Moments in Constructivism: How Does Accepting Failures Allow Us To Examine Our Teaching?

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Abstract: This paper examines the past teaching experiences of four chemistry instructors who would ultimately like to be considered successful in their classroom endeavors. In defining success, each of these teachers point to student learning as examples of their achievement. This was not always the case. Intermittently, each teacher taught as they were taught, focusing solely on content, using other people's curricula, and worried exclusively about their performance as instructors in the classroom. Although each of these instructors are now self-proclaimed constructivists, they continue to struggle with what the term means empirically, how it actually manifests itself in their classrooms, and how they can adequately measure the achievement of their students. Through the course of this selfexamination, each began to recognize many of the successes and failures that occurred as they became constructivist educators. Each independently noted that the transformation from what they were to what they would like to be is an on-going process; the ultimate goal of teaching should focus exclusively on students' learning. This paper is not a litany of rosy successes, nor is it a string of miserable failures. It is the description of their classrooms, of who they are, and who they would like to be.

Moments in Constructivism

It is only after being out of the classroom for a year and a half that I realize how much I assumed and how little I really knew.

The first step to becoming a success is to realize that you have been a failure.

…of the total, 50% of my classes, meaning my teaching, suck out loud.

Introduction

Failures are rarely looked upon as favorable events in most parts of our world. In fact, most people would believe that failures are detrimental to our very being. Most systems reward successes and not failures. In the United States, nearly 50% of all teachers leave their profession within five years of starting [1–3]. The Salish Project, a long term study of beginning science teachers, identified specific feelings of despair, isolation, and failure as being critical in those teachers who decide to abandon teaching [4, 5], but these teachers may not necessarily be failures. What we believe is missing from these reports is that individual failures often allow teachers to see themselves for what they truly are. Furthermore, failures encourage teachers to examine their professional choices without falsely deceiving themselves and to make alterations in their teaching methodology. Eventually, these alterations may help teachers to improve themselves and the world in which they operate.

Bodner [6] notes that schoolteachers who spend more of their professional lives in the classroom, unlike college and university teachers who spend 10 to 20% of their time in the classroom, are constantly faced with the discrepancy between what they believe and what they are able to achieve. According to this notion, the likelihood of teachers staying in the classroom is directly related to how well and how quickly new teachers begin to make the connections between their internalized belief systems and their practiced classroom activities and to give to each a method of how they view individual successes and failures in their teaching. Just as all learners construct knowledge for themselves in their own minds, new teachers must also determine for themselves how to make connections between their actual experiences and their knowledge of teaching.

Several researchers have recently examined the role of the teacher's belief system in science teaching. Phelps [7] identified how strongly influenced prospective teachers are by their own teachers' teaching styles while others have shown how resistant to change these beliefs are [8–11]. For a constructivist, this should come as no surprise.

Taken together, all these factors create a Catch-22 situation for science teaching reform. As students, individual disappointments were events to be avoided. In the traditional school world, problems were synonymous with failures. When we acknowledge such reality, we not only let ourselves down, but we also let down those who may have once respected us. These perceived collapses represented defeat for us, and perhaps to our teachers. When we became teachers, we tried to avoid issues of success and failure, thus protecting ourselves from exposure. Hence, we hide what we did not want to admit or what we did not want others to know. Far from being helpful or useful, nothing good came from ignoring the reality of our initial inabilities at teaching.

If the first few years of a teacher's career are critical in terms of establishing a belief system that matches a defined pedagogy so as to avoid abandoning one's career, then only

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those teachers who have a belief system that matches how they were traditionally taught must have a good chance for long and sustained careers. This situation leads to a paradoxical struggle of reform in science teaching. The challenge, therefore, is how to implement reformed pedagogy with unreformed teachers, that is, teachers without a constructivist belief system.

Brooks and Brooks [12] have identified 12 of the best teacher practices necessary for a successful constructivist teaching approach; however, effective constructivist teaching is not something that can be put together and noted in a "how-to manual" for constructivist teaching. It is based on a core belief system about how people learn and come to personally know the world in which they live. There are, however, some promising techniques that can be used to assist in the development and implementation of constructivist teaching in an individual's classroom; however, if the teacher does not believe in constructivism as a theory of how individuals learn, then these techniques become nothing more than a bag of "pedagogical tricks" to be used to teach the same old content.

Some teachers do embrace constructivism as their personal belief system and their classrooms actually do become testaments to what science teaching, and in particular chemistry teaching, can become [13–15]. Many articles are descriptions of specific chemistry teachers facilitating easily described activities and making note of how their students are actively constructing scientific concepts. This paper is not one of those descriptions.

The four of us, whose stories are told in this paper, have an intricate relationship with each other. For instance, John Young was the high school chemistry teacher of Barb Short (1976) and Jeff Carver (1986). For the past year, both Barb and Jeff have been doctoral students with Willy Hunter. Barb has interviewed and visited the classrooms of the other three. Jeff and John have both served as colleagues in the Illinois Association of Chemistry Teachers. The importance of this information is that the descriptions of our teaching are based upon our individual recollections as well as our experiences with each other.

We have all changed our teaching pedagogy. Initially, each of us taught as we were taught. Though we adopted ideas from others, we each initially focused on content using traditional methodology rather than on our students; however, it was not until we openly addressed our own failures that we truly began to discover both how to improve our teaching styles and how to help our students learn. Although we are now proclaimed constructivists, we only think that we know what the term actually means. We continue to struggle with how constructivism manifests itself in our classrooms, and how we can actually measure the academic achievement of our students. For us, this paper addresses the fundamental question: How does accepting that we will have failures allow us to examine our teaching?

Jeff Carver

Jeff Carver currently teaches chemistry at Illinois Valley Community College and Northern Illinois University after having taught at two high schools during his eight–year career. He is also working on a doctorate in curriculum & instruction.

JC: In the Fall of 2000, I opened my non-majors chemistry course at Northern Illinois University by reading two passage from Aldous Huxley's Brave New World, which describes a version of a utopian society. This culture of genetically altered test-tube babies is described with painstaking detail. The passages include a description of how "second-class" citizen babies are taught by the use of shock treatments to not to want to read books or smell flowers [16].

> It is the early part of the twenty-first century, 2026 to be exact. We have chosen to have a daughter. Unlike most of today's parents, we will not preselect her IQ. However, we do agree with our genetic counselor that her system should be genetically engineered so that she will be immune to all known bacterial and viral infections [17].

The conversation that ensued between my students was unlike anything I had experienced in my teaching before. The parallels that existed between the two selections were clearly noticed by the students and they began asking questions regarding the ethics of genetic engineering and how it affected them in their daily lives. By the end of the first night of class, the students had determined for themselves why it was that they were taking this course in chemistry. They discussed issues related to the election process and how their ability to understand information was important to how they make decisions regarding elected officials. They discussed the ethical lines that will be approached and possibly crossed with the advent of genetic engineering. Questions such as, "Isn't that playing God?" were asked. The students led the discussion and I simply facilitated.

My teaching was not always like this. The beginning of my career met with many struggles. I was educated at a four-year university with teaching in mind as my career goal. My first extended experience with teaching took place under the supervision of what I will call a traditional chemistry teacher. My purpose in being there seemed to be the propagation of a series of behaviorist techniques that centered on classroom control more than teaching itself. The very method of teaching for me was restricted to using the classroom teacher's already prepared notes and handouts. I was expected to follow in his footsteps and fit into a mold that would create an individual with similar teaching style and characteristics. The problems arose when the teaching style that I was expected to use did not fit within my own ideas of what I expected teaching to be.

My first year of teaching high school chemistry met with much failure. I was assigned a mentor, who was a fellow chemistry teacher in the school. His idea of teaching chemistry was very similar to the individual with whom I student taught. If I wasn't doing what I was told by him, I was not teaching chemistry "the right way." I managed to spend most of my class period lecturing to my students. I would break up the fifty-minute period by using shortened lectures with "something" inserted between, but the format was mainly lecture. I was praised for splitting up my lecture to meet the ever-shortening attention span of the high school students; however, I managed to turn more students off to chemistry than I managed to turn on. I did insert laboratory experiences in the midst of my teaching, most of which were formatted as confirmation labs instead of discovery labs. I was more concerned that they follow the correct procedure than that they learn anything about the chemistry in the experiment.

However, there were times in my high school classroom when my students did take control of their own learning. I had never taught a class of physics and I found myself in a situation where survival was a standard mode of operations. The whole first year of teaching I found myself either questioning myself or being questioned by others. There were moments of enlightenment within that first year but most of them were overshadowed by extreme doubt and disillusionment. One thing that stands out in my first year happened within my physics class. In all of the chaos that existed in that experience, I had managed to go to a science teachers conference and discuss the types of learning that college physics teachers expected to have already occurred. I was expecting these individuals to site a number of concepts or chapters in a particular textbook. The response I got was that most expected that the students had some capability to work with tools and their hands. From that conversation, I designed my first project-oriented lesson. Students were to work in teams of two to design a model car powered by a single stage, class A model-rocket engine. Crucial to the design was that the car be able to stop within a given distance of the start line. The cars were secured by a taught 20-gauge wire so they were kept on track so that the project did not become an exercise in avoiding flying projectiles. The students had to come up with a design that was "patented" and approved by the teacher. They were then required to build the vehicle. When the day of the "test" had come, the class convened on the schools track to launch the vehicles. Of the vehicles built, there were only two that accomplished the project goal as stated in the specifications. Only a few of the students learned to use tools well; however, I noticed that by having the students use tools and by having them work on their own project that they took ownership of their own learning. The students had not been informed that the main goal of the project was not simply to accomplish the given task. Rather, it was the involvement in the task that was the true goal of the project; however, due to my inability to fully recognize and articulate the strengths of the project, I was unable to follow through in such a way that the students and others felt that it was beneficial. I had a hint of what I wanted to happen within the project, but was not able to carry it through.

When I started teaching in my own classroom at the university, I began the course by teaching what was in the book. I was told that we needed to have a standardized curriculum and that I should remain reasonably consistent with the other three teachers who were teaching other sections of the same course. In this vein, I taught the concept of reduction–oxidation (redox) equations to my students. I started off by showing the students what a redox equation was; however, what I didn't know was that they saw a redox equation as being the same as any other kind of equation that we had discussed. There didn't appear to be any difference in redox equations except for the electrons that were, in their eyes, added and subtracted arbitrarily. Not only did the students not understand the material and how it was different from anything else that we had already learned, but the material was presented to them in a lecture format with very little interaction between the teacher and students. As I looked back on the experience, I asked myself why it was that I was teaching this concept in the first place. "Would students taking Introductory Chemistry have any use of learning how to balance a redox-reaction equation either in their career or in their life in general." I found that I couldn't answer for myself why I was teaching this particular concept, so I ended up not teaching it in the future sections of the course. This met with some concern from the other faculty teaching the same course, but when I asked them why they thought it is important the only answer they could come up with was that it was taught to them in their introductory chemistry course, so it belongs in this one. In the course of one semester, I taught 180 students a topic that they didn't learn and I taught it for the wrong reasons—because it was in the book and other, more experienced teachers said it should be done.

As I continued to teach at the university, I realized that my course was the only course in chemistry that my students would take, and that very few, if any, of my students would become chemistry majors. I began to understand what I had already realized years before in my physics course; students need to be drawn in with something that makes the content relevant to something in which they are interested or to what they want to do as a career. As many of the students that take this introductory-level chemistry class are in the preprofessional programs, I began to introduce lessons that were relevant to those fields. I also began to listen to the students' questions and statements. If a student asked a question that wasn't relevant to the course, I previously would have said that we wouldn't be discussing that in this course and recommend that they take a course where that topic would be discussed. I began to realize, however, that this would be the only course in chemistry that many of these students would take. Now, instead of dismissing a topic that a student wants to inquire about even though it might not be part of the planned syllabus, I try to focus in on what the students' needs are and use their interests to drive my teaching. I used to be very driven by the syllabus that I had designed before the class met and before meeting any students in the class. Now, I try to let the students' need-to-know drive the material that I teach.

The most difficult aspect of changing one's teaching is knowing when it needs to be changed. The identification of successful teaching and unsuccessful teaching is probably the reason that most teachers teach the same as their teachers taught. For many of us entering the teaching profession, it is easy to model after someone who is apparently a successful teacher. Of course, this assumption can, and often is, made of teachers that have been in the profession for an extended period of time. To determine what is, or will be, successful for you as an individual, however, you must internalize those successes and failures. The students must do the same for the concepts that you are teaching them. The teacher as the knower of all things important is an image that must be destroyed.

As I look back on my own successes, I realize that the most successful teaching moments are when the students have taken control of their own learning needs. My course is no longer the same solely content-driven course it once was. The other condition that seems to need met in my classes is that there needs to be applicability to the real world. That becomes even more important with the nonmajors chemistry class that I teach. It was very difficult for me to relinquish control of my classroom for the first time. I was concerned that the students wouldn't behave properly and that I might have discipline problems. What I discovered for myself was that when the students took control of their own learning, they took control of their behavior as well. The students weren't sleeping in the back of the class, were involved in the lesson, and I never had to answer the question, "Why do I have to know this?"

> I want to be a better teacher! I need to offer more learning opportunities for my students! I want to change. I want to be like the teachers depicted by Brooks and Brooks [17]. But, no matter how hard I try, I often fall short of the goal. Sometimes, it seems as if my students will learn more from a well-prepared lecture than from my constructivist lesson, which I haven't planned as carefully.

Although there are many variants of constructivism, one important tenet of the theory presumes that knowledge is constructed within an individual, as that individual interprets sensory perceptions of the external world [18–20]. These perceptions are interpretations of external phenomena that are actively rationalized into a coherent understanding of the world. Humans develop their knowledge by constantly reevaluating the patterns in their perceptions against the patterns that exist in their own knowledge structures. Constructivist theory, therefore, suggests that in order to learn individuals must rationalize novel perceptions in light of their current knowledge.

Likewise, teachers must endeavor to create an environment in which students have the opportunity to actively construct a coherent understanding of their world. JC wants to create this environment and he knows his teaching "needs to be changed," and has been successful at doing it on a limited basis. In this sense, JC has taken steps to becoming a more constructivist teacher.

While the teacher's role in the learning process can be clearly stated, the implementation of any teaching activities is rarely so straightforward. JC is finding it difficult to implement constructivist teaching into his lessons. Brooks and Brooks' attributes of constructivist teachers appeal to JC, but sometimes JC falls back upon his traditional methods. He makes this choice because he believes that students will learn more from his prepared traditional lectures than from his ill-prepared constructivist lessons—a necessity of survival rather than a failure of his beliefs—a lesser of two evils. Given his beliefs about what he should do, why does JC not teach the way he believes he should? Often JC cannot fathom how to teach concepts appropriately, and even when he can, it takes a lot of work to make the change. It is easy to prepare a lecture where JC is in control and the role of the students is minimal. Preparing a class where students can go in a variety of directions and control their own learning is a mammoth task. Faced with the job of designing constructivist lessons, JC often reverts back to the traditional method by which he was taught.

No matter what the belief system of the teacher, nor how he or she tries to teach his or her classes, instruction is rarely smooth. Brickhouse and Bodner [21] observed how teachers of various career lengths and belief systems struggle given the constraints under which those teachers work. These constraints may be political, philosophical, pedagogical, practical, or personal. No matter what the teachers' goals are, the complex personal and professional environment of teaching make it difficult for the teacher to superimpose his or her will upon the classroom. The second teacher in this group is free from many of the political and philosophical constraints experienced by other teachers, yet he still suffers problems in implementation of his desired teaching methods.

Willy Hunter

Willy Hunter is an Assistant Professor of Chemistry and Curriculum & Instruction who teaches chemistry and chemistry methods to preservice teachers. Previously, he was a high school teacher of chemistry, mathematics, and computer science.

Unlike JC, WH has strong convictions and beliefs about the power of constructivism as a basis for teaching and learning chemistry; however, just like JC, WH has experienced failures and successes in his teaching of chemistry, beginning with his first experiences as an undergraduate teaching assistant.

> **WH:** During my junior year at Mount Allison University, I looked beyond graduation and wondered what I would do the subsequent year. Many of my friends were applying to graduate school in chemistry, and I knew with certainty that graduate work in chemistry was not for me. My deliberations led me to think about what aspects of my life I enjoyed the most. The most commonly occurring experiences were tutoring, assisting in the laboratory, and helping (and being helped by) other students. The common thread through these activities was teaching, and so I decided to apply for a one year Bachelor of Education degree. While I was not exactly passionate about teaching at that point, I could at least postpone facing reality for another year.
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> Fifteen months later, I was sitting in a Junior High Science Methods course at Dalhousie University when the instructor gave each of us a small piece of paper and wrote "Why Teach Science?" on the board. I hope that I will never forget the feeling of revelation that overcame me as I was forced to contemplate the question. I may have been asked the question many times before. At that moment, however, I was not only ready to hear the question; but also, for the first time, ready to answer it. It is only in the past few years that I have come to recognize the two-fold significance of the event. Not only was it important for me to think about the question at that particular time, but also I can now use the episode as a personal reminder of how I, like my students, need to be cognitively ready to answer questions that arise. I had fallen in love. I had articulated in my own mind that science was a way of thinking about the world in which experiments and replication allowed us to look at the world and make careful and predictable observations of patterns. We (scientists) could understand, predict, and control the physical world—and probably the human world as well. I viewed my role as a chemistry teacher as to show my students that they too could control world/things/….
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> As I started my career, I expected that I could help my students understand the intricacies of chemistry. Imagine my surprise when I discovered that through teaching chemistry for the first time, I actually learned the concepts myself. I was forced, through the process of organizing my curriculum, to develop my first coherent organizational structure for understanding the chemical world. (Remember now that I had known that chemistry graduate school was not for me because I clearly did not "get" chemistry as an undergraduate. I had barely attempted to memorize a few facts and principles and failed miserably at that.) Again, I had a revelation that my students needed to do the same thing, but during the first year of my full-time career, I didn't have the personal strength to try these things out. (I was intimidated by the forcefulness of my teaching colleague, and throughout this first year, I was

just beginning to formulate my ideas and thought processes.)

Fortunately two great things emerged from that year. First, I saw a chemistry curriculum where the students only replicated laboratory exercises. In that activity, however, I saw possibilities for how they could be rearranged to have the students build from one idea to another through the course of these laboratory exercises. These exercises were not student ownership of the curriculum, but they could be organized so that the rationality of the chemistry concepts could be logically built within the minds of the students. Although I didn't have the language at the time, I now realize that this process was halfway to having the students construct their own chemical knowledge

As I moved to teach in a second school the next year, I took what I had learned and built a new curriculum based upon the previous year's experiences. First, students were taught (told) that four gases, (H_2, O_2, CO_2, and H_2O) could be identified by specific chemical tests. These tests were reproduced over and over again through the course of determining the products of metal and acid reactions and in building a reactivity series of metals that led to periodic properties, atomic structure, and other key chemistry concepts.

My nadir in this school was being thrust into the position of being Science Department Head. I was too young, too naive, too immature, and too selfconscious about my lack of knowledge of chemistry. I was always on the defensive, even though I would have adamantly denied being on the defensive. I don't even know if my colleagues knew I was defensive. After all, who would question the science/chemistry teacher who seemed to have his courses and students so organized and successful?

So I went back to school to get a doctorate, concerned I might add, that they might find out how little chemistry I knew. Seriously, though, I got over the selfconscious part, and now I dedicate myself to thinking about how I can teach chemistry better and help others to teach it better as well.

These lessons translate into my chemistry classroom in two forms. First, I saw through this process that chemistry could indeed form a logical sequence that could be learned by students just as it was learned by me when I was forced to organize it. Second, the act of taking ownership through teaching was and is critical to what I would like many students to do in my classroom.

The most successful episodes of teaching have occurred when I have presented data to my students, and I expected and helped them to decipher the patterns in the data, to make the generalizations from the data for themselves. For example, when teaching nomenclature, I used to carefully explain the rules for naming compounds by starting with ionic compounds and then moving to covalent compounds, then to acids. Organic nomenclature was left to the end of the course, of course!!! In my third year of teaching, I realized that my students could figure out the rules for organic nomenclature if I carefully scripted the compounds they saw and the names for those compounds. By giving the students a list of ten structural formulas and ten names, they were able to construct for themselves the rules that are required to name most simple organic compounds. They then applied those rules to other structural formulas that I produced. That was 1991. So you think I am a pretty smart teacher, eh? That was a great success. My students constructed knowledge just as I wanted them to.

Here is the corresponding failure: It took until 1999 for me to realize that I could do the exact same thing with inorganic nomenclature. I was explaining to someone and all of a sudden, "Eureka!" I can do the same thing with inorganic. Argh, I am so stupid. At least I now walk around reminding myself of this story because it helps me to question why I can't teach all my classes like this. My classes do a great job forcing the students into positions where they try to figure stuff out for themselves. Overall, out of the total, 50% of my classes, meaning my teaching, suck out loud, but I do improve each year by doing a couple more things that I didn't do the year before.

Now, when I teach nomenclature, I never review the rules; my students discover the pattern to learn the rules, and far more of my students can name organic and inorganic compounds than could previously. Not only that, but they have more confidence in their ability to succeed in the course and understand the chemistry around them.

W. H.'s experiences highlight how both he and JC will continue their struggle to become the teachers that they might like to be. Early in both of their careers, WH and JC recognized shortcomings in their teaching and also recognized what they might like their teaching to be. WH saw "possibilities for how the laboratory activities could be rearranged to have students build from one idea to another." In the next year, he taught concepts that allowed students to construct their own knowledge. He became a "proclaimed constructivist"; however, even that strong conviction has not made his teaching all that it could be. Both WH and JC are willing and have made changes within their teaching styles as a result of their new beliefs; however, as each step occurs sporadically within their teaching, they find becoming a more constructivist teacher to be frustrating, slow, and fragmented. It took eight years for WH to make even the simplest connection between how he taught organic and inorganic nomenclature. Changing from traditional methods to constructivist methods can occur, and is occurring, for WH and JC, but those transformations are neither predictable nor inevitable.

Very early in his career, JC knew that his teaching was not as good as it could be; however, it took JC eight years to determine how to begin to change his teaching. The issue is not just time, of course, but also one of juggling responsibilities and having the moments of inspiration, followed by experimenting with the new ideas in the classroom. Their successes as constructivists are evident in their students' engagement in classifying, analyzing, and evaluating concepts within activities such as nomenclature, the periodic table, gas laws, and physics car exercises. Equally, however, their failures are failures not because their hearts were unwilling but because they struggle to apply the theory into all their practice.

Likewise, the third teacher in our group struggles with the implementation of constructivist lessons in her teaching in a variety of subjects and grade levels in elementary education.

Barb Short

Barb Short was an elementary school teacher for fourteen years at a public elementary school in Normal, Illinois. She currently writes science curriculum materials as part of an integrated math, science, and technology middle school curriculum project. She is also working on a doctorate in curriculum & instruction.

Similarly BS's teaching experiences are filled with successes and failures. She taught as she had been taught herself. She adopted others' ideas, but was not satisfied until she had made them her own. She focused on her performance rather than upon her students' learning.

BS: I expected that by the time I had been teaching for 14 years, my plans and delivery would be flawless. My students would know exactly what I wanted them to know, and the world would be wonderful. At least that was how I started out. That is what I believed when I started teaching in a K-12 unit district. I was hired as an itinerant language arts teacher, traveling between classrooms to assist students or help the teacher. It wasn't a glorious position because it required no ownership of a space, of a certain group of students, or of any set of guidelines for performance. Because I only remember schedules and the amount of effort it took to work with other teachers during this phase of my teaching, the huge number of students that I tried to help is only a vague memory.

In my first solo classroom in a small rural town that was part of this larger district, I was expected to teach math, reading, penmanship (cursive writing), and maybe a little social studies. About the only thing I remember from those years was a lot of "skill and kill" because that was the trend of the time. And I remember hating it. I read a lot to the children and I taught the students to partner-read often. That engagement was my first awakening, though I was not listening to the little voice inside me.

A move out of that environment jostled my thinking. It was not until six years later, when I found myself in a fourth grade classroom in a larger school in town, that science was considered an expectation for teaching. I cannot evaluate the reason behind the lack of science. It could have been a lack of expertise on my part, the expectation of the grade-level shift, the expectations of the time, and/or the school district. I cannot accurately assess the reason. In that grade level, we must have done some science out of the textbook that consisted of learning vocabulary, reading the text, and doing an occasional repetitive activity. I vaguely remember some very trite activities that I used with students using magnets to illustrate polarity. I remember how unexciting it was and how students were more interested in playing with the magnets than actually following a set of directions that proved nothing other than some isolated principle of magnetism. The textbook activity had no experimentation with variables, no inquiry, no discovery, and no problem solving. I must have realized at some point that this method of teaching science, or any other subject, was meaningless for students. What they needed at this level was more inquiry, tied to meaningful discovery and experimentation. When I recalled the kinds of real life experiences involving science that I had had as a kid with my dad in the garden, morel hunting in the woods and visiting cornfields in the Midwest, I knew the answer. I had to foster the same excitement for science in my students as my dad had instilled in me by allowing me to experience the natural world with him. I didn't have a clue how to do that. This was my second awakening.

For an elementary teacher, life is full of variety. Teaching in a self-contained classroom forces a person to became an "expert" quickly on several different subjects. Therefore, part of my story shares successes and failures that were not science-related. My second awakening occurred first in language arts and then in science. Using literature circles, I first attempted to change the way students interacted with reading text: discussing the text with each other, and then constructing their own ideas about the meaning. At some level, I knew that the interaction and the way that humanities dealt with idea development was less rigid and more open to the individual than traditional science claimed to be. I knew that my fellow teachers shied away from science and taught it as very factual in both process and content. From this literature circle experience, I had witnessed great success with children interacting with each other and me about ideas. Personally, I enjoyed the circle interactions so much that I decided to test the process in science.

The success in changing the reading process with literature circles gave me the boost I needed to explore science because I was still dissatisfied with the way that students engaged scientific concepts. Science was a great choice. I personally enjoyed science, despite having both positive and negative experiences as a student. The process used in literature circles seemed applicable because it focused on concepts based in processes, not unlike the themes emerging from discussions in literature circles. After all, knowledge about science is based in an established set of concepts and ideas, but it would be the test to see if students really could engage in the concepts, engage each other, talk about ideas using their own understanding about what they saw, and have a good time doing it.

One of my developed activities started with invertebrates. Using our acreage around the school and the meadow areas seemed like the right thing to do for a beginning-of-the-year opening activity for science. The insect safari became the opening theme that carried over into every subject to motivate students, getting us outside into the world to learn observation skills in addition to concepts about invertebrates. I had been fascinated with insects since I was a kid, so taking a group of students on a safari seemed curiously similar to scout camp. Because students came to me with varying degrees of comfort concerning the activity level that I wanted to use in class, I had to provide lots of reassurance at the beginning. I had to let the students know that it was o.k. to not know something, that it was o.k. to ask the question. I soon discovered that some students had perceived attitudes about spiders that would soon be confronted, explored, and maybe, at the least, confirmed or refuted. Students conducted the following activities in the process: explored the meadows for insects, learned safe ways to capture them, spent time establishing a habitat for them to live in the classroom for a week, kept daily observation logs, wrote original poetry and narratives about the creatures, determined identification of the creature, determined a food web that they might belong to, performed Sid Fleischman's dual voice insect poetry for parents, etc.

What I did not expect to discover was how much I enjoyed doing the activities right along with the students as a learner in the classroom. I do not remember being concerned that someone was not perceived as being "in charge" and openly admitting that I may not know everything about invertebrates either. In fact, my students seemed to accept my student role freely. Maybe that was

because I thought aloud with them. I speculated with them about why something might happen a particular way, why certain insects may behave as they do, or how insects fit into the bigger picture of the meadow. I'm not sure I conducted every lesson as a conscious leader. I'm quite sure that I had no clue about what I really was modeling for them because I was the biggest student in the room and having a great time, and all they had to do was follow for a while. Soon there were lots of leaders, lots of questions, and lots of chaos. The energy being generated by students soon shifted into teaching for some students. I found that students were better at explaining connections to each other than maybe I was. I knew that my students had learned some valuable science concepts and process skills for the scientific method, but my biggest concern was that students were not learning experimentation in its truest form, that problem solving and higher level skills were not being developed to the fullest extent, and that student learning was suffering because I was teaching from either extreme: too student-controlled or too teacher-controlled.

At this stage, after 14 years of teaching, the larger issues are starting to unfold before me at a more conscious level. For instance, I never dreamed that the previously mentioned control issue would be so important to students because I know how important it is for a teacher. I believe that I intuitively moved, mostly in good faith and with some smarts, into uncharted territories of teaching. I know I wasn't doing what my peers were doing in their classrooms. I had achieved a certain level of making my teaching my own, but there were too many burning desires of what could be done that I wasn't doing at that point. I was not satisfied that more of my students were not doing better in class. Some students still were not taking responsibility for their learning. They were engaging in interesting activities, but some were not always able to adequately tell me or demonstrate to me the knowledge they gained. I questioned and still question myself about asking the right questions. Not the questions about the content, but the questions about how the learning process truly works. Did students really establish for themselves the kind of environment where they could take responsibility and control? Did I know what I wanted them to learn? I knew that added benefits from process learning always means more collaboration and more communication. Did I ask them the right kinds of questions to spur them into the next realm? I know that I considered them as individuals, working into their individual personalities high standards of achievement, knowing that the idea of achievement may not be in the form of competition. With all of these methods I used, trying to discover what they each knew continued to be a vague, time-consuming, and exhaustive process on which I still clearly do not have a handle.

Somewhere along the lines of the science development, I saw my students believing in ideas about science and showing interest in exploring ideas that I believed they should know. Students would demonstrate a problem in the thinking of the concept. That was where I realized that science is not a set of facts to teach, but concepts to discover. I think I always believed in the concept idea but I couldn't give myself permission to use it until the meadow. When I became a learner in the classroom, I realized learning from their perspective, and my teaching took on a new excitement that was contagious to students. I believe myself to be at the edge of the third awakening, contemplating issues in teaching through science and working with teachers and students at the high school and college levels. I'm feeling a great loss without a classroom of my own to teach and test ideas. Because of the intimate involvement with my new high school and college chemistry teacher friends, I discovered that they, like me, have experienced various stages of change in their teaching through visiting their classes, discussing their beliefs and teaching practices. This personal development superimposed upon the professional goals is precisely what Houtsma [22, 23] has indicated for successful chemistry teaching.

I think my biggest mistake, however, was that I continued to draggle students into directions that they might have explored for themselves if I had organized the learning environment differently. They would have had more opportunities to find out what they didn't know and understand without me interpreting that information for them. It is only after being out of the classroom for a year and a half that I realize how much I assumed and how little I really knew.

B. S.'s early frustration was that she continued to teach her students using a "method of teaching science that was meaningless." She now believes that her students might have discovered concepts on their own if she had "organized the learning environment differently." When her students "were more interested in playing with magnets than actually following a set of directions," BS saw an opportunity for them to "understand without [the teacher] interpreting that information for them." In transferring knowledge from one setting to another, BS made the same translation that we would like our students to accomplish.

Over the 14 years of BS's career, she experienced several stages of teaching. At several times she became dissatisfied by the superficiality of her students' understanding. These stages are characterized by moments in which she had revelations about how to more fully engage students. In hindsight, however, these points were not predictable. "Only after being out of the classroom for a year and a half" did she "realize how much [she] assumed and how little [she] really knew." The questions BS asks about her teaching are an important epiphany. "I questioned and still question myself about asking the right questions, not the questions about the content, but the questions about how the learning process truly works." Even though she has recently seen what her teaching can become, she cannot predict when the next insight or dramatic improvement in her teaching will be. These moments or insights are the highlights of her career; however, their paucity emphasizes how infrequently they occurred for BS. After all this time, BS still questions herself, and is frustrated that she is not better than she is. Like JC and WH, when she started teaching, she expected to be great by now; however, it seems that BS has identified a life-long process of intellectual and creative thought for a teacher, rather than eventually finding *the* right way. While Barb has experienced a 14 year career and experienced two "awakenings," the senior teacher of our group reflects upon his 33-year career and identifies 3 critical periods of transition. According to John Young, the cycles that Barb describes above in teacher development are not uncommon to other teachers.

John Young

John Young, the senior member of the group, was a high school chemistry and physics teacher for 30 years in Illinois

and has recently retired from his position. He continues to provide curriculum materials to schools and to other science teachers.

JY: At the beginning of my career, I taught as I was taught; I lectured. My method was very teacher-directed. I offered a good course. It was a college-preparatory course—at least I thought so at the time. The students I turned out went on and did unbelievably well at the university level. Many of these past students have come back and conveyed to me that they had been extremely happy with the course that I offered to them because it was like a college class. At the time, I did not worry about those students that had not returned to tell me that they were not happy.

After about five years of teaching this way, I really believed that I had firmly planted my feet on solid ground. I felt secure. I was also on tenure. The prominent philosophy of the time, the so-called "method of perfect teaching," was called individualization. Because I was an experimentalist at heart and I believed that I was now "safe," I decided to go ahead and experiment with my teaching methods. I experimented with individualization and put together a noteworthy program. Classes grew from two to three. Enrollment went up. The basic concept involved setting up a new methodology. We used films, audio-tapes, lectures, worksheets, and individual laboratory experiments. All aspects of the course were safe, and all were contained within the classroom setting. When the students finally got through the basic material, they would come up, roll the dice, pick up an individualized version of a test that had been placed on index cards. Each student had to get 80% of all questions right before they could move to the next section. If a student did not, they had to go back, recycle through the pre-existing material, and take another test. The individualized method worked for some people but, again, it didn't work for all. This was the first true inclination I had, that my approaches to teaching didn't work for all my students.

Individualization was interesting because it was in the philosophy of the time. Because it did not work for all students, it made me very realistic in evaluating new ideas and very skeptical of the many new ideas of educational philosophy that I would later encounter. Every teacher must go through a decision point, as I did. Teachers today go through block scheduling and are told that it is a panacea. People get into cooperative learning and define it as the new panacea that will positively affect all learners. What teachers eventually find is that there is not a single panacea or a single idea that will work for all students. Teachers must then begin looking at their own methodology and start blending and bending it to fit diversified situations. I began to blend my teaching and base its success on what I found in the eyes of my students: noting how they adapted to it, how they learned from it, how they functioned during it, and how they eventually showed signs of becoming an educated human being. As I approached the year 1986, I got myself into a feeling of, "o.k., I've had it; I'm either going to make this thing work or I'm going to completely fail at the try, *but* I'm going to try!" At that point, many things started to change in my life. In the past, my teaching had worked for some people. It especially worked for boys; it didn't generally work for girls. It worked for people who liked science, but those that were borderline weren't turned on at all. That was the real fallacy illustrated through that type of teaching that I had earlier pursued. I realized that when I had used a lecture orientation, I basically wrote off half of my class. I understand this now because most simply couldn't keep up with me. I would not slow down, because I would have held the rest of my students back. y excuse was simply the time factor. With this type of methodology, it is now obvious to me there was an elitist attitude established within the classroom, and that is why lecture orientation does not work, except in selected homogeneous groups.

At the same time that I was re-evaluating my methods, the one thing in my life that seemed to really affect me was that my two daughters were then in junior high school. I knew that they were soon coming into my high school and that I wanted to give to them the best science program that I possibly could. At the same time, there was funding that became available all over the state of Illinois, via science literacy grants. I thought, "o.k., let's go out on a limb and do something that has never been done before." So we developed an advanced science curriculum, under the funding of two state grants and over two consecutive years. Part of the program was to eventually disseminate this new curriculum throughout the state.

My determining teaching philosophy at this time was if students are to learn chemistry, a teacher first has to hook them. If students are to learn physics, a teacher must also hook them. To hook a student, the teacher has got to do something that the student wants to do, not necessarily something that the teacher wants to do. My theory was that the way to hook kids in chemistry was to hook them on a mystery investigation, a forensics unit. To get kids into liking physics, we decided to explore roller coasters and the physics of sport. If we can raise a student's batting average by 10 points, hit an overhead serve or volleyball spike without tearing their arm apart, improve one's golf game, or improve any other athletic endeavor via a study of physics, the students are going to love it. We did this, not as if we were coaching, but instead by teaching science.

Of course we also threw in the general topics of an application of momentum, kinetic and potential energy, velocities, accelerations, energy, etc. We constructed the curriculum as a real authentic assessment with no tests. All was based on laboratory reports; all involved cooperative learning and was based on the idea of self-discovery. We actually used directed learning most often, even though the students did not know that we were actually doing so. It was the methodology that was important, not the way it was written, but the way that it was approached. Advanced chemistry was developed based on forensics, new and past technologies, and eventually evolved into microchemistry. We had a carrot at the end of the rope! We had kids wanting to raise their batting average or solve a murder mystery, and in order to do so they had to take a basic chemistry course or a basic physics course before first. We began teaching by discovery.

Departmental enrollments continued to grow; the ACT scores went through the roof; the state test scores were up. Since we began the program, we have never dropped in any science assessment score on any science test. I believe the primary reason for our success is that we had our kids involved in things they wanted to do. If they want to do it, they will do it. We tried to respond to different groups of students by applying different philosophies to males and females, in order to bring more females into the curriculum and to value the contributions that those females could make.

I really had to start learning about students as individuals. When I did that on a professional level, all of a sudden they realized that somebody really cared about what they were doing. When I started doing that, my kids became a team. We all acted as a team during whatever course we were involved with. Even today I have kids coming back from this group; I have phone calls at night from kids in college who are 20-plus years old. What do you do about this or that? My standard comment is always, "Have you used the scientific method to solve your problems, because that is what I tried to honestly teach you.

There were three times in my career when I changed my teaching style and my basic teaching philosophy. One was very, very early and is when a lot of young teachers bail out. They have gotten tired of teaching and are disillusioned. They don't like the kids; they don't like to interact with them; they feel insecure about their job and the methods used and will simply leave the profession for a better life. In some cases, this might even be due to a financial descrepancy. It might be the fact that they had no educational support in the system that they were in. This first stage occurred early in my career, and for me it would have been anywhere from three to five years into it. If a teacher happens to make it through this particular time, is in a good school system, has a good mentor, or has something that keeps them there, then a teacher can transition into the second stage of their teaching career.

Ten or twelve years later, a more important transition occurs. At that time, I was re-evaluating what I had done through my own teaching endeavors. Had I done the right thing? It was still early in my life, and I again questioned if I should change my career, but, I continued on in that career, until I was 20 to 30 years into it. At that time I started to reflect, with some perspective on my career, as to whether it had been successful or not. It is more of a question early, "should I continue and pursue" while at the end it is, "did I do the right thing?" It was a kind of a get-to-know-yourself routine. In each of the three transition periods, people will bail out. More people bail out during the first interval because, in addition to their inexperience, they have many options. Young teachers can be disillusioned easily. During the middle transition stage, maybe there are not as many teachers leaving the career because many have already left. The last transition was really scary though, because I got to that point when I had only 5 to 10 years left before the conclusion of my career.

After a certain point in my career, my theory of teaching evolved from just teaching facts. It centered on how to use those facts. In life, it isn't the facts you remember that are important, it is what you do with them. When we got across to kids that it wasn't important if they got a true/false question right or wrong or if they got a definition completely right or wrong, but if they used the material in the proper context, that was when they had actually started to learn science. They learned to survive in the world. The whole idea of teaching science is simply not to teach just chemistry, or just physics. Many new teachers don't know that. Chemistry and physics are only vehicles to teach students how to live and survive in this world. If I could teach them the vehicle as well as why they are learning about the vehicle, then they will actualize the subject matter.

If you are a good teacher, you have to realize that your kids must be learning no matter how many times you have been through the material yourself. Every teacher gets into that trap. The more they teach the same thing, the more they know it, and they honestly expect the students to know it too. "Why in the world don't you know that? This is so simple." It would be so if they had been through it 15 or more times. By then they should understand it. As we do things, we are more apt to accelerate so as to get all things done, efficiently, but we too often skip those little things. We skip the eyes. We skip the Johnny in the back who has his head on the table and has had it there for the entire day. The bottom line is that you have to become like Johnny. You have to understand him. By the way, this is really tough to do. The older you get, it gets even tougher to do. When you can solve the generation gap, if you can pull that albatross off, then you might become an effective teacher forever. If you can't solve the generation gap, you will never be satisfied as a professional teacher.

I didn't know much of the above for the first 10 to 15 years of my teaching career. I was raised and mentored by traditional teachers. They were great teachers, people I love even today, but that is the way they were taught; that was the way I was taught. What caused the metamorphosis was the idea that I can do better than I am doing. I can do better than I've done.

JY, like the other three teachers, has experienced both successes and failures in his classroom. JY considered leaving the profession at several times. His frustration at not being able to meet his high expectations nearly drove him out. By watching and listening to his students, he took the risk and made a breakthrough in his approach to teaching and learning. Having taught longer than the other teachers, he has had more opportunities to learn that failures are just a pathway to the next reflective step in changing his teaching. When JY embraced these failures, he began to interact and respect his students as learning individuals, subsequently becoming a more constructivist teacher.

Conclusion

Through the course of this selfexamination, we began to recognize both our successes and failures as constructivist teachers, how our transformation from what we were to what we would like to be is an on-going process, and how the ultimate goal of our teaching focuses exclusively on students' learning. We are at times very successful in our classrooms. When our students "get it," we know. Even when only our intuition provides confirmation, we will adamantly defend what our students have accomplished. Our accounts show that we "look into the students' eyes," we read their body language, we listen to the students' questions, and we respond to the students' comments. At this stage of our careers, our definitions of success all focus upon student learning rather than our own actions.

Juxtaposed against this success, however, we have all experienced massive failures in our teaching. In our own words, we have taught as we were taught. We also adopted others' ideas. We focused on content and methodology rather than on students. We have worried exclusively about our performance as instructors in the classroom. In fact, at times we still do; however, when we accepted our failures and began to examine our teaching within the framework of our beliefs of how students learned, our teaching began to change for the better.

In dealing with successes and failures, teachers and students are very similar; however, especially for teachers, there are added difficulties that exist in dealing with the failures. First, as we get older, the failures should theoretically become more significant because the failures are supposed to occur less frequently and become less meaningful and less traumatic. We discovered that for us, however, the failures we experienced are often more meaningful and more traumatic. As a result, we often experience feelings of incompetence. Second, for many teachers, ourselves included, the concept of perceived power and control in the classroom becomes a concern. Traditionally, teachers are perceived as being powerful people who are in control of the environment that surrounds them in a classroom. Powerful people are not supposed to make mistakes. If they do, the mistakes must quickly be corrected in order to keep peace and tranquility for themselves and others in their world. Teachers are expected to set an example of success in the classroom by taking control and demonstrating how success can be achieved. As teachers, the four of us now recognize that our failures were not signs of incompetence, nor were they signs of a lack of power; they were a stage in an on-going process.

Having recognized these failures does have a terrific positive outcome. It makes the successes of our teaching even sweeter. When we create an environment in which both students and teachers can fail and succeed in constructing knowledge that comes from learning a concept rather than never losing a concept, then the triumph will never be lost. This is truly a magnificent moment in teaching. It is not getting ready for the next test, not transient ideas that are swiftly lost, but ideas and skills and attitudes that will last for the students' lifetime—the knowledge that the student has constructed that will allow the student to encounter and tackle even greater challenges and problems.

Implications

Maybe our whole belief system is entirely backwards. Successes may not be solely what we want to watch and emulate. The successes alone have not enabled us to reflect and change. When teaching goes "well," the teacher just moves on without contemplating improvement. As such, these successes are deceptions to ourselves about what we are accomplishing. People can grow and learn from the successes, but in our cases, failures have been more productive in promoting substantive analysis and change.

Should we, therefore, promote failures as being events that should be sought out, even celebrated? How can we explain such ludicrous desires? Why would anyone want to openly admit failure to their peers, their bosses, and even themselves? Maybe what we have missed all along is that the most beneficial learning experiences are those situations when we fail. If we are celebrating successes only, then we deprive ourselves of moments of exposure, reflection, and revelation. Somehow, out of the bewilderment, chaos, and bleakness, can we gain meaning by seeing the pieces lying around us? From these pieces, we may find what is missing and what is needed. We may never discover this information without the trauma that comes from failure and the reflection that causes revelation. It is only after we realize how lost we are that we can begin to find our way. If recognizing failures helps to promote change, then failure should be welcomed in the classroom for the sake of learning. If teachers believed that their students would successfully fail and rise to a greater understanding from the learning achieved, then students would fail without total devastation.

Because this revelation is true for the four of us, and because we believe that is also true for other teachers, then shouldn't this recognition be part of the teacher education process? Shouldn't preservice and in-service teachers be encouraged to confront their own failures in a supportive environment so that they can learn from them? Given our society's intolerance for perceived weakness, any acknowledgement of failure on a teacher's part must be allowed to come out in an extremely supportive manner. That is the challenge for us, to begin a dialogue in which we can openly admit our frailty.

In that open frame of mind, which fosters perseverance, problem solving, analyzing, and reflection, new hope for change exists. Brickhouse and Bodner [21] have identified that teachers face a constant battle between their beliefs and achievements. Adams and Krockover [4] have shown that retention in teaching is directly attributable to frustration with this discrepancy. If we teach in teacher education programs that both successes and failures as a teacher are inevitable, then teachers might be more resilient to the discrepancies in their classes. We also believe that teachers would benefit from failure experiences by becoming more conscious of their students, more conscious of their interactions with their students, and more conscious of the learning phenomenon in order to begin to understand what happens to students. Taking risks would become comfortable and celebrated in order to explore new ideas, regardless of the outcome.

References and Notes

1. Ingersoll, R. The Problem of Underqualified Teachers in American Secondary Schools. *Educational Researcher* **1999,** *28* (2) 26–37.
2. Julius, N. B.; Krauss, H. H., Eds. *The Aging Work Force: A Guide for Higher Education Administrators;* College and Univ. Personnel Association: Washington, DC, 1993.
3. Cipriano, P.A. Demographics: Blueprint for Growth. *American School & University* **1987,** *59* (April), 58–65.
4. Adams, P. E., Krockover, G. H. Beginning Science Teacher Cognition and Its Origin in Preservice Secondary Science Teacher Program. *Journal of Research in Science Teaching* **1997,** 34 (6), 633–653.
5. Krockover, G. H. The SALISH Project. Presented at the Purdue University Chemical Education Seminar, West Lafayette, IN. 1996.
6. Bodner, G. M. The Beginning Teacher: Classroom Narratives of Convictions and Constraints. Presented at the 16th Biennial Conference on Chemical Education, Ann Arbor, MI., 2000; paper 282.
7. Phelps, A. The Power of Good Practice: What Students Learn from How We Teach. Presented at the 16th Biennial Conference on Chemical Education, Ann Arbor, MI, 2000; paper 279.
8. Lumpe, A. T.; Haney, J. J.; Czerniak, C. M. Assessing Teachers' Beliefs About Their Science Teaching Context. *Journal of Research in Science Teaching* **2000,** 37(3), 275–292.
9. Lumpe, A. T.; Czerniak, C. M.; Haney, J. J. Science Teacher Beliefs and Intentions Regarding the Use of Cooperative Learning. *School Science & Mathematics* **1998,** 98(3), 123–135.
10. Czerniak, C. M.; Lumpe, A. T. Relationship between Teacher Beliefs and Science Education Reform. *Journal of Science Teacher Education* **1996,** 7 (4), 247–266.

11. Bybee, R. W. *Reforming Science Education*. Teachers College Press: New York, 1993.
12. Brooks, J. G.; Brooks, M. G. In Search of Understanding. The Case for Constructivist Classrooms [Revised]. 145 ASCD Publications, 0-87120-358-8, 1999.
13. Francisco, J. S.; Nicoll, G.; Trautmann, M. Integrating Multiple Teaching Methods Into a General Chemistry Classroom. *J. Chem. Educ.* **1998,** *75,* 210.
14. Jones, L. L. Preparing Preservice Chemistry Teachers for Constructivist Classrooms through Use of Authentic Activities. *J. Chem. Educ.* **1997,** *74,* 787–788
15. Metz, P.; Pribyl, J. R. Measuring with a Purpose: Involving Students in the Learning Process." *J. Chem. Educ.* **1995,** *72,* 130–132.
16. Huxley, A. *Brave New World.* [Reprint ed.] Harper Perennial Library: New York, 1998, p 268.
17. Russo, S.; Silver, M. *Introductory Chemistry: A Conceptual Focus*. Addison Wesley Longman: San Francisco, CA, 2000.
18. Staver, J. R. Constructivism: Sound Theory for Explicating the Practice of Science and Science Teaching. *Journal of Research in Science Teaching* **1998,** *35* (5), *501–520.*
19. von Glasersfeld, E. Radical Constructivism: A Way of Knowing and Learning. *Studies in Mathematics Education Series* **1995,** *6,* 231.
20. Tobin, K.; Tippins, D. J.; Gallard, A. J. **1994,** Research on Instructional Strategies for Teaching Science. In Gabel, D. L., Ed. *Handbook of Research on Science Teaching and Learning.* MacMillan: New York, 1994; pp 45–93.
21. Brickhouse, N. ; Bodner, G. M. The Beginning Science Teacher: Classroom Narratives of Convictions and Constraints. *Journal of Research in Science Teaching* **1992,** 29 (5), 471–485.
22. Hunter, W. J. F.; Nakhleh, M.; Calhoun, J. C. *Working with Preservice Science Teachers? What Would You Like Conveyed?* Presented at the 27th Annual Hoosier Association of Science Teachers Convention, Indianapolis, IN, 1997**.**
23. Carver, J. S. What Is Teaching Science All About? Presented at the 2000 PSP, Science Discovery Series, Chicago, Il, 2000.