention. Inductive or deductive thinking are used.
5	Evaluate	Teachers assess both the content and metacognitive knowledge of students related to the assigned topic by, for example, examinations and reflective essays. There is no finality to this process, and the cycle reiterates.

The 5E Learning Cycle begins with an Engage activity where the instructor captures the attention of the audience by performing a demonstration that sets the stage for learning, and focuses student attention. In the next phase, Exploration, students perform an inquiry-oriented activity, and construct knowledge with minimal instructor intervention. Next, in Explain, students formulate explanations, with the teacher stepping in only to resolve misconceptions and summarize the class findings. The Explain step is really an example of Vygotsky's social construction of knowledge (*141*) through which students formulate answers by interacting socially with each other, with students from different backgrounds contributing in different ways. In the fourth step, Elaboration, students apply their knowledge to a new activity, with the hope that they will be able to transfer their knowledge. Finally, in the final phase of Evaluation, students are assessed on their understanding. An idea that goes along with 5E is the discrepant event (*142*, *143*), which can be incorporated in the Engage activity. Discrepant Events produce a result contrary to what learners expect. They are designed to induce an unsettling feeling, forcing students into cognitive dissonance until a satisfactory explanation is constructed.

Johnstone's MPS Model

The 5E learning Cycle is applicable to all science instruction, but one very helpful and all-encompassing chemical pedagogy is the Macroscopic-Particulate-Symbolic or MPS approach developed by Johnstone (*144–146*), who reasoned that students don't understand chemistry because they are unable to integrate all three levels into their conceptual frameworks. New chemistry instructors should consider studying and using Johnstone's MPS approach in the classroom in conjunction with inquiry and constructivist theories. For example, an instructor could start out a discussion on the thermodynamics of solutions by dissolving ammonium nitrate crystals in water while using a temperature probe to show a graph of the negative temperature change. These macroscopic observations allow students to quickly determine that the reaction is spontaneous, and endothermic. Students then deduce the symbolic parameters of the system: deducing that (a) $\Delta G < 0$ and (b) that $\Delta H > 0$, (c) writing a balanced chemical equation. Next students construct before and after particle diagrams illustrating the dissolution process in picture form. Last of all, based on: the macroscopic observation, the symbolic balanced equation, and the particle diagram, students infer that $\Delta S > 0$. Taber (*147*) offers a recent review of how to implement Johnstone's model.

SoTL Educational Strategies

The Scholarship of Teaching and Learning or SoTL, although a non-chemistry specific educational strategy, fits in very nicely with the type of work published in chemical education journals. In SoTL, the function of scholarship is to translate newly discovered information, derived from research, into useful disseminated knowledge (*148*, *149*). SoTL chemical educators use their teaching and student learning together, to synthesize a scholarship that improves both. Toward that goal, self-reflection and metacognitive knowledge play important roles. SoTL was recognized by chemical educators in 1994 (*150*). An example of SoTL work was the volume edited by Bunce (*151*) that describes where instructors use research on teaching to investigate classroom myths, and global myths dealing with course work and longitudinal change.

An important SoTL educational innovator, L. Dee Fink, seeks to improve teaching and learning by creating significant learning experiences in the classroom that would be especially helpful to a Type I/II CEs. In his book, Creating Significant Learning Experiences (*152*), L. Dee Fink introduces a new model for course design that has the potential to transform the college classroom from an expository platform, to one of engagement that creates interactivity, and satisfaction on the part of the student. Fink's Taxonomy of Significant Learning (*153*) may over-emphasize the affective side by stressing "Caring," and the "Human Dimension," but teaching students metacognition helps students reflect on their learning, evaluate their misconceptions, and become independent learners.

In his book, Fink (*154*) provides an example of an Electronics Lab course redesign that increased student satisfaction in each Significant Learning Domain. However, the class size was small, and it appears that the study was not peer-reviewed. Moreover, it is not clear what effect student grades may have had on the ratings, since that information was absent. For example, if student grades increased in the redesigned course, then it would not be clear whether higher ratings were due to grades or the significant learning experience. However, the affective side of learning is a much overlooked and undervalued, and more attention to it can increase student satisfaction and lead to a more fulfilling career.

Another innovation discussed by Fink, L. Dee, is Backwards Course Design (*155*), where an instructor begins with the summative course assessment and student evaluations, and then works in reverse to design: (a) learning goals and (b) specific instructional and learning activities. This method has several advantages over the forward course design approach, namely being intuitive, convenient to implement, and helping the instructor to focus course design on the big course ideas. However, this method breaks down when the summative evaluation is initially poorly done. Another criticism of it is that it could be mistaken as a teaching to the test approach.

An example of a very creative Type I CE who is well known for his work in SoTL, is Brian Coppola who has won numerous awards. Coppola has engaged students in online discussion boards (*156*), improving Wikipedia (*157*), case studies (*158*), establishing teaching groups (*159*), and integrating lecture/lab in general chemistry (*160*).

Student Ratings

Instructors should read and analyze student evaluation forms, discuss results with other professionals, and take corrective action when needed. Instructors should also understand how much weight the university places on student evaluations. From day one, it is essential that Type I/II CEs understand how teaching will be evaluated in their contracts at their specific institution. Therefore they will need to understand the importance of student ratings. Evaluations that are too high may indicate a lax instructor, while those that are too low may indicate conflicts with students. One study suggested that student ratings most closely correlate with classroom grades (*161*). Another study showed that better looking instructors received higher evaluations (*162*). The author believes that students appreciate the opportunity to provide feedback on the course, and especially exams through evaluation sheets. What's more, personal attention and sensitivity is always appreciated by students. The author's experience has been that very few students cause significant problems, and even in difficult cases, the problem involves only a specific issue. If a problem becomes persistent, then one should seek advice from a colleague. It's not a bad idea to error on the side of leniency, and to always admit and correct one's mistakes. L. Dee Fink's work, referenced earlier, on creating significant learning experiences should be consulted for numerous ideas.

VIII. Service

Service is any type of activity that supports the department, university, or community, but not through teaching or research. To be recognized, it must be performed within the context of the employment contract, and evidence of it must be obtained through careful documentation, for example, through thank you letters or program announcements. Departmental service may take the form of being graduate student coordinator, course coordinator, instruction committee member, student advisor, or serving in any other visible leadership role. Service to the university usually involves serving on one of the numerous committees or councils. Last of all, community service can take the form of an educational partnership, involvement in civic organizations such as the United Way, or participating in one of the many programs sponsored through the American Chemical Society.

Service as a contractual requirement is a side of chemical education that many Type I/II CEs are not familiar with. Furthermore, like teaching, few have received any training or instruction in its regard. Generally speaking, it is the most intangible, non-quantifiable aspect of the triad, and often, formal guidelines for its evaluation are lacking. Many academic promotion systems do not attach much importance to service, and it may contribute little to promotion and tenure. Therefore the key rule pertaining to service is that candidates must understand the very specific requirements of service within *their* promotion and tenure contracts. To understand these specific requirements, candidates should discuss service contractual obligations with their colleagues, their chair, and their personnel committee. The decisions made by the candidate regarding service will certainly impact career progression. If service has little emphasis in the contract, as is usually the case, then it is counterproductive to career advancement, and must be avoided at the beginning of one's career, including during the time before tenure. In that case, instead, Type I and II CEs should focus their efforts and time on research. Perhaps departmental attitudes toward service will change in the future.

While department chairs often shield junior members from the time-consuming nature of service, professional societies and the academic community may pressure one into performing it. In 2004, Pienta (*163*) found that Type I CEs publish at a rate five times lower than that of traditional research specialists, probably due to high service loads such as administration, management of preservice teachers, and high teaching loads. However, by 2012 (*164*) this disparity largely dissipated. Naturally, there may be some committee assignments at the department and university level for the second year faculty member, but even these should be avoided during year one. In some cases, however, service can even be useful because it can raise one's profile on campus.

Service in the form of outreach is an under-appreciated activity that takes up large blocks of time, in planning, preparation, and execution, and in fact, drains valuable time that can be devoted to research. However, it is highly valued by the American Chemical Society, and is often rewarding. In fact, if one is hired with the idea that he performs outreach, then outreach should be placed in the faculty contract, by both the Department Head and Personnel Committee. However, one should choose outreach activities judiciously, so that they have maximum impact on students and performer. Outreach activities should be done well, and it takes a knack to become a showman like, for example, Shakhashiri (*165*). The best known outreach activities are sponsored by the American Chemical Society and include: National Chemistry Week, National Chemistry Olympiad, Earth Day, and ACS Chemistry Club. Other important outreach activities include Science Olympiad, judging science fairs, and supervising high school students in their science fair research. In addition, another form of outreach involves running summer workshops for K-12 students and teachers in, for example, crime scene investigation. Aside from taking away vacation time, outreach activities carry heavy responsibilities dealing with the safety and welfare of children, and in some cases require that all staff undergo safety training. One should never attempt any kind of service activity without first planning it, and considering all safety aspects, including liability insurance.

IX. Social Networking Online

As much a professional development tool, as a job-hunting strategy, social networking (*166*) can be used for career and professional development, collaboration, or to obtain help with a scientific problem. It is a continually evolving field. Social Networking can be face-to-face or online. Face-to-face networking via scientific conferences can be effective, but travel costs and time make it prohibitive. The American Chemical Society offers face-to-face networking opportunities at its professional meetings on the local, regional, and national levels.

Online networking web sites have proliferated, but some sites appear to have a short half-life, while others may be phishing attempts, ripe for identity theft. Using online social networking, users can post profiles, CVs, and network with other scientists, or even pose questions. Many sites provide far more than just social networking, offering productivity tools and services for a fee. New faculty should network through multiple professional societies, because each one brings slightly different benefits. In the narrative below, several important social networking sites, including some useful productivity applications, will be delineated.

The ACS Network (*167*) is the major social platform of the American Chemical Society, and is an excellent forum for its members to network and collaborate with colleagues both safely and securely. It is available on both Apple and Droid mobile devices. This site has several major functions. For example, users may organize and participate in forums, blogs, and specialized groups. It contains separate network toolkits for Divisions, Local Sections, and Student Chapters. The *Volunteer Support* section of the website allows users to share best practices and successful ideas involving outreach, including specifics on, for example, demonstrations. The *Paying it Forward* forum is devoted to job seekers, and is a place where they can obtain advice. It also contains a separate *Resume and CV* forum. Users can even discuss the science of chemistry on the *Science* section, and promote and develop their careers on the Profession website. Last of all, on the *Educators and Students* section, users can access the Division of

Chemical Education and view its strategic plan, access the ACS Exams Institute, and also access the webliography and Journal of Chemical Education,

The *ACS Division of Chemical Education* website (*168*) provides its members with opportunities involving outreach, special meetings, and news. It allows for networking in several ways, for example, by allowing users to share interesting ideas and posting job vacancies.

FriendFeed (*169*) is not necessarily for scientists, but this website allows users to share anything online. On *Epernicus* (*170*), research scientists can network with, find new colleagues, post questions, and find specialized help (some fee-based) for their projects through discussion boards. Users can also create profiles listing their specialized competencies. *myExperiment* (*171*) is a site devoted to finding and sharing scientific workflows and other research objects. It is useful in large-scale science experiments such as E-Science. On *iAMSCIENTIST* (*172*), researchers present proposals and request crowdfunding for new research projects. Once a project is Kickstarted, users pay a fee. Academia.edu (*173*) is free to all academic researchers allowing them to stay abreast of the latest research of others, and share their own research papers in an open-access format. It utilizes a dashboard module to monitor the impact of research using analytics that, for example, monitor the number of readers of scientific papers (in this case, the ".edu" extension does not imply that this site qualifies as an educational institution). *ResearchGate* (*174*) is tailored to research results in biology, engineering, and medicine but also serves chemists. It offers a "RG" score that measures an individuals' research reputation as perceived by peers; it is free. *LabRoots* (*175*) allows scientists across the physical and social sciences to collaborate with others and become more prominent within the scientific community. *LinkedIn* (*176*) is a well-known site devoted to job and career growth.

Several useful productivity apps allow users to collect, organize and share research source citations and bibliographies. *Zotero* (*177*) is a free and easy-to-use interactive reference management system tool. *Citeulike* (*178*) allows users to employ social bookmarking to accelerate sharing of scientific resources amongst researchers of similar interests. An academic social network and reference management tool, *Mendeley* (*179*) also provides researchers with a desktop application for managing citations and PDF files. The site generally functions to provide free and open source material to doctoral students and academic researchers. However, its premiums options, like in *Papers* (*180*), are not free.

Two novel apps deal with videos. *SciVee* (*181*) allow users to view and upload scientific videos, and moreover, to synchronize videos with published papers and posters. It also has a lecture capture tool for educators. *The Science Network* (TSN) (*182*) features videos of scientific lectures, but these often focus on medical and ethical issues.

On the Faculty Focus section of *The Teaching Professor* (*183*) articles are offered on effective teaching strategies for the college classroom - both face-to-face and online.

In concluding this section, one last note is that employees should remember that posting impropriety in the digital arena using university computers or web-services can be risky, and inappropriate posts can have severe repercussions on one's academic career.

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Chapter 13

Lecturing at a Research 1 Institution: A Rewarding Position for Someone Who Loves To Teach

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Many graduate students know that they want to teach when they enter graduate school (instead of pursuing a career in industry). For most of these people the "big decision" is whether to prepare for an academic career that focuses on research at an R1 institution or to focus on working with undergraduates in both the classroom and the lab at a primarily undergrad institution (PUI). Another often overlooked option is to pursue a largely teaching position at an R1 institution as a lecturer. In this situation there is the benefit of having the resources and students of a world-class research institution, but the job description now focuses on teaching and the scholarship of teaching and learning. Lecturing to a group of 200-400 students can be intimidating at first, but using innovating teaching methods allows the classroom to feel quite personable. This chapter will focus on lessons I have learned in my time as a lecturer at the University of Illinois at Urbana-Champaign.

Getting the First Job

Applying for a Lecturer Position

The first requirement for many lecturer positions will be a Ph.D. in chemistry or a related subject. By earning your Ph.D. you have demonstrated that you have strong overall chemistry knowledge, are an expert in one area of a specific field of study, and that you have learned how to perform chemistry based research. Having a strong background in chemistry will be important as you embark on your teaching career, but will your lab experience and thesis project knowledge help you directly as you teach a freshman-level introductory chemistry class? Perhaps! Your experiences in the lab and your expertise with cutting-edge chemistry may help make your classes more relevant or interesting, and they may help you advise a student on future career paths; but specific knowledge from your thesis research project will most likely not help in your day-to-day teaching. In terms of your teaching career, one of the most important skills you will have gained by earning your Ph.D. will be the ability to take criticism and stand up to vigorous questioning. There will probably be times where your students will press you almost as much as your committee members did in a preliminary examination. The ability to think calmly under pressure will be a great asset in the classroom.

To obtain a position as a lecturer you will go through a hiring process that is as rigorous as you might find when applying for a primarily undergraduate institution (PUI) faculty position. There will often be hundreds of applicants for each lecturer position that is posted on the jobsite boards. It is imperative for your application materials to be well thought-out and presented. Be sure that your cover letter specifically addresses each of the qualifications listed in the job description. Also make sure that your application materials are tailored to a teaching position. When an application lists patents, research publications, and then finally highlights teaching experience, it is hard to believe that the applicant is serious about teaching. Lastly, a teaching statement is your opportunity to show the hiring committee what your classroom would look like. Use specific examples of teaching methods you have used (or propose how you plan to handle situations if you do not have much experience). Include examples of problems you have written and quotations from class evaluations highlighting your strengths. If you know you have an area that you need to work on, explain how you plan to address your deficiency. The search committee is trying to predict how you will teach based on your application materials. If you can demonstrate you have been thoughtful and reflective in your teaching decisions you will make a strong impression.

Once you have been invited to interview at an institution, you have passed the bar, the committee thinks you have great potential! At this point the committee will be evaluating if "you" on paper matches "you" in person. The hiring decision is often based on which candidate best fits in the departmental dynamic. So during the interview, relax and be yourself; you do not want to end up in a department that does not fit your personality and the institution does not want to hire someone who does not have a strong potential to be successful.

Lecturing at an R1 Institution

Lecturing for large classes (more than 200 students) is in many ways just like lecturing for a class of 40 students. It has been said that "Good teaching is good teaching," and this holds true with small and large classes. A large lecture class offers challenges that are not often found in smaller classes (as well as a few advantages). The largest challenge is the number of students that are in the setting. General chemistry lectures at the University of Illinois at Urbana-Champaign often have more than 300 students. This means that great care has to be taken to develop a comfortable, welcoming atmosphere to encourage student engagement, but this is no different than the approach that would be taken in a smaller classroom. With such large numbers of students it is also more of a challenge to assess student learning; technology must be used to facilitate adequate feedback on student problem solving. We have accomplished this goal by using an online homework system (LON CAPA) that allows us to tailor our questions to our educational goals and customize student feedback to help the students learn the materials through text, animations, and videos. In the classroom setting clicker technology has been used to render student responses anonymous and collect data on how the students understand a given topic. Given our large sample size we get a wide range of responses, which give many opportunities to address the common misconceptions students often have with material.

Many different teaching approaches are used in our "lecture" courses. Our lecturers use "traditional" lecture at times, while "flipping" the classroom at other times. We have a dedicated demonstration room (and staff) that allow us to prepare demonstrations to help students visualize concepts that we are presenting, as well as staff dedicated to helping us create online content (including videos, animations, and web-based applications). We also hold many review session and office hours. Our lecturers attempt to use the right tool for the situation: what are we trying to accomplish with our students on this particular exercise and what tool will help us reach our goal?

Do lecturers get to know their students? This is a concern that comes up when talking with potential candidates for lecturer positions and the answer depends on how you define the question. Will lecturers get to know a large percentage of their students? No. Given that a lecturer may have 700 students in two sections of a class in a given term, getting to know a large percentage of those students would be virtually impossible. However, my experience is that I will get to know 30-40 students reasonably well during the term, and there will be five to ten students that I will know well and keep in contact with throughout their undergraduate careers and beyond.

What is it like to teach a large lecture class at an R1 institution? If you are comfortable talking to a large group and are passionate about teaching there is no better position. Your whole job description revolves around teaching well, developing new teaching methods and materials, and sharing your experiences with people from other institutions who are equally excited about teaching. For many people interested in teaching a lecturer position may be the perfect job!

What You Need for the First Job, Besides the Ph.D., as a Lecturer at a Research 1 Institution

A Strong Education Background

A lecturer's primary role is to teach, and teach well. But how do you teach well in a large lecture setting? Having a background in education will give you the tools you need to reach your teaching goals. There are many ways that you could cultivate a strong educational background including: asking for teaching-intensive assignments as a teaching assistant in graduate school, taking part in a teaching post-doctoral fellowship after earning your Ph.D., or acting as a visiting assistant professor for a year or two. All of these options will give you extra experience teaching and may help you define your teaching style. However, you may be defining your style without understanding why (or why not) your teaching methods are working. Taking an education class will expose you to the theory behind different teaching methods and show you how to use your unique talents to help your students have the best experience possible.

If taking an education course is not a possibility there are many other ways to become immersed in the chemical education culture. *McKeachie's Teaching Tips* (*1*) and *What the Best College Teachers Do* (*2*) are both books that give broad overviews of what works well (and what does not) in teaching. *McKeachie's Teaching Tips* would be especially useful for someone just learning to teach, as it walks one through how to plan topics for a class, preparing a syllabus, the first day of class, and beyond. Other ways to learn more about teaching include following the literature (*The Journal of Chemical Education* and the *Journal of College Science Teaching* are two examples), attending CHED talks at regional and national ACS meetings, and working with colleagues/mentors.

In my own classroom I have used lessons learned from my graduate school education class many times. These include simple techniques such as having an overview of topics to be covered during lecture on the board at the beginning of class, to more complex ideas such as using Kolb cycles to present material. One example of a Kolb cycle would be to: perform a demonstration to show students a new concrete experience (putting a balloon in liquid nitrogen), asking students to describe or think about what they saw with other students in the class, and then frame their observations in the context of one of the gas laws, and finally giving students another similar problem to work on. Many times what I learned in my education class was not necessarily a new teaching method, but why a certain teaching method often worked (or did not work) in a particular situation. This information has been of great value, as it allowed me to become a better teacher.

Curiosity To Try New Things and Document the Results

Chemical research in the laboratory often follows the pattern of posing a question, performing an experiment, gathering data, evaluating the data, and determining if your goal was met or if further experiments are needed. Teaching follows a similar pattern. The best teachers are always tweaking their methods, attempting to explain difficult material in a different fashion or using a new approach to involving students. However, before you attempt new experiments, you must have a baseline. The greatest piece of advice I have received in my teaching career follows: "The first time you teach a class, do exactly what the person before you did. Do not change a thing!" This is really important! Your first term teaching you will be doing well to just keep up with lectures. Developing new materials or using new teaching methods on top of just keeping up with lectures is a recipe for disaster. The first time you teach a class, use a colleague's notes and methods, but also take notes yourself! Make a note when a particular lecture goes well or when a certain discussion falls flat. Would a demonstration you saw at a presentation help explain entropy better? Make a note to use that demo next time. Not enough time to cover the Nernst Equation in your lecture? Make sure to budget more time next time through.

Once you have taught a class the first time you are almost ready to start changing the structure of your classroom, but what do you want to change? You may start by making small changes based on the notes from your first time around. However, at some point you will want to develop a more comprehensive research question that ties into a larger educational theory. A great resource for developing a chemical education research plan is the book *Nuts and Bolts of Chemical Education Research* (*3*).

There are many different ways to assess how the changes in your classroom are changing your students' performance and perceptions. It may be possible to assess student understanding of certain topics by tracking student scores on specific questions on an exam for a number of years. Surveys are convenient methods to determine if student attitudes toward your class have changed based on the changes to your teaching methods. Or perhaps you could track the number of chemistry majors over a period of time based on your curriculum. Careful choice of your assessments will allow you to determine if the changes to your classroom have been successful.

If you are interested in publishing any student data you will need to make sure your proposed experimental design is evaluated by your institutional review board (IRB). This process often requires that you get training on ethical research practices, and does take a bit of time, so start early!

Comfort Using Technology (or the Willingness To Learn New Technologies)

One drawback to teaching large lecture classes is the difficulty of trying to reach the hundreds of students in your classroom. Ideally, each student would have the opportunity for one-on-one interactions with their instructor and the instructor would be able to personalize explanations and assignments for each student. The reality is that such a situation does not exist in large or small lecture halls. However, such an idealized picture of a lecture should be our goal for lecture classes. Some of our more successful programs/interventions have been: online pre-lecture video materials to help students better prepare for lectures, post-lecture video materials to give students the opportunity to review/clarify concepts from lectures on their own time after class, online quizzes with randomized questions to allow students to learn from mistakes on quizzes, and online retakes where students can earn points on the exam by working through different versions of exam problems. Each one of these resources has anecdotally led to a positive effect on student perceptions of our chemistry classes, and all of these resources are dependent on using forms of technology.

Simple videos can be created using relatively inexpensive materials (webcam, microphone, and one of many commercially available software programs such as Camtasia or Screen Cast). These videos can be used to outline lecture material, offer supplemental instruction, or any other purpose that fits your educational goals. Personalized homework assignments, quizzes, and exams can be created by coding problems in an assessment tool. At the University of Illinois at Urbana-Champaign we use the open source LON CAPA platform, but similar results could be accomplished with commercially available assessment tools. By coding your own problems you can test exactly what you want, in any way you want. A basic understanding of computer science and coding languages (and the ability to learn from your mistakes) is often enough to learn how to code your own problems in any commercial homework package. Once you can code your own problems you are no longer required to use questions provided from publishers, you can tailor your questions to your own students. The ability to write your own problems gives you the power to ask any question that you want.

Using technology to deliver course materials can sometimes have unintended results. Due to a change in our teaching assistant allocations I decided that quizzes in our class would be delivered through an online format. These online quizzes would be more complex than the quizzes given in a face-to-face format, but now students would be given multiple attempts at the problems. My motivation for this format was to deal with the reality that students would most likely work together to complete the quizzes; if students were pooling resources I wanted to make sure the quizzes were still a challenge.

Toward the end of the semester I was talking to a parent of one of my students who I knew from outside of my role as a lecturer at the university. Without any prompting, the parent began to tell me how much her child enjoyed the online quizzes we had in our class. This parent had watched her child work on our quiz with other students, watched the group of students get the problem wrong, and then watched in amazement as the students talked over the material and worked on the quiz again. The student told the parent that quizzes were "no longer one and done. Now I go back and actually try to learn from my mistakes on the quizzes." I never dreamt that having quizzes online would result in quizzes being both assessment and learning tools, but that seems to be the result. Without the ability to code my own problems these online quizzes would never been possible.

Courage To Ask for Feedback Early and Often

One of the most important practices that any teacher can adopt is asking for feedback early and often. Why? In a large lecture class you have hundreds of students who can give you their opinions of how successful your teaching methods have been to that point. With such a large sample size you will begin to see important trends: things that you are doing well and areas for improvement. But these students are not evaluating your class in a vacuum; they are comparing their experience in your class to the many dozens of other classes they have taken in the course of their academic careers. The collective experience of thousands of classroom hours can be pooled to help make your class better! The following teaching methods/techniques are a small sample of the suggestions from student responses on informal student feedback:

- Start class with an overview of the topics that will be covered that day
- Use more challenging questions on quizzes to better prepare students for exams
- Change the format of the discussion sections to spend more time solving problems
- Keep using "clickers" to see if we (the students) are "getting it"

Many of the suggestions I receive on informal feedback are repeated, but students offer some very insightful suggestions!

While student suggestions are an important reason to request feedback, perhaps a more important result is the change in student perception. When you ask for feedback, consider the comments offered, and discuss them with your class so that the students understand that you care about their success. A criticism I receive often is that my course moves quickly. I let my students know that I agree with them, and I explain why we teach the topics we do. While I am not willing to change the pace of the class, at least they can now better understand why I teach the class the way I do. By asking for, considering, and then discussing their feedback, I ensure that the class is no longer "my" class, but "our" class. The students know that I care about their wellbeing and success, and will work with them to make reasonable changes.

When should you ask for feedback on your classes? I use the following schedule: day one, end of week two, after exam one, before the final exam, after the class is over, and any other time anyone wants to visit my class. Why so often? I want to train the students to feel free to give me feedback early and often. I also preface each round of informal evaluations with the comment, "Feel free to tell me I suck, but please tell me why I suck." I want to encourage students to be brutally honest with me, but to be constructive at all times. I also encourage colleagues and teaching specialists to visit my class at least once a year. A few years ago I had a graduate student from an education class sit in on class. After class the graduate student and I were discussing what she had observed, and she pointed out I could improve the class by summarizing the lecture before class ended. She was right! This was a practice I had formerly used, but had just forgotten. We schedule regular maintenance for our vehicles, it only makes sense we should do for our professions. My former department head once told me that, "A teacher that does not want your feedback is not worth observing." Ask for feedback early and often, and do your best to make any changes you think will improve your class!

An Understanding That the Role of a Lecturer Is To Be a Resource for Students

A lecturer has different responsibilities than the professors found at a primarily undergraduate institution or at research institutions. As a lecturer, our main responsibility is to be an outstanding teacher, but lecturers often also serve as informal mentors, committee members, career advisors, the bearers of bad news, and friends. These different roles all have one thing in common: the students are the focus.

My biggest concern about being a lecturer at an R1 institution was that I would not get the opportunity to know students on a personal level. On a percentage basis, I do not get to know many of my students well, only five to ten percent at the max. However, due to the large numbers of students I work with, there are always a handful of students each term who I end up working with for the rest of their careers. These are students who will come to me for advice on careers, will share their best successes with me, and will on occasion use my shoulder to cry on. These are students in whom I am very invested, students I will consider friends as they move on to the next phase of life.

We forge this relationship by talking. Initially our conversations revolve around chemistry or problems they are working on in my class. However, after we are comfortable with each other we learn about each other's interests outside of the classroom. This helps me advise the students as they think about potential career options, including graduate school, other professional schools, or a career immediately after graduation. Having a comfortable relationship also helps when helping students realize that their potential career plans may not work as planned. I can share my academic struggles and help students to see that not going to medical school may help them find careers they are really passionate about.

I recently had one of the most rewarding conversations I have ever had with a student. This student was one of the kids who sat in the back of the lecture hall when in my class; in fact, this student sat in the very last chair possible. In our lectures I often walk around the room asking questions to see how well students understand the material. One day I ended up in the back of the room, and asked this student sitting in the last chair a question, not really expecting an answer. The student responded with the correct answer. Not long after this interaction the student started showing up to review sessions and office hours. Soon after that we were talking after class; sometimes chemistry, sometimes not. At the end of the term we parted with a handshake and a promise to keep in touch, a promise the student kept. I had not seen this student over the summer or at the beginning of the fall semester, but out of the corner of my eye I caught them crossing the street to talk to me. With a huge smile they told me of their recent interview for a prestigious and lucrative internship, and the subsequent invitation to join the internship program. I warned the student that I would be hugging them, and then I let them know how proud they should be of their accomplishments. I can take no credit for this their success, but I was told that our conversations helped give them the confidence to apply for the internship. Being a lecturer gives you the opportunity to have more impact than simply being in the classroom.

Have Passion for Teaching

Lecturers are teachers. Lecturers work closely with students. The job of a lecturer revolves around giving students the best academic experience possible. If you are not passionate about teaching and working with students, lecturing will not be a good fit for your career. However, for those who enjoy working with students, being a lecturer can be the perfect situation. Every day gives you another opportunity to work with the amazing students we have at our R1 institutions.

Conclusion

My story of how I came to be a lecturer at an R1 institution actually starts with a professor at a PUI. My career path did not start with being a lecturer in mind. In fact, I did not even start as a chemist! It took a crazy chemistry professor who threw a chair across the room to show the students just how cool the Nernst Equation was to make me a chemist. But it was not just that he was crazy, or that he was a good teacher. I think it was that he cared about all of his students as people (and we could all tell). Being a lecturer at an R1 institution lets me try to emulate what I learned from my undergraduate professors in my own way. I have the resources to try to blend the best technology offers with the strengths of traditional teaching methods. I get to try to “make things click” for students using my education background and my chemistry experience. I have the pleasure of working with and getting to know many of the best and brightest students of the world. Every day I go to work I know I have one of the greatest jobs in the world.

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