Let Us Not Leave Any Qualified Teacher of Science Behind

by

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When *EJSE* Editor John Cannon invited me to prepare an editorial, I was thrilled. Moreover, he stated that I could choose my own topic. Telling me that is tantamount to letting a fox loose in a chicken house. Dinner will be ready shortly, as will this editorial.

Reports from scholarly societies (e.g., National Research Council, 2001) and independent researchers (e.g., Ingersoll, 1999) tell us that qualified teachers are sorely needed to teach our nation's students. Given the teacher's central influence on student achievement, we know that the mandates of the new Congressional funding act for elementary and secondary education, also known as the No Child Left Behind (NCLB) act, cannot be attained without qualified teachers in all of our nation's classrooms. Whereas several additional factors (e.g., culture and working conditions of K-12 schools) also weigh heavily in achieving the provocative mandates of NCLB, science educators have little or no control over many of the additional factors. Therefore, science educators can contribute best by assuring that no qualified future teachers of science are left behind.

Purpose

But, how can I avoid leaving a qualified teacher of science behind, you may ask? My response, which leads directly to my purpose herein, is to tell you that I was almost left behind, some 38 years ago. My purpose in this editorial is describe some of my crucial learning experiences and some of the influential people who helped me avoid being left behind. I also include some aspects of my career in higher education. By doing so, I hope to convey to the readers of *EJSE* a sense of the complexity, serendipity,

opportunism, and sensitivity that may be necessary to assure that qualified young people today will not be left behind as tomorrow's teachers of science, and also as tomorrow's science educators.

My Story

Let me begin my story by returning to my excitement at being invited to prepare an editorial for *EJSE*. Many readers are perhaps surprised that a senior citizen – I will celebrate my 59th birthday on August 8, 2003 – could be exhilarated by most anything, but I must confess that I still "get a rush", as the younger generation says, by writing. I offer two reasons. First, I write to learn, and during the course of learning I write about what I have learned, am learning, and will perhaps learn. If any of my junior high and high school English teachers were to read this paragraph, they would surely go into a state of shock! Yet some of what students learn does not emerge until much later. Writing certainly falls into such a category for me.

This learning-writing-learning connection is perhaps a never-ending circle, but I view it as the road ahead that I can see all the way to the horizon. This leads to my second reason; I am motivated to learn. I see my career as a drive along a road, stopping often to investigate and report on interesting places (e.g., constructivism) and events (e.g., controversy over evolution), but always moving toward the horizon, wondering what lies beyond. At this moment, however, I am looking in the rear view mirror, and I can view the road already traveled. Given my senior status, I can now see clearly why and how I was not left behind as well as why and how I have come to this point. If anything I say rings true – in a constructivist sense - for readers, then I am pleased for you. If nothing resonates, then turn to the next article. I will not be offended.

Sources of Motivation

Sir Isaac Newton once credited the work of his predecessors by saying that if he had seen farther than did others, it was because he had stood on the shoulders of giants (Steen, 1990). Whereas I make no claim to have seen farther than others, I do wish to acknowledge that the sources of my motivation are my own teachers and my experiences as a teacher.

I have stated elsewhere (Staver, 1998) that my motivation stems from my 7-year experience teaching high school students chemistry. These years (1968-75) were filled with immense joy as a then 24-year old teacher embarked upon a career chosen only a few years prior (I will say more about that later). However, these years also included a great deal of puzzlement and frustration, which centered on a single question: Why did my students struggle so much and their learning sometimes fall far short of my expectations when both of us worked diligently, me at teaching, them at learning? Vivid memories of students' struggles with the mole concept, stoichiometry, and the dimensional analysis - also known as factor label - method of solving stoichiometry problems remind me that, then as now, I teach for students' success based on the assumption that when the teacher and students are giving strong efforts, then the teacher must assume the responsibility for improving students' learning. Moreover, when students resemble couch potatoes in terms of their efforts, it remains the teacher's responsibility to find and use strategies to get them off the couch. Consequently, I spent more than a few moments figuratively, and sometimes literally, staring at the bathroom mirror, silently commanding the image staring back at me to find remedies that I could employ to improve students' learning.

Theory and Practice

Having been introduced to Piaget's theory by Hans Andersen during my undergraduate teacher preparation program at Indiana University, I experienced a long-term, in-depth treatment of Piaget's ideas from Dudley Herron at Purdue University during my masters program. Moreover, these ideas were applied specifically to teaching and learning chemistry as I earned an M.S. in chemistry at Purdue via a four-summer (1970-73) institute for chemistry teachers funded by the National Science Foundation. Considering my teaching and my students' learning in terms of Piagetian theory produced numerous valuable teaching-learning insights, and the sight of my students' improved achievement simultaneously elevated their personal satisfaction and fueled my desire to learn more. Alas, I wish that today's action research (e.g., Jordan and Sutton, 2002) had been fashionable 33 years ago.

Puzzlement and frustration, while diminished, eventually began to return in a newly evolved form. Beginning in the 1972-73 school year, I slowly realized that I wanted to learn the answers to many other questions, but I would never have the opportunity to inquire and perhaps find answers if I remained a high school chemistry teacher. From this source of annoyance emerged the notion that I should perhaps consider a doctoral program. I applied to the doctoral program in science education at Indiana University in fall of 1973, in part because it seemed to offer a broad perspective on science education, but mostly because it offered me an opportunity to study again under the direction of Hans Andersen, who was my undergraduate science methods teacher and a then young IU faculty member who helped a lost, confused, and wandering undergraduate student find his way into teaching.

Indebted for Life

Explaining Hans Andersen's influence upon me requires that I fast-forward to the present day. I advise secondary students at K-State who are seeking licensure to teach high school chemistry and physics. I also discharged this duty with great pleasure at two prior institutions of higher learning, DePaul University and the University of Illinois at Chicago. Throughout my advising experiences, I have found that many future high school chemistry and physics teachers begin their college educations with other career paths in mind, especially those careers in research and industry that build upon the foundation of a major in chemistry, physics, or engineering. Toward the end of advising meetings, I ask the following question: How is the university treating you? Students' responses sometimes convey their sense of discomfort and concern, occasionally disillusion, and rarely even failure. Many have devoted two or three years of their college educations successfully – meaning high grade point averages - studying their chosen disciplines; yet, they questioned – some are still questioning - their majors and have switched to teacher education or are considering doing so. Looking at me, they perceive that I must have had an easy time in college. After all I hold a doctorate as well as the title of professor. At this point I take the opportunity to tell part of my story, thereby revealing that the road to success can be filled with confusing directions, sharp turns, and obstacles.

Thirty-eight years ago I sat across the table from Hans Andersen, having a similar conversation. Then a new assistant professor of science education, Andersen listened quietly as I expressed many of the same feelings of discomfort and disillusion that I hear from my advisees. I had spent nearly four years at Indiana University, briefly as a pre-

medicine major followed by aimless wandering, then as a chemistry major and mathematics minor. Well along in my major and minor, I had serious concerns. I did then, and still do, enjoy chemistry; however, I experienced a growing discomfort with the work of a chemist, what I saw as long, lonely hours in laboratory research. Professor Andersen helped me realize that I could apply my enjoyment of chemistry and my people-person character in other ways, such as teaching. Hans Andersen was the catalyst who helped a confused, disillusioned college student sort out his thoughts and emotions, then set a new course to become a teacher. I transferred from the College of Arts and Sciences at IU to its School of Education, and Hans Andersen then proceed to teach me how to teach science. He was, without doubt, the key person who helped me to not be a teacher left behind, and I owe him a priceless debt of gratitude, one that can never be repaid, only passed on as a teacher's legacy. Thus, when the opportunity arises, I tell this part of my story to my advisees, hoping that it will offer them safe harbor in a storm of confusion as well as an opportunity to chart a new course as the storm begins to subside.

Additional Important Influences

I also inquire of my advisees about important people in their lives. They usually talk about their parents, siblings, other relatives, and teachers. If the moment seems appropriate, I tell them another segment of my story. This part reveals why I chose chemistry as a subject, a choice made long before I considered teaching. My answer is simple; his name is Mr. Troth, my chemistry teacher at Speedway High School in Speedway, Indiana. If he were to walk into my office, today, I would still greet him as Mr. Troth. Tall and lean with a crew-cut flat top hair cut, Floyd Troth was a no-nonsense teacher. He also challenged us to think. Although I didn't realize it at the time, his

intellectual challenges and his ability to make chemistry interesting were the source of my subsequent choice of chemistry.

An illustrative snapshot of Mr. Troth's class is the day early in the second semester when he distributed the unknowns. Emerging from the preparation room with a cardboard box full of test tubes, Mr. Troth strode slowly and purposefully throughout the rows of students, stopping occasionally to allow a student to draw a test tube from the box. The contents of those test tubes represented the next 6-8 weeks of intensive laboratory work as we conducted extensive qualitative analyses to determine their chemical contents. I vividly remember a friend who drew a test tube containing apparently a clear, colorless liquid. Amazed and staring at the test tube, my friend blurted out, "Mr. Troth, there is nothing in here but water," to which Mr. Troth responded, "Do you wish to turn in that answer today?" "No, no" replied my friend, "I need to run some tests."

I did not distinguish myself in his class, but I worked hard to earn a mixture of Cs and Bs for the six-week grading periods throughout the school year. Perhaps ten years later, I attended a basketball game at the school where I taught, North Central High School in north suburban Indianapolis. North Central's opponent that evening was Speedway, and in walked Mr. Troth. I watched as he took a seat in a row of bleachers near the top of the gymnasium, and I debated as to whether I should say hello. Surely, I thought, he will never remember me, but I knew clearly by then that my experience in his class was the driving influence in my choice to study chemistry at I.U. Slowly gathering my courage, I mounted the bleacher steps. Seeing me approach, he said, "Hello John; what are you doing here?" Attempting in vain to hide my surprise that he remembered

me, I somehow managed to reply, " Mr. Troth, I teach here." "John, what do you teach?" he asked. I answered, "Well, Mr. Troth, I teach chemistry." I have absolutely no idea whether Speedway or North Central won the basketball game. Mr. Troth and I talked about teaching chemistry, about students, and about schools the entire time. When we parted, he knew the importance of his influence in helping his former student, who was then a young teacher, to not be left behind.

Going for It

Following the 1973-74 school year, Patricia Love Staver and I packed our bags. I drove to IU in Bloomington, Indiana to begin my doctoral program. She went to France. As a French teacher, she had never been abroad, and she took advantage of a rare opportunity. Reflecting today on our decisions, I often gaze at one of several motivational pictures I purchased and placed in the hall near my office. One picture shows a basketball goal in an old gym. The scene is rather dark but sunlight streams upon floor in front of the basket. The caption, "Opportunity", is followed by these words: "You'll always miss 100% of the shots you don't take." We returned home at summer's end and taught one more school year, then left our jobs, sold our house, packed our bags again, and headed for Bloomington together, she to earn a doctorate in foreign language education, me to continue what I began the previous summer. I marvel at the many graduate students who have not only spouses but also children. I remain unsure as to whether the Stavers would have taken this step had we had children at the time.

I chose IU, as I stated above, because I felt that I needed a broad perspective of science education. Once there, I became involved with elementary science education in terms of teaching, and Piaget's theory continued to serve as an excellent theoretical

framework for understanding K-6 science education issues and teaching future elementary teachers. Moreover, I reestablished a student-teacher connection with Dorothy Gabel, who would direct my doctoral thesis research. Dr. Gabel had been Dudley Herron's doctoral student at Purdue during my masters program; after earning her doctorate, she became a faculty member in science education at IU. Under her direction and Hans Andersen's mentoring, I continued to probe deeper into the depths of Piagetian theory, eventually developing and construct validating a group-administered test of several formal reasoning patterns for my doctoral thesis (Staver, 1978; Staver and Gabel, 1979). My purpose was largely instrumental; researchers needed such instruments to study teaching and learning with large groups of students, but Piaget's clinical method involved time-consuming, task-oriented interviews of individual learners. I, as did several colleagues in my own generation (e.g., Tony Lawson and Ken Tobin), then used group-administered tests in our subsequent research.

As scholars began to find fault with Piaget's theory, particularly with its logical formalisms, researchers in science education and other fields moved beyond Piaget. My own movement was in the direction of the constructivist epistemology that formed the philosophical foundation of his ideas. I must admit that I my early investigations into constructivism were from a skeptical viewpoint. Introduced to the provocative, even controversial concepts (e.g., we have no assurance that human knowledge corresponds to reality; thus, we think of knowledge as a coherent organization of our experiences), I searched for evidence to perhaps disprove these ideas. But, the more I searched, the more I became convinced that constructivism is sound theory for understanding and conducting the practice of science and science teaching (Staver, 1998).

Constructivism again proved its value as an explanatory framework as I became involved in the on-going controversy over evolutionary theory in school science. I have often asserted publicly that this has been, and continues to be, the single most frustrating experience in my career as a science educator. My rationale is two-fold. First, I have encountered many individual extremists on both ends of the broad continuum of thought, religious fundamentalists and atheistic scientists. I use adjectives such as close-minded and not teachable to describe such folks. Second, my fundamental character is that of a teacher, and I must work with some individuals who are essentially not teachable, in that there seems to be no evidence sufficient to cause them to reconsider, let alone change, their positions. As I interact with people in the context of this controversy, I utilize constructivist theory to develop an understanding of their positions in terms of their past experiences, prior knowledge, and so forth. Moreover, I have spent considerable time reflecting on my own position as a theistic evolutionist in terms of constructivist theory.

Moving On…

Bringing this editorial to closure, I want to make two points. First, I have continuously embraced what I describe as a professional orientation. The three traditional aspects of faculty work in institutions of higher learning are research, teaching, and service. Whereas I see a teacher when I look in the mirror, I like to think that the person looking back at me exhibits an integration of research, teaching, and service that has resulted in the emergence of an unpredicted property, a professional orientation, one that is analogous to the way in which stereoscopic vision emerges from the placement of our eyes on the front of our heads where they can function together, as a result of evolutionary forces.

Second, given my senior citizen status and this reflective editorial, it occurs to me that readers may think I am ready to announce my retirement. I will know when it is time to retire because that will be the day when I am no longer motivated to travel a road I have navigated for my entire career. I will then park my car, kiss Patricia Love Staver, my wife of 36 years, enjoy my grandchildren who are yet to come – my two daughters are still in college and not yet married so grandchildren aren't even on my horizon just yet – and play golf. But, as that preeminent ESPN college football commentator Lee Corso, says: "Not so fast!" I am pulling onto the road and moving toward the horizon, because I see two or three interesting places just ahead. One is neuroscientific models of brain function, a place which I have visited before (Lawson & Staver, 1989; Staver, 1998); another is evolutionary psychology. Can these areas of research and scholarship perhaps improve my current response to my original question? Can constructivist theory resolve conflicts between antagonists in the evolution controversy? If so, would anyone be willing to accept such a resolution? See you down the road, and when we do, I would appreciate hearing about a teacher or science educator whom you helped to not be left behind.

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