Chapter 3
Policy and the Planned Curriculum: Teaching High School Biology Every Day

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In late July of 2005, I began full-time teaching at a large, diverse high school in the southeastern United States. Having previously resigned my academic position at a university, I applied for the open position of biology teacher through the regular process for job applicants. Although I had several personal and professional reasons for this endeavor, my main motivation can be summarized as the desire to practice in an authentic classroom setting what I had learned, taught, and researched for many years as a professional science educator. I sought to develop a deeper understanding of the promoters and barriers for teaching science as a process of meaningful construction. I wanted to investigate why reform-based practices, such as inquiry-based teaching, were not more widely used. At the time, I considered remaining in the classroom for the next phase of my career, although I ended up leaving after one academic year. This chapter begins with a description of my teaching context so that the reader will be able to form a picture of my daily teaching life. I then go on to present a theoretical model for social change that I believe captures the dynamics of influences on my teaching. Third, I will expand on how these influences came together to shape my everyday practice. I will conclude with some implications for both science teacher education and research from my personal perspective.

My Teaching Context

My teaching job was in a large high school in the southeastern United States, and as the sole high school in the district, it served a socioeconomically diverse population of about 2,800 students. The demographics of the school included approximately

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65 % Caucasian students and 35 % African American students in grades 9–12. The school was located near a large naval base and many of the students' parents were in the military. The building was approximately 20 years old and generally in good physical condition. There were five administrators in the building including the principal and four assistant principals, each with a specific domain of expertise. Our high school sponsored a large and comprehensive athletics program, including football, which was very well supported by the local community. In addition to athletics, the school administration prided itself on academics and belonged to the league of schools group, known as "High Schools That Work." During the year of my teaching, the administration also implemented a professional development program for teachers based on a commercial package of "effective" teaching strategies known as "Learning Focus." The goal was to have all teachers in the building trained in the program by the end of the academic year. I was required to attend two "Learning Focus" professional development days during the year.

My classroom was one of the smaller science classrooms and was equipped with lab counters and sinks around the perimeter of the room and 14 blacktop tables that accommodated two students each. There was an adequate supply of materials and equipment that the 22 science teachers in the department had ordered and collected over the years and were generally willing to share. For ninth grade physical science and tenth grade biology, students were grouped heterogeneously with the exception of a few honors sections. The school was on the 90-min block schedule with students completing the entire biology course in one semester. Biology was one of the courses for which a mandatory standardized "End of Course" exam was given to provide data for the formulation of the "Annual Yearly Progress" report, which was in turn required for continued federal funding under "No Child Left Behind" legislation. I taught three 90-min blocks of biology each day and had one 90-min planning period that was taken up with mandatory meetings on the average of twice each week.

My Classroom Culture

My students were heterogeneously grouped teenagers from 14 to18 years old and for the most part were Caucasian or African American. They came from neighborhoods ranging from poverty-ridden trailer parks to luxury homes. I had two or three students in each class period who were served as special needs students mainstreamed into science classes. I also had two or three students each class period that had previously failed biology and were repeating the course. The culture I sought to establish in my classroom is perhaps best described as a learning community. As a science teacher, I emphasized thinking and problem-solving skills over factual content, worked to foster students' metacognition, included nature of science lessons, and most of all tried to promote the belief that all students could learn science. In general, I did not have much difficulty with classroom management and discipline. Once my students became accustomed to my learning community orientation, questioning, active collaboration, and task engagement for the most part became the norm. I did, of course, have a few students throughout my classes that did not engage meaningfully on a regular basis. And there were some occasions when I did find classroom management to be a challenge. These times tended to occur when I was teaching very abstract content from the mandated curriculum and students, losing their ability to follow the concept, gave up on understanding and began off-task behavior.

My teaching year was personally rewarding in so many ways. I often felt uplifted from my daily interactions with the students. Students told me that they enjoyed coming to my class and that they liked the way I taught. I saw "the light come on" dozens of times. A few examples include (a) a lesson in which a student repeating the course for the third time came to the front of the class and explained the process of protein synthesis accurately from beginning to end, (b) a lesson in which a girl who considered herself to be "dumb" in science came out with an original example of natural selection, (c) and the experience that an African American male student who had formerly made "Cs" in science began achieving very highly on assessments. On the other hand, I was consistently frustrated with what I perceived to be a lack of autonomy in the classroom. The school management imposed practices on teachers that I felt were in opposition to the needs of my students. As I attempted to implement innovation in my own classroom and engage in discourse with other teachers about innovation, I often felt that I was "up against a brick wall." Constraints of the mandated curriculum and testing regimes, along with social pressure to conform to the school culture, proved to be much more profound than I had ever imagined as a university academic. Some details of my experiences are explicated in the sections that follow. The reader should, however, keep in mind that my experiences were in a particular teaching context and may not be generalized to all high school science classes.

Critical Realist Social Theory

Approximately 2 years after I completed my year of high school teaching, I came across a theory, known as *critical realist social theory*, created by Margaret Archer (Archer 1988, 1995, 2000) that provides a framework for analyzing factors influencing change and/or stasis in social systems. I found critical realist social theory to be quite powerful for elucidating the dynamics surrounding my attempts to affect change in the classroom. Critical realist social theory (Archer 1988, 1995, 2000), which examines the ecology of systems, allows us to hypothesize how and why change occurs (or fails to occur) in social settings. Figure 3.1 illustrates how a social system might be represented in this way.

Critical realist social theory posits a realist ontology and a social constructivist epistemology for describing how knowledge and practice are created in complex social settings, such as schools. Realist ontology reflects Archer's perspective that entities such as cultural ideas and knowledge exist outside the mind and persevere

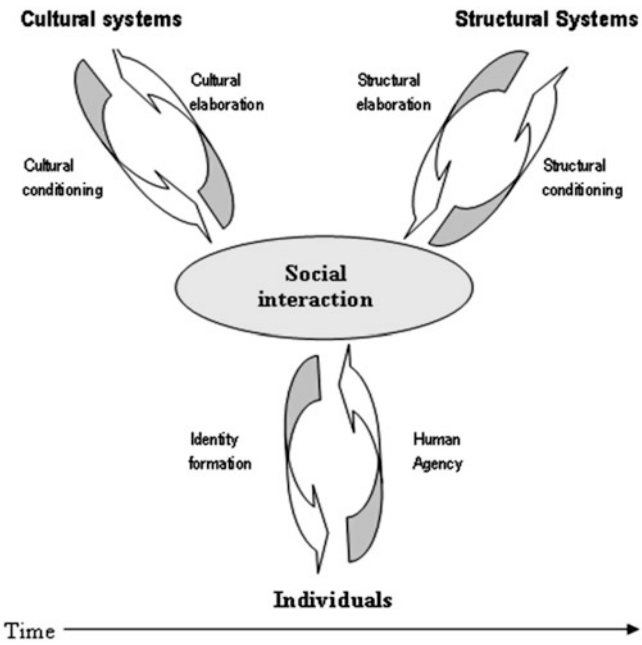

Fig. 3.1 Archer's (1995) theory of morphogenesis and morphostasis (First published in Wallace and Priestley (2011))

through time. For example, an ancient book may be discovered that sheds new light on what was previously thought to be a well-understood set of ideas. A social constructivist epistemology is illustrated by showing how three social factors, structure, culture, and agency, meet and are mediated in zone of social interaction, which in turn acts back on structure, culture, and agency (see Fig. 3.1). Archer (1988) further describes the possibility for change or stasis as morphogenesis/morphostasis (M/M). The term "morphogenesis" is derived from biology and literally means "beginning of the shape." Archer uses the term to signify the emergence of change in any complex social system. "Morphostasis," on the other hand, refers to the stability of a structure and is used by Archer to refer to continuity in the system.

M/M facilitates our understanding of how change and/or continuity occurs in social systems. First, society consists not only of people but also of social structures and cultural forms. Structure refers to the recognized relationships that characterize a stratified society, for example, the hierarchy of school classroom, department, administration, district, and state legislature, and the emergent properties of these relationships, including power. Cultural forms include enduring social norms, values, ideas, and knowledge (Archer 1988). Examples in the school setting would be bell schedules, classroom management routines, and well-known forms of instruction, such as "lecture" and "lab." Agency includes what Archer (2000) describes as "personal emergent properties," such as beliefs and identity of individuals, and may be represented through teachers' daily actions. Archer's social theory allows us to separate cultural forms, social structures, and human agencies for the purposes of analysis, providing the opportunity to tease out the relative contributions of each to the system's capacity for change. In the sections below, I describe some of the interactions among social structures, cultural forms, and my own teacher agency that unfolded during my year of teaching. These interactions shaped both my own classroom teaching and the potential for M/M of science teaching at my school in general.

Social Structure Influences

As described above, social structure refers to relationships among various stratified organizations and their properties, including power. I felt that the social structures most affecting my everyday life as a biology teacher included the power of the state legislature and the state Department of Education to determine what I might do as a teacher in a classroom. Decisions made by these entities resulted in the adoption of a mandated curriculum with characteristics that often thwarted, rather than promoted reform-based teaching. In this section, I elucidate how policies adopted by those political bodies empowered to oversee public education create social structures that critically impact the teaching actions of individuals.

The impact of the mandated curriculum on teachers' beliefs and actions has been researched for many years (see, e.g., Olson 1981 and Yerrick et al. 1997). However, I believe that many science educators, myself included, have continued to lack a deep understanding of the ways curriculum policy works in schools. Perhaps we have been hoping that individual reform-minded teachers would be bold and assertive enough to cast away these mandates in favor of more innovative instruction. For example, Tobin and McRobbie (1996) wrote about the "cultural myths" of secondary science teaching including the transmission myth, the efficiency myth, the myth of rigor, and the myth of preparing students for examinations. They asserted that teacher beliefs about the necessity of covering the mandated curriculum and preparing students for exams must be taken into account when innovators attempt to introduce inquiry-based instruction into the classroom. The use of the word "myth," however, suggests the notion that while popularly believed by teachers, traditional views and stories told by teachers about transmission, efficiency, rigor, and exam preparation are not necessarily true. In this section, I argue that forces at work in the system that are larger than teacher culture affect the way curriculum policy is interpreted in the classroom. Science educators may not be aware of these ways in which teacher practices are embedded in much larger systems of social structures which place enormous pressure on the social interactions that go on in schools.

Historically, educational policy has changed from a regime of professional accountability in the 1970s (teachers making decisions as professionals) to a regime of conservative and neoliberal corporate accountability in the decades since (Hursh 2007). In the 1980s, politicians, no longer trusting the judgment of teachers to determine characteristics of a high-quality student performance, ushered in models of accountability located in the hierarchical practices of bureaucracy. These models are based on business and emphasize productivity, performance, and efficiency. Schools and teachers are held accountable based on a model of producing academic performances. Ball (2003) coined the term "performativity" to describe school systems' preoccupation with demonstrating achievement through observable performances. Students produce observable performances in the form of scores on standardized achievement tests. The most overt product of this policy shift in the United States is "No Child Left Behind" legislation that provides federal funding for schools in direct relation to the production of desirable test scores. High-stakes, standardized tests are claimed to be objective, valid, and reliable assessments by which parents may hold teachers and schools accountable in the market economy (Hursh 2007).

Thus, a central role for curriculum standards has become to specify what constitutes a successful academic performance, so that the public can easily compare the effectiveness of particular schools or districts in an analogous fashion to comparing brands of material products. In order for standardized tests to appear objective, valid, and reliable, they need to be based on a set of curriculum standards that appear to be value neutral, in other words, framed on factually correct or unquestionable science content. Kelly (1999) explains that many Westernized countries have been using a model of curriculum planning known as curriculum as *content* and *product* to achieve these goals. The content aspect of the model is predicated upon the belief that there is a common body of high-status knowledge, independent of the knower that all must learn. Individuals in charge of curriculum design determine the body of knowledge and thus control what is to be taught in classrooms (Apple 2004; Kelly 1999).

As Apple points out (2004), since curriculum designers choose the content, their values for what counts as science are actually incorporated into the curriculum, despite its value-neutral appearance. Curriculum as content ignores the interests, abilities, or cultures of the recipients of the curriculum. The product aspect of the model further indicates how this content is operationalized with the construction of educational objectives that can be explicitly observed through a learner's performance. Every educational aim is broken down into behavioral objectives that are discrete and decontextualized. The demonstrated achievement of each objective is considered to be the product of the learning process. Teachers are expected to deliver the product in terms of high test scores. The content and product model of curriculum planning serves the interests of the designers of educational policies based on accountability.

For example, one of the Georgia Performance Standards for biology is for students to be able to "distinguish between DNA and RNA." Although most would agree that the concept of how genetic material transmits information is important in biology, when this statement is operationalized for classroom teaching, it in fact necessitates the learning of isolated biochemistry facts. RNA differs from DNA in three ways: (a) it contains the sugar ribose, instead of the sugar deoxyribose; (b) it contains the base uracil, instead of the base, thymine; (c) and it is single stranded instead of double stranded. For a scientist, these biochemical facts trigger understandings of how genetic information is coded and moved from the cell nucleus to the cytoplasm where proteins can be built. However, few 14-year-olds will have the prior knowledge to assimilate the importance of these facts into a complex explanation for protein synthesis. The knowledge is decontextualized in the language of the standards, because it is not directly associated with other understandings about protein synthesis. Yet, the three facts will be fair game for a standardized test question presented in a similarly decontextualized way.

While behavioral objectives are nothing new (and in many ways quite helpful in guiding instruction and providing equity), the social pressure to keep what is taught rigid, technical, and decontextualized so that students' standardized test performance will be an "objective" measure through which schools can be compared has never been greater. The consequences of this web of policies include the stripping away of teacher autonomy, creativity, and instructional actions that correspond to the cultures, backgrounds, and needs of students (Au 2007; Lingard 2005). Teaching is therefore regulated through a hierarchical chain that represents the power relationships of strata in the system. Teachers must be accountable to lower management, such as lead teachers, who are in turn accountable to upper management, including the school administration, who are in turn accountable to the district, state, and the national governmental educational authorities. The system is enforced through a social system of power in which it is made clear to teachers that their very jobs depend on their adherence to the mandated curriculum.

This allegiance to the mandated curriculum is enforced through the renewal of teachers' contracts being directly tied to their students' scores on standardized tests. In my situation, while it was theoretically possible to ignore the mandated curriculum and disregard exam preparation in my daily teaching, consequences of the majority of my students failing the End of Course and High School Graduation tests would have included: (a) answering to irate students and parents; (b) being closely observed and coached in my classroom to insure there would be a change in my teaching practices; (c) being ostracized by my colleagues; and (d) eventually losing my job due to lack of student achievement. The enforcement of adherence to the mandated curriculum therefore posed a dilemma for me that proved impossible to completely resolve. Teaching science through reform-based practices such as inquiry- and project-based learning requires instruction that is divergent, promotes questioning, is contextualized into real-world situations, relies on students' prior knowledge, and is often open ended in outcome. These instructional goals are in direct opposition to a curriculum that is designed to be rigid, prescribed in terms of content, technical, and decontextualized. In order to keep one's job as a teacher, it becomes necessary to implement instruction that will maximize the probability that all children will land on the same concept in a form it will be recognized on a standardized test item. The social structure of power relationships between policy makers and individual teachers limits opportunities for scientific inquiry, investigation, and intellectual independence of both teachers and children.

For example, when teaching the ecology unit, I was required to teach six comprehensive and complex behavioral objectives with their associated terms in about 3 weeks. Since any of these concepts and terms might be tested on the standardized exams, it seemed fruitless to try to prioritize some over others. One of the most troublesome of these objectives read as follows: “Assess and explain human activities that influence and modify the environment such as global warming, population growth, pesticide use, and water and power consumption.” Somehow, I was expected to teach complex causal chains of reasoning within four large topical domains in a couple of days. Knowing this was essentially an impossible task, I used a cooperative learning activity for students to practice their science reading skills in relation to these topics. I divided the class into “expert” groups for the four topics and the students read printed literature with a reading guide. Then they were rearranged in groups with one or two individuals responsible for teaching the main concepts from the topic they had studied to the group. I felt that the students treated the ideas somewhat superficially, but it was hard to get them engaged without some type of authentic experience with concepts such as “greenhouse effect” and “biological magnification of pesticides.” After completion of the activity, I decided to move on to other objectives that seemed more reasonable.

Cultural Influences

Research has consistently shown that the social cultures of school science contribute to teachers’ compliance with structural forms of power (see for example, Munby, Cunningham and Lock 2000). For example, my colleague and I (Wallace and Kang 2004) investigated the competing beliefs of high school science teachers who were generally enthusiastic about implementing inquiry-based instruction in their classrooms. Through this study, we gained a deeper understanding of how these teachers tried to balance their desire to teach science as inquiry with the social pressure to address all the content in the planned curriculum. One theme emerging from this work was that teachers held both “private” belief sets about inquiry that they expressed in the safety of our group and “public” belief sets about the importance of curriculum topics and testing that they expressed in their school environments with other teachers and students. The teachers confided to the researchers that they would use inquiry-based teaching much more often if they were not responsible for teaching the mandated curriculum. This study helped me understand that the development of a “reform-minded identity” (Luhemann 2007) in teachers might only be one step in reforming science teaching practices on a large scale.

Once I was in the classroom myself, I discovered that what I had learned in the Wallace and Kang (2004) study was only the tip of the iceberg. Having taught and researched effective science teaching strategies for some 18 years, I faced the classroom filled with optimism that I would not fall under the cultural influences that dominated the instructional decisions of many teachers. At the beginning of my teaching, I was sensitive to the fact that I did not want to appear as a “know it all” to my colleagues by virtue of my advanced degree, research knowledge, and publications. I soon learned that I did not need to worry about this issue; not only did my fellow teachers know nothing about my role in science education research, they had no interest in learning about my background or expertise in topics such as assessment or inquiry-based teaching. Much to my dismay, I found that my colleagues tolerated and even in some cases embraced the culture of accountability and performativity set in motion by the social structures and policies described in the previous section. The vast majority of professional discourse occurring between teachers in my science department dealt with the topics of testing and how best to prepare the students for End of Course exams. For example, a veteran teacher who taught in the class next door to me insisted that I use an activity she liked to demonstrate the loss of energy in steps of a food pyramid. The activity involved having students transfer water in a relay-type fashion, spilling some along the way. When I suggested students might have difficulty making a connection between that activity and the biological concept, she said, "I've found there's no better way to drill it in their heads for the test." When I offered to share various labs with other teachers, they had to first be vetted by the lead teacher for their usefulness in conveying terms or concepts identified in the mandated curriculum. The social pressure to conform to a culture of producing high test scores was immense.

One vignette which illustrates the science teachers' allegiance to the cultural practice of testing was the "episode of the 9-week exam." When I began teaching in August, I had decided that I would not use any paper and pencil test items that forced convergent thinking, such as multiple choice or fill in blanks. My idea was to use more authentic assessments, including writing, a sketch portfolio, concept mapping, and projects for the basis of judging my students' performance. I quickly learned that the teachers in the biology section of the department were obligated to give a long, multiple-choice 9-week exam at the midterm and that the test scores had to count for at least 10 % of the students' 9-week grade. Further, teachers were obligated to administer ten common multiple-choice questions on each unit test throughout the semester. The other teachers generally supported these requirements as an opportunity for students to "practice" for the End of Course and High School Graduation tests.

The six biology teachers were required to attend a "common planning" meeting once each week, so that we could coordinate our efforts to prepare students for the 9-week and End of Course exams. Much of this meeting time during the first half of the semester was taken up with reviewing the construction of test items that the lead teacher had written for the 9-week exam. Being required to participate in this exercise, I decided to make the best of it and lend my expertise to the endeavor. The lead teacher had had no formal training in test writing or assessment, and I determined there were validity and reliability problems with a large number of the test items. However, she and the other biology teachers had no aspirations to engage in meaningful dialogue that would actually improve the test. They limited discussion to tinkering with the wording of the stems or answer choices without critical evaluation. I got the impression that most of the other teachers just wanted to "go along" with the lead teacher's test, so that they could (understandably) leave the meeting and get back to their classrooms. Therefore, the irony was that although a great deal of time and attention was focused on the development of the 9-week test, in the end, the test remained a poor measure of biology achievement. The discussion of the test was a formal hoop that the teachers needed to jump through to show allegiance to the culture of testing. It was as if the other teachers, viewing the test as uncontestable, had lost the interest or will to challenge the lead teacher. However, in their acquiescence, they supported the culture of performativity that the test represented and helped the lead teacher as a representative of this culture save face.

Again, it was a couple of years later that I was able to gain perspective on the culture of allegiance to performativity by reading literature from educational policy. An article by Stewart Ranson (2003) was of great help here. Ranson (2003) posits that accountability is more than just a system of record keeping; it becomes an instrumental event that shapes the ongoing course of practice. When individual teachers are evaluated in terms of their performance for producing test scores, their present performance and the expectations for improving their future performance become seemingly normal modes of thought. As Ranson (2003, p. 469) suggests, accountability fosters "a routine disposition of public service professionals, shaping their modes of thinking, feeling, speaking and acting." He further explains that the two trends, increasingly specific regulation from the outside and the internalized disposition for increased performance by members of the culture inside, "fuse together into an intensive system of performativity . . ." Performativity works from the outside in, through regulations, controls and pressures, but also from the inside out, "colonizing lives and producing new subjectivities (Ranson 2003, p. 469)." The practiced norm of the culture became a corps of teachers desiring to comply with the system and be socially rewarded for producing high test scores. Individual teachers who differ in their opinions about curriculum and testing would therefore appear to have abnormal views. In my science department, there was meeting time set aside for the public declaration of the results of each teacher's standardized test scores at the end of the semester. Teachers with poor test scores were encouraged to observe the practice of teachers with high test scores. When the science department as a whole achieved a "passing" status for the "annual yearly progress" assessment, congratulatory announcements and flyers were posted throughout the school building. These public practices served to cheer on those teachers with high scores and punish those with low test scores.

Agency Influences

Agency is the third point of the triangle of influences on the zone of social interaction from which change or stasis emanates, according to Archer (2000 see Fig. 3.1). In simple terms, agency is the capacity of individual actors to act independently of social structures and to critically shape their own decisions (Priestley et al. 2012). Archer (2000) has written extensively on the nature of agency and rejects both an overly individualistic view of agency based on psychological concepts of efficacy and an overly socialized view in which social structures render the individual as little more than a conduit of the values of society. I found this centrist notion of agency to be resonant with reflections on my high school teaching experiences. In a similar vein, Biesta and Tedder (2007) have asserted the notion that agency is achieved under certain ecological conditions, such as the social environment in a school. They posit that agency can be viewed as a combination of the personal capacity to act in combination with the conditions of the environment in which that action occurs. They write:

> [T]his concept of agency highlights that actors always act by means of their environment rather than simply in their environment . . . the achievement of agency will always result in the interplay of individual efforts, available resources and contextual and structural factors as they come together in particular and, in a sense, always unique situations. (Biesta and Tedder 2007, p. 137)

To me this means that while individuals may have an extraordinary desire and capacity to effect change, at least in the sphere of their own classroom, their actions will always be mediated by contextual and structural factors in the system. Priestley et al. (2012) studied the teaching practices of three high school teachers in Scotland with respect to their projection of individual agency in the classroom. Two of the three teachers expressed the desire for their students to develop thinking skills and connections within their disciplines, rejecting the narrow goals of high achievement on exams that dominated the discourse in their schools. They provided multiple opportunities for students to learn through dialogical, experiential, and student-centered instruction in keeping with these values. A third teacher in the study was content with enacting instruction compatible with the espoused values of motivation and high exam scores that permeated the culture of performativity within which he worked. He did not assert his capacity for agency, presumably because he did not see a need for students to attain educational goals beyond high test scores.

In terms of my experience teaching biology, I consistently searched for opportunities to provide experiential, investigative, and inquiry-based instruction within the environment of my classroom. In practice, this amounted to continual deliberation and reflection on where and how within the confines of the mandated curriculum and the social culture of scrutiny in my department I could enact reform-based teaching strategies. I carefully assessed each unit section of the mandated curriculum for opportunities to secure canonical concepts in a form in which they might be tested and at the same time allow students to construct meaningful understandings through reform-based practices. This was a tiring endeavor to say the least.

In many cases, I believe I was an effective agent for promoting questioning, thinking, problem solving, metacognition, nature of science understandings, and the building of important conceptual understandings in biology. One activity that was particularly successful was having my students plan Project WILD activities for third graders at an elementary school and then go to the school and teach them to the children. The high school students needed to have a strong command of the ecological concepts behind the activities in preparation for leading instruction. They felt a great responsibility for providing the children with a positive science experience and all of the groups did very well conducting the activities and interacting with the children. It was such a pleasure to see one of my students who was a football player with minimal interest in science enthusiastically discussing bear habitats with young girls and boys!

Some other activities I did that I believe promoted science learning included having students (a) create a story board of Darwin's exploration of the Galapagos to explain how his observations shaped his thinking, (b) investigate how the use of increasingly better technology led to theories about the structure and function of the cell membrane, (c) create their own laboratory procedures for testing the effects of various factors on enzyme reaction rates, (d) write respiration "stories" for younger children to explain how humans process food, (e) use a computer program from the University of California Paleontology Museum to explore the evolution of flight in birds, and (f) prepare arguments to evaluate the Atkins (low-carbohydrate) diet from a biological point of view. Another one of my most successful activities was a project-based science style investigation of how human development affects the ecological balance and biological diversity of marsh hammock ecosystems that comprised the local environment in which the students lived. This project was feasible because the language of the mandated curriculum objective for this set of concepts allowed for an integrated and experiential approach while still fostering students' construction of the biological terms and their relationships (see Wallace 2012 for more details).

For other units and topics, I found that in order for the students to have any opportunity to pass the End of Course or High School Graduation tests, it was necessary to simply explain concepts to them, albeit with the use of analogies, examples, models, demonstrations, technology, and guided inquiry labs. Some of these concepts included the parts and functions of the cell, genetic probabilities and crosses, protein synthesis, the relation of meiosis to genetic combination, osmosis, and gene technology.

Thus, I feel my agency as a biology teacher positively impacted the learning experiences of students in my classroom, at least to a moderate degree. On many occasions, I was able to provide a causative force that shifted instruction towards thinking, inquiry, and argumentation. However, I was always aware that I was working within the ecology of system that included structure and culture, having to find gaps and openings in the curriculum that provided unique opportunities for developing reform-based teaching. I had originally envisioned myself as being an autonomous agent in determining the instructional experiences and curriculum in my classroom. In fact, I had to exert a great deal of time and energy to find ways to challenge the system and teach in a way that I felt met the students' needs.

My advice to new teachers would be to remain optimistic about opportunities for reform-based teaching. Even though some topics don't lend themselves to investigative styles of instruction, others do. I would encourage all science teachers to continually assess their own curriculum standards with an eye for possibilities for inquiry-based teaching. For example, the section in my curriculum on enzymes could have been accomplished with a "cookbook" lab, but I chose to guide the students into designing their own experiments on factors that affected enzyme action. They not only learned about enzyme action from this activity but increased their independent scientific thinking skills. Second, while it is not possible to completely ignore the impact of testing regimes on instruction, beginning teachers should keep in mind that tests are not the sole measure of students' accomplishments in the classroom. I continued to implement authentic assessments with my students throughout the semester, even though my colleagues were focused on quizzes. I felt that my students responded very well to these. In many cases, I would give a test which was half traditional and half alternative, such as the inclusion of a concept map. Many students who did not do well on the traditional questions excelled at the alternative assessments and therefore felt a sense of pride that they had achieved biology learning.

Implications and Conclusions

My year of teaching high school biology has profoundly impacted my career as a science educator. I feel it is not an exaggeration to say that I will never view science teacher education or research in the same way that I did before my teaching experience. I am personally satisfied that I found some answers to my question of why reform-based teaching is not more widespread. To gain this insight, I needed not only to experience authentic day-to-day teaching firsthand but also to read more widely in the literature including articles from social theory, curriculum theory, and educational policy. Fortunately, my career took me next to a position at the University of Stirling in Scotland where I was able to gain an international perspective and have access to an even broader range of literature and perspectives on curriculum. I have been extremely fortunate to have had these experiences which I feel are somewhat out of the ordinary for science education academics in the United States. These insights and understandings have directly impacted my teaching, research, and world view of science education.

Changes to My Teaching and Research

In terms of teaching methods classes for secondary science education, I no longer privilege inquiry-based teaching as a central model. I do introduce inquiry and provide several firsthand experiences and readings on inquiry, so that students can critically evaluate inquiry as one approach to science teaching. I try to convey to students the intellectual benefits of inquiry-based teaching and let them analyze the potential of inquiry for fostering thinking, problem solving, and conceptual change. However, I now organize my courses around an *Evidence-Based Teaching* model by Geoffrey Petty (2006) that sets out a practical guideline for instruction as "Present, Apply, Review (PAR)." Petty posits that presenting new information should take no more than 25 % of class time, application of this information should comprise about 65 % of class time and review should comprise about 10 % of class time. Further, he asserts the importance of orienting students to the lesson through real-world examples, evoking prior knowledge and using instructional strategies that have been shown to be effective through extensive research such as productive questioning, cooperative learning, interactive direct instruction, and problem solving. I feel that this model better provides my students with the skills they need to both succeed in the modern classroom and to promote meaningful learning in science. My course emphasizes ways to include reform-based practices including concept mapping, reading and writing to learn, guided inquiry-based labs, and modeling into the "apply" phase of the model.

While I enjoyed productive and interesting research agendas on writing to learn in science and teaching science as inquiry from 1993 to 2004, I no longer have the desire to promote and research classroom interventions that may result in better science learning. While there are probably an infinite number of questions to be asked and answered on how to provide better learning environments and experiences for children, if these are not realized in the ordinary classroom, they are of little consequence. As science educators, we already have an incredibly rich knowledge base about what promotes high-quality science teaching and learning.

My personal research agenda has shifted to two strands: (a) the usefulness of service learning experiences for preservice elementary science teacher education and (b) unpacking teacher learning, beliefs, and agency and examining those conditions in which agency can flourish (Wallace and Priestley 2011). In regard to the first strand, recent research has indicated that informal science education environments, such as camps and after school programs, hold potential for fostering positive early teaching experiences with science. In these environments, preservice teachers are able to interact with children in ways that are not possible within the ordinary constraints of the classroom. When working with small groups of children in an informal setting, novice teachers have more freedom to experiment with inquiry-based learning without concern for testing, time schedules, pressure from mentors, or adherence to the mandated curriculum. I am enjoying researching these experiences where there is more opportunity for elementary preservice teachers to become interested in and committed to science teaching.

In regard to the second strand, I continue to want to champion teachers' empowerment to create curriculum in ways that they feel best meets their students' needs. I am thus interested in unpacking those situations in which teachers can make impactful decisions and document the fruitfulness of their efforts. I am committed to promoting the idea of intellectual independence (Munby and Roberts 1998) for both teacher and students, because I feel it is at the heart of science teaching.

The Importance of Curriculum Standards

My experience in Scotland subsequent to my year of teaching high school has led me to appreciate the power of looking at different types of curriculum standards around the world. There is a recent trend for national curricula or other versions of official planned curricula to begin moving away from a strictly content and product model of curriculum design towards models which embrace values, thinking skills, intellectual autonomy, and other broader educational goals for the twenty-first century. This is critical, in my view, because with current technology, it becomes less important for students to attain information and more important for them to be able to critically read and evaluate information.

For example, Scotland has recently adopted "Curriculum for Excellence" which is focused on four core educational values: responsible citizens, successful learners, confident individuals, and effective contributors. Using these four value-based anchors as a starting point for design has led to curriculum objectives that, although still based in content knowledge, provide for teacher creativity and local knowledge to become part of the learning outcomes (Learning and Teaching Scotland 2012). Similarly in New Zealand, the national curriculum has been rewritten (Ministry of Education, New Zealand 2009) to scale back content objectives, leave content-based performances more open ended, and link content attainment aims with the thinking processes needed to achieve them (see Wallace 2012). In the Netherlands, university researchers and teachers are working in collaborative teams to implement curriculum based on students' achievement of self-regulation in learning (Meirink et al. 2009).

The United States is also currently involved in creating new national standards for the science curriculum, the Next Generation Science Standards (Achieve Inc. 2010). Since the standards have not yet been published, we don't know the extent to which the new standards will emphasize values, thinking skills, or intellectual autonomy in learners. However, the current political climate in the United States is still centered on the accountability system of high-stakes standardized testing that will undoubtedly shape the curriculum standards. My hope is that a significant number of science teacher educators and science education researchers will come to recognize the importance of the language of the planned curriculum and the intricacies of the social structures and cultural forms which enforce it. Much more research is needed into the impacts of educational policy on the daily lives of science students and teachers.

Final Comments

Despite my frustrations with the constraints of the system, I would advise fellow science educators to take advantage of any opportunity to return to the classroom. Teaching real children is the only way to experience authentic, situated learning. Recently, Cochran-Smith and Lytle (2009) have proposed that inquiry be the primary mode of learning pedagogy. Their use of the term "inquiry" in this context refers to approaching teaching as research, including hypothesizing, experimenting, gathering data, and drawing conclusions about what works and what does not work in a particular context. Science education researchers have the skills and experience to go into the classroom as teacher/researchers of their own practice. Being immersed in this problem-solving mode is the only way to form a personal philosophy of contemporary science teaching that is based on evidence. The experience is invaluable as a method of learning what it truly means to teach in a constructivist fashion.

My advice for novice teachers would be to try out many strategies and actively reflect not only on how well these work with students but also on how well they fit with one's own sense of what learning science is all about. As a new teacher gains experience, she develops both her pedagogical content knowledge and her belief system (Veal 2004). Even within the cultural constraints of schooling, there are opportunities to create meaningful learning activities. I would encourage novice teachers to cultivate a wide variety of resources for teaching in different ways and to always be on the lookout for those opportune moments to teach through authentic scientific practices.

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