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Collaborating to Study Science Teaching: A Case Study

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Abstract

The purpose of this study was to form a science teacher and graduate-student researcher team in which its members engaged in a study of science teaching, and to examine the progress of the team's work through the creation of a case study. A graduate student and science teacher team was formed in one high school, and used collaborative action research methods to investigate students' learning in a general education biology course. As well, the action research project was used to examine the attempt of the research team (graduate student and teacher) to change instructional patterns in the teacher's classroom. Records were maintained throughout the project and examined to arrive at the study results, which revealed mixed success in improving learning and making change within the context of the classroom. Three tentative conclusions were warranted from an examination of the results of the case study:

1. A chain of reasoning exists that inhibits reform of existing teaching practices in ways that engage students,

2. Formation of a science teacher-graduate student team facilitates the adoption of a critical perspective on instruction, and

3. Beliefs about science teaching are firmly established and difficult to alter.

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Over the past few decades, there have been calls for reform and the improvement of school practice. That is to say, members of the teaching profession are invested in seeing that schools are 'doing better'. As part of reform, it has been noted that schools and higher education institutions must enter into true collaboration to achieve this improvement goal (NRC, 1996). Out of this call to action we developed the goal of this study, namely to form a university-school partnership in which members inquire into students' learning of science and document their progress through creation of action research case studies.

We see the need for all educators, experienced as well as novice, to take action and be accountable no matter their apparent powerlessness (Gramsci, as cited in Cochran-Smith, 1991). It is through action research that action *can* be taken regardless of the power position of the individual. This is what Cochran-Smith (1991) acknowledged would work in the company of experienced teachers who are themselves struggling to be reformers in their own classrooms, schools, and communities. To coin her phrase, 'learning to teach against the grain' is at the heart of reform. Furthermore, we have challenged ourselves and our teachers with the idea of 'learning to teach against the grain' within a culture and region that has a history of 'teaching with the grain'.

This study describes a project that includes an action-research case study in which university-school partners set out to develop and implement practices designed to improve student learning in general education biology course taught in a high school located in rural, eastern North Carolina, USA. The case study focuses on the understanding of the nature of the teacher's beliefs and what he was willing to change within the context of his classroom and why. The project is presented as follows: (1) Theoretical Underpinnings, (2), Science Teaching in North Carolina, (3) Context for the Case Studies, (4) Design and Procedures, (5) The Science Case Study, (6) Findings, and (7) Conclusions.

Theoretical Underpinnings

Three theoretical perspectives framed the teacher research reported in this project. These perspectives shed light on the goal of understanding what it means for science teachers to transform existing discourses-practices (post-structuralism), work collaboratively with their colleagues and be self-directed in their professional growth (adult learning), and engage in a systematic inquiry into their teaching (action science/learning/research). Structuralism is reviewed first, as it is the certainty of the structuralist perspective on social and political systems that is challenged by the poststructuralist movement.

Structuralism

According to Cherryholmes, structuralism is a systematic way of thinking about whole processes and institutions whereby each part of a system defines and is defined by other parts (1988, p. 13). Moreover, structuralism operates prescriptively in education when preferred structural procedures, interpretations, and organizations are promoted with promise of order, accountability, efficiency, certainty, control, and rationality (p. 16, 30). As a philosophical tradition, structuralism is characterized by the belief that all manifestations of social activities

that are practiced in a society constitute languages, and hence, their regularities may be reduced to the same set of abstract rules that define and govern language.

Structuralist thinking pervades educational discourses-practices today. The content of what is said and done in US schools constitutes an unacknowledged, taken-for-granted way of thinking about education. Furthermore, these discourses-practices create an educational structure, increasingly driven today by accountability, one that has put into place new relationships among the structure's units and those relationships regenerate and reproduce the structure. These new accountability relationships define, for example, what science is to be taught in US schools, how and what learning is to be measured and by whom, what constitutes successful science teaching and learning, how well schools perform, and which teachers are identified to be excellent.

Structuralists are convinced that systematic knowledge is possible, and poststructuralist claim to know only the impossibility of this knowledge (Cherryholmes, 1988, p. 32). For systematic knowledge to be possible, it must be based on meanings that are fixed. One way to fix meanings in a text or discourse is to appeal to a transcendent idea, one that rises above the text or discourse, to which the meaning of other words can be determined by comparison with this foundational idea. A number of educational ideas today qualify as transcendent truths, including excellence in education, accountability, effective schools, critical thinking, teaching to standards, scientific literacy, to name a few. A poststructural analysis asks of transcendent truths: Where do they come from? How were they produced? How are they reproduced? Why are they authoritative?

Poststructuralism

The central premise of poststructuralism is that things in themselves (objects, events, experiences) can never finally be known, because anything that humans attempt to know must be

expressed through language or some other symbolic form. Thus, the world, the self, one's experience, are all words, metaphors, or signs that humans create to try to say something about the world and, as such, are already distanced from and different from the world (Martusewicz & Reynolds, 1994, p. 11). A closer look at poststructuralist argumentation follows.

Poststructuralists attack structuralist assumptions and arguments built upon them using two forms of critique, deconstruction of discourses-practices as text and a critique of knowledge claims as political productions. Argument based on deconstruction, according to Jacques Derrida (as cited in Cherryholmes, 1988, p. 36), questions the foundation of structuralist programs and meanings, namely that word-meanings are definitive and fixed. According to Derrida, ultimate meanings do not exist; instead they are dispersed throughout language and texts and are deferred in time. The ABCs of Public Education in North Carolina (North Carolina Department of Public Instruction [NC-DPI], 1996) serves to illustrate the shifting meaning of achievement. The plan is founded on three cornerstones, accountability, high standards and local control, and these word-meanings can be deconstructed to reveal their illusory and transitory nature.

Accountability and high standards are defined by a steering committee with input from citizens and educators from across the state. As a result, the meanings of accountability and high standards ultimately were defined by results on key measures of school learning. High schools, for example, are held accountable for their students' learning, and high standards are set for each school. Schools are assigned a growth standard based on past performance of their students on end-of-course tests, results of a high school writing test, year-to-year comparisons of percentages of students who complete college preparation or college technical preparation programs, and results of the grade-10 North Carolina Comprehensive Test. The meanings of accountability and high standards for any high school for an upcoming year, therefore, are defined in terms of a

'growth standard' which, in turn, is determined by past test scores, numbers of students enrolled in specific programs of study, and past school-wide performance.

It becomes obvious after examining each layer of word-meanings pertaining to accountability and high standards for any high school that meaning is dispersed throughout language (dependent upon word-meanings, which in turn are defined further by other word-meanings, etc.) and deferred in time (word-meanings that change with time). As a consequence, accountability and high standards lack a universal definition, and when deconstructed, their meanings are seen to be ever-changing and are agreed upon only by a small, elite group of educators. There are no transcendental, foundational, universally agreed-upon meanings for accountability and high standards. Consequently, the goals of accountability and high standards have unstable meanings and are likely to go unmet.

Poststructuralist arguments based on knowledge as political production, according to Michel Foucault (as cited in Cherryholmes, 1988, p. 33), account for how discourses and institutions come to be what they are, not explain or interpret them or say what they 'really' mean. In the process, discourses are shown to be materially produced by specific social, political, and economic arrangements. Consequently, what is said in the name of 'truth' is not simply an idealist construction. Instead, discursive practices have a material basis because they cannot be extricated from their construction in an historical setting. The rules of a discourse in a specific historical period and geographical location govern what is said and what remains unsaid; what counts as true, important, or relevant; and identify who can speak with authority and who must listen (Cherryholmes, 1988, p. 34-35). Power operates visibly and invisibly through expectations and desires and helps shape subjective feelings and beliefs (subjectivities).

Nowhere has power and privilege exercised greater authority over public education, perhaps, than it has in the development, implementation, and monitoring of North Carolina's ABCs plan. Visibly absent from any commentary on the ABCs plan are the voices of North Carolina's public school teachers. Their silence has been attributed to embarrassment for those teachers who teach in low-performing schools, fear of falling test scores for those teachers who teach in high-performing schools, and fear expressed by all teachers of such punitive measures as the loss of pay incentives or requirements to take a teacher competency test. In fact, at least part of the goal of the ABCs plan has been to embarrass low-performing schools into higher achievement (Jones et al., 1999, p. 200). Shaming low-performing schools into improved student learning may result in little more than the reproduction and reification of existing educational discourses-practices.

Adult Learning

Researchers who have examined adult learning for the past quarter century have come to see important distinctions between the learning that takes place in adulthood and the learning that takes place as a pre-adult. For the most part, early learning is formative in nature rather than transformative as it is in adulthood. Adults can become critically aware of how and why their meaning perspectives and presuppositions can come to constrain the way they perceive, understand, and feel about the world. This awareness is the first step in reformulating adults' assumptions or habits of expectation, to permit a more inclusive, discriminating, permeable, and integrative perspective and in making decisions or acting upon new understandings (Mezirow, 1991). An additional feature of adult learning is its self-directedness as opposed to other- or teacher-directedness (Merriam, 1993, p. 9). Current forms of self-directed learning have taken on a critical perspective and emphasize self-initiated learning that focuses on bringing about change in the social, political, and economic order through the questioning of assumptions held by adults

about the world in which they live and work (Caffarella, 1993). The ability to be responsible and in control of what, where, and how teachers learn, for example, is critical to their survival, success, and prosperity in school settings characterized today by cultural diversity, statewide accountability demands, and an increased need for universal scientific literacy.

Action Science/Learning/Research.

Action science, learning, and research emphasize the use of knowledge in service of action and are participatory and collaborative endeavors. Action research is the systematic inquiry into group phenomena and results in the production of knowledge, which is shared among practitioners. Out of the action research movement has arisen two action strategies, action learning and action science. Action learning occurs in any real-world environment in which people seek to learn from their actions and produce knowledge that results from and improves action. In action science people employ methods that enable them to explore the hidden beliefs that drive their actions for the purpose of improving their interpersonal and organizational effectiveness (Raelin, 1997).

Science teachers, for example, are designers of their pedagogical actions in the service of achieving intended learning outcomes. They make sense of their surroundings by constructing meanings (cultural, social, and individual) from their environment, and these meanings form perspectives that guide their actions (Watkins & Shindell, 1994). Teachers engage daily in automatic rapid reasoning processes, which may be flawed, that involve an escalation from the observation of specific instructional events to abstracting about these events based on their individual, unique, oftentimes unquestioned meaning perspectives. Using action science and action research methods these processes can be made explicit.

When teachers engage in designed action they develop from their meaning perspectives a set of causal theories to describe and predict their world, called theories of action. Causal theories are of two types, espoused theories and theories-in-use. Espoused theories consist of chains of reasoning that teachers claim to follow, and theories-in-use are reasoning processes that are inferred from teachers' actions. The general model of action science and action research begins with strategies to reveal the values and beliefs that underlie intended actions and their consequences. Unintended consequences may involve a mismatch between action and its governing beliefs, intentions, and values.

The history of action research is well documented (Noffke, 1997; McTaggart, 1991) as is the emergence of its critical nature (Carr & Kemmis, 1986). References also exist that describe the action research process, dating back to 1953 (Corey, 1953; Elliott, 1991; Kemmis & McTaggart, 1988; McKernan, 1996; Oja & Smulyan, 1989; Sagor, 1992), teachers use of action research (Altrichter, Posch, & Somekh, 1993; Anderson, Herr, & Nihlen, 1994; Calhoun, 1994; Cochran-Smith & Lytle, 1993; Kincheloe, 1991; McLean, 1995; McNiff, 1993; Sagor, 1992), and teaching action research courses (Crawley, 1998; Noffke & Stevenson, 1995). Of particular interest to this study are references that shed light on the ways that new insight and understanding potentially emerge when teachers and researchers from two different cultures (university and school communities) collaborate to inquire into teaching practice.

Action research can play a key role in advancing the professional, personal, and political dimensions of education (Noffke, 1997). It can serve as a vehicle for improving student learning and growth, provide opportunities for promoting teacher learning and growth, and at the same time offer a means for promoting school-wide change and renewal (Calhoun, 1994). The very nature of action research promotes job-embedded learning in that the process of engaging in

action research links learning to the immediate and real-life problems faced by teachers and administrators (Sparks & Hirsh, 1997).

The cyclic, four-step action research process (plan, act, observe, and reflect) engages teachers in a systematic inquiry into their practice, offers a structure for them to reflect on their practice, and facilitates their development as reflective practitioners. As a form of practical inquiry, action research develops, enhances, and formalizes learning from teaching—just 'what matters most' to great teachers, according to the National Commission on Teaching and America's Future (1996). Furthermore, school teachers and university researchers who engage in action research have an opportunity to build mutual understandings, clarify complementary interests, and narrow the research-practice gap.

Practice does not make perfect. Without systematic reflection and critique, practice serves only to perpetuate itself (Britzman, 1991), especially in teaching. When asked why they teach as they do, for example, teachers responded with one of three reasons (Marshall, as cited in Henson, 1996): (1) it's the way I was taught, (2) it's the way I learned, or (3) it's the easiest way to cover the material. These underlying beliefs are inadequate sources of motivation for teachers to contest and transform existing teaching practices.

Science Teaching in North Carolina

Calls for the reform of science content, teaching, and assessment standards at the national level and the move toward end-of-grade, end-of-course, statewide accountability present today's science teachers in North Carolina with competing demands. On one hand, the National Science Education Standards (NSES) call for the development of universal scientific literacy. The goal of universal scientific literacy is that all students are able to use scientific information, engage in discourse and debate about scientific issues, and share in the excitement and personal fulfillment

that comes from understanding the natural world (National Research Council, 1996, p. 1). In North Carolina high stakes accountability system, students' complete end-of-grade and end-of-course tests under the state's New ABCs of Public Education plan (NC-DPI, 1997). In grades 3, 5, and 8, students must meet proficiency in reading, writing, and mathematics on end-of-grade tests. By the end of grade 10, students must demonstrate mastery of reading and mathematics competencies on the North Carolina High School Comprehensive Test. In addition, end-of-course tests are given throughout their high school education, and students are expected to meet goals specified in the Standard Course of Study for each high school subject they complete (including biology, chemistry, physics, and physical science, but not the state's new earth science course) (NC-DPI, 1999). The format for all tests, except the writing test, is multiple-choice. Test results are made public and schools are identified as 'exemplary', 'meets expectation', 'adequate performance', or 'low performance'.

In response to high-stakes testing, a recent study revealed, elementary school teachers are teaching to the test, teaching less science and social studies, and abandoning schools identified as 'low performing' to teach in more prestigious ones (Jones et al., 1999). An examination of statewide ABCs test results revealed that 20% of the variance in a school's score was attributable to the percentage of students receiving free or reduced-price lunches (Dulaney, as cited in Jones et al., 1999).

The New ABCs of Public Education plan has defined what constitutes the new professional discourse (what is said and written about in education) and practice (activities that are performed on a regular basis in education) of public education in North Carolina. In science classrooms across the state, the Standard Course of Study now constitutes the science curriculum. Increasingly teachers are being asked by administrators to teach to the test, emphasizing discrete

facts and skills and utilizing drill and practice teaching methods, especially approaching end-of-grade or end-of-course test time. Practicing for the test and the use of practice tests become increasingly popular ways for teachers to respond to the demands of high stakes testing in schools where teachers feel the pressure to raise test scores. Financial incentives of $1500 await teachers if their school exceeds expectations and is designated 'exemplary', whereas threats of mandated assistance teams, loss of jobs for principals and teachers, and competency testing for teachers await a school that fails to meet expected growth standards.

Out of the accountability movement in North Carolina has arisen a new discursive practice, a body of anonymous, historical rules, determined in the time and space that define education in the state today (Cherryholmes, 1988, p. 3), and new rules for what constitute acceptable performance in a teacher's practice. Ironically, North Carolina's ABCs plan calls for school-based accountability, a focus on the basics (reading, writing, and mathematics), and increased local control, thus leaving school districts 'free' to choose ways to improve learning outcomes. Clearly the state's control over education, however, remains pervasive and direct, and the ABCs plan is tantamount to embarrassing low-performing schools into improving students' test scores. Statewide accountability has produced new educational structures and shared ideas, which educators have come to believe to be true and valid, and has put into place new social, political, and material asymmetries by which some teachers, schools, and districts are rewarded and others are sanctioned and deprived. To radically alter the outcomes of high stakes testing it is essential to examine more closely the systemic relationships that exist among the elements in the educational structure.

Reform at the state and national levels consists of the redesign of existing science curricula to reflect teaching to and learning of high standards (NC-DPI, 1999; NRC, 1996). The goal today is

that all students will become scientifically literate. To reach this reform goal, teachers must engage in a critical reconstruction of their beliefs about what it means to teach and learn in today's accountability-driven classrooms (Jones, et. al., 1999). It is unthinkable though, that schools can hold improved student learning and growth as their primary goal without simultaneously promoting teacher learning and growth (Little, 1997). Since in the end, teachers will only change the world of the school by understanding it (Stenhouse, 1985).

Traditional science teaching practices if left unchallenged will only produce 'more of the same' low-level learning outcomes. For all students to become scientifically literate, teachers must rethink their traditional science teaching practices and consider what it means to 'teach against the grain' of conventional wisdom (Cochran-Smith, 1991; 2001). Through the provision of a supportive, reflective learning community, teachers can construct and introduce a complex, contextualized teaching strategy (Young, 1998) into their classrooms, one that is uniquely tailored to develop the deep understanding of science called for in today's reform documents. The success of any complex intervention, however, requires systematic data collection and critical inquiry (Altrichter, Posch, & Somekh, 1993; Cochran-Smith & Lytle, 1993) into science teaching and learning for all students.

This study was developed to examine the potential of action research to empower one teacher to change his existing teaching practices within the context of his classroom. More specifically, this study was designed to bring together a biology teacher and a graduate-student researcher who would engage in a study of the teaching of biology and document the progress of the team's work (understanding of their own teaching) using collaborative action research methods. In addition, the team members examined their success in changing existing instructional patterns in the teacher's classroom.

<u>Context for the Case Study</u>

Eastside High School (a pseudonym, EHS), the school site for the case study that follows, is an urban school within a rural city located in eastern North Carolina. The county has a population of 56,670 (1990 Census), and the median family income is $26,000/year, which places the county in the lower one-third of all North Carolina counties. Twenty percent of the population lives on an income that is below the poverty level, 76% of these families have children, and 66% of the families lack a male head of household. Eastside High School is not immune to the problems of larger, inner city schools. City police officers are on duty each day as resource persons. Their presence has resulted in decreased violence, and when fights occur they are often related to circumstances generated outside of the school. Drugs, violence, gang memberships, and poverty are factors that EHS students have in common with their sister schools located in the larger metropolitan areas. The dropout rate at EHS is 4.8 %, which places it at or slightly below the state average. The success rate on the biology end-of-course test at the time of this study was 55.5%, above the state average. Teachers at EHS are mostly white and female and serve a student population which is 60% African-American, 35% Caucasian-American, and 5% Hispanic/Asian-American. Consequently, students have few teachers who serve as role models.

The science department at Eastside High School consisted of mostly young, white and relatively inexperienced teachers at the time of this case study. Six teachers served 850 students in science courses. Employed within the department were two lateral entry teachers, one initially licensed teacher, two newly tenured teachers, and one career teacher with fourteen years of experience. Faculty youth and inexperience resulted from a recent retirement and attrition. Four years prior to this study, three of the science teachers developed and implemented a national pilot

curriculum consisting of two science courses called Integrated Science I and II, which the local school board later adopted district wide and required that these two courses be completed, along with biology, by all students for graduation.

<u>Design and Procedures</u>

The research design for this study was that of an interpretive case study. The interpretive case study design was selected as it was determined to be the best suited of the qualitative perspectives to construct the chain of reasoning and action leading to the goal of improved student learning. It is the most inclusive of the qualitative research traditions, and its use facilitated examination of the '… human meaning in social life and in its elucidation and exposition by the researcher' (Erickson, 1986, p. 119). The central research interest in this project was to learn about one biology teacher's goals for himself and his students as learners and about the teacher's views on individual and collective responsibility for the academic success of all science students.

The study procedures followed those of collaborative action research (CAR) as described by Carr & Kemmis (1986). Moving through the four-step action research cycle (plan —> act —> observe —> reflect) can produce systematic changes in teachers' beliefs and actions, shifts which have the potential to bring theories in use into alignment with their espoused theories. Three collaborative action research teams were formed, each pairing a graduate student in science education with a science teacher in Eastside High School. Data gathered by team members included video and/or audiotapes of team meetings and science instruction, student and teacher products, teacher journal entries, written documents, printed instructional materials, and notes recorded during classroom observations. Teacher and university partners maintained up-to-date journal entries to document the detailed operation and evolution of their research project,

including descriptions of events, written tasks, group and individual conversations, changes in the teacher's perspectives and teaching practices, and topics of and notes from informal meetings.

<u>The Case Study—An Empty Bag of Tricks</u>.

    The university team member was a first-year graduate student in science education enrolled in an 'Action Research in Teaching' course. Graduate students in this class read about action research and learned about action research as they collaborated with a practicing science teacher to study students' science learning. The graduate student in this case study, Arthur, was enrolled in a masters degree program in science education and collaborated with James, (names are pseudonyms). Arthur has taught science for three years in another state and James was beginning his fourth year as a science teacher at Eastside. James was a graduate from East Carolina University and he was certified to teach secondary school science. For their project, James and Arthur collaborated to investigate learning in an introductory-level biology course.

    Arthur and James were knowledgeable, experienced teachers of biology. Arthur's interest in science began at a very early age. His hobby was to collect, and he collected everything! A meaningful event occurred one day when he was rounding up butterflies for his collection. He approached his father and asked whether he had seen a particularly beautiful specimen that Arthur lacked in his collection. On hearing his interest and intent, his father replied, 'don't you think it would be much more fun to study living butterflies as they go from one plant to the next rather than capture, kill, and pin the butterfly to a piece of cardboard?' Arthur was deeply moved by his father's words, and, from that day on, he has championed the study of living organisms in their natural habitat, particularly in the biology classes he taught. Graduate study in science education too has been a moving experience for Arthur who admits to only recently coming to

the realization that he led a privileged life as a youngster growing up in Georgia. The son of professional, well-educated parents, he attended schools populated by predominantly white students from middle- to upper-class backgrounds and became a model student, learning everything his teachers asked him to learn, according to Arthur, for they knew best what was important. Only recently has he come to see that he is 'typical of male, white culture, [and] grew up ignorant of the existence of any significant racial inequalities in [his] county or community'. He was attracted to working with James in the introductory level biology class and to having the opportunity to interact with the diverse group of students who attended Eastside High School.

James and Arthur shared similar educational backgrounds. Like Arthur, James 'has been immersed in and encouraged to study science all his life'. James too loved to collect biological specimens. However, he recalled vividly the problems he had with a graduate-level course in botany. His approach to overcoming the challenges he faced was to collect botanical samples, not just a few, but samples of everything he could find that the professor mentioned. Lacking an accompanying laboratory course in which to examine leaves and bark of trees, James decided to construct one—in his kitchen! Soon he became the 'unofficial' laboratory teaching assistant, to whom his peers turned for help.

Given their similar backgrounds, it comes as no surprise to find out that Arthur and James shared similar convictions about teaching and learning. Obvious to him, Arthur raises this concern early in the research process with James. He worries that he and James have always been driven to succeed, especially in science, and that they may have great difficulty understanding how to improve learning for students who don't share similar convictions about the importance of learning science. Here is the way Arthur put it.

Like myself, James has been immersed and encouraged in science his entire life. His

quick mind is apparent to and, as a teacher, this might be a frustrating characteristic. Is it

possible that ability or skill in science is a hindrance in understanding students who do

not seem to have inclinations toward learning science? I believe we both share the

unusual 'burden' of excelling at academics and especially science. James learned science

from experience; it is not surprising that he provides this opportunity for students as

much as possible. … 'Hands on, minds on' describes his conception of how best to learn

science. However, James struggles to balance a number of conflicting priorities … and is

challenged by student boredom, pacing guides, shortage of time, and [performance

expectations of] the end-of-course test.

The first week or two Arthur and James talked about themselves as learners and teachers. On

one occasion, Arthur asked James what might be done to 'make learning more accessible' to

students in the biology class in which Arthur was an observer. James' response was immediate,

to the point, and laced with frustration, "I don't know any more I can do." For Arthur, James'

comments were poignant and all too familiar. While teaching, he too had experienced similar

frustrations. In defense of James, he seized the opportunity to put to rest any thoughts that

inexperienced teachers who might read his report would think that James had violated an

unspoken, sacred ethic of teaching, namely 'never to give up'. Arthur was sympathetic to James'

situation and reported so.

When I taught I experienced similar feelings of frustration, hopelessness, and isolation

and became completely baffled by my attempts to teach well. I also came to a point in my

career where I felt there was nothing else in my 'bag of tricks' that could ever help me or

my students' situation in class. James' attitude is not a betrayal but natural. … James was not asking me to help implement an idea he already formed, he was out of ideas.

Arthur felt privileged that James would share his frustration with him. Though he was pleased to know that James saw him as a reliable source of useful ideas for his classroom, Arthur was uncertain that there was anything new he could offer. Arthur and James went back to the drawing board, so to speak, and Arthur decided to carefully observe and record the events that took place during the fourth period biology class, because this class had proved so troublesome for James. According to Arthur, the school's class schedule only added to the problem. Eastside High School makes use of the block schedule, which consists of four, 90-minute classes each day. This schedule places unique demands on teachers to provide meaningful, engaging instruction for students in their classes for 90 minutes each day, for one semester, rather than the 60-minute classes, taught over two semesters as is the case in 'traditional' school schedules.

From his observations Arthur learned that James has developed a highly structured instructional sequence. He divides the teaching schedule into six strategic steps and this pattern repeats itself every two weeks. James begins the six-step cycle by reviewing vocabulary and definitions for key biology concepts to be covered in the chapter/unit. Next, James presents a lecture and discussion session in which he provides notes on the chapter, given in a way that draws 'meaningful ties between vocabulary terms', according to James. The lecture concludes with a summary of knowledge to help students 'nail down' details for the laboratory investigations and other exercises that they will encounter later in the week. During this time, James also invites students to talk about their ideas regarding key concepts in the lesson. In the third step, James provides a study guide to help students 'remember the key concepts' taken from their textbook and covered in the lecture. Students engage in an inquiry, in step 4, what James

calls an 'authentic science' lesson. James and Arthur see 'step-4 days' as the high point of the 6-step instructional cycle. During these student-centered laboratory lessons everyone is engaged in 'self-directed learning' while James acts as a resource person to resolve any confusion that may arise. During step 5, James uses concept maps or other forms of 'critical thinking activities' to help students reflect on past lessons and apply what they have learned to new situations, in preparation for step 6, which is 'test day'. On tests students are expected to 'recall information and apply what they have learned'.

As a result of Arthur's observations of James' teaching, they decide that lectures and discussions (step 2) appear to be the most problematic, least effective events in the 6-step cycle to promote student learning. During lecture and discussion lessons, Arthur noted that James moves about the room, makes eye contact with students, varies his tone of voice, makes extensive use of visuals, and encourages students to share their ideas— all to no avail. By the end of class, Arthur reported, many students have 'checked out' of the lesson and have disengaged completely. On one day, for example, Arthur observed that within 15 minutes after James started the lecture/discussion, 12 of 17 students were either asleep or had their heads on the desks for five minutes or more at a time. Many students who take an active part in student-centered inquiry lessons, according to Arthur, are the same students who 'check out' of the lecture/discussion lessons. As these lessons progress, according to Arthur, James seems to become increasingly distant from the group and, instead, attends to the questions and comments of a few vocal, outgoing students.

James and Arthur decided to commit their time and energies to resolving the lack of involvement associated with lecture/discussion sessions. Arthur is sincere in his desire to develop a plan of action that '…will be sustainable in [his] absence at the end of this project'.

Whatever form the plan takes, it must meet two special constraints, which James has imposed. First, the plan must work with existing time and resources, in particular this rules out the use of more student-centered inquiry laboratory lessons, according to James, as they are time and resource intensive. Second, the plan must engage all students, not just the few people who seem to take part in any lesson, regardless of is content or level of activity.

Arthur began reviewing the science education literature using several search terms, including time-on-task, attention span, engaged time, learning time, teacher-centered instruction, and inquiry. He gathered key references and met with James to share his findings. Three studies, in particular, seemed to James to be pertinent. For example, he was encouraged to learn that in 'teacher-centered inquiry students use cognitive inquiry behaviors to seek solutions to problems, and the teacher assumes a major role in the inquiry process' (Wright, 1973). Moreover, Arthur reported that he and James learned ways to 'expand [the] use of teacher-centered inquiry activities to include different ways of solving problems (Reck, 1990) and collaborative learning in small groups' (Foster, Gaa, Nowicki, & Ross, 1997). These ideas seemed to be compatible with the successful student-centered inquiry activities already in use in James' class. Hopes were high that the success of the student-centered, investigative climate would be extended to the teacher-centered inquiry lessons. According to Arthur, he and James believed that teacher-centered inquiry lessons, if designed properly, would bring a 'lab feel' to lectures.

Arthur and James planned to include a day of teacher-centered inquiry in the next lesson, a unit on primates. In the activity, paired students were asked to arrange and paste pictures of seven primate species in an evolutionary tree ranging from most ancient originating species to most recent species. Based on their own criteria, students then were asked to justify their answers in written form on the back of the activity sheet. These were the only instructions given. Most

students sought more definitive guidelines from James to construct their evolutionary tree, especially at the beginning. Students were confused too by the similarity between the evolutionary trees they were asked to construct and pedigree diagrams used in previous lessons. This was a problem outside the scope of this action research project but, according to Arthur, it was a serious one 'akin to the well-documented bewilderment students experience when presented with traditional models of the atom and the solar system'. Students discussed in their group the different ways of constructing these species trees. James pointed out to students that there are several ways the tree could be assembled to make reasonable sense, especially since the students had not received behavioral or genetic data. After this simple-turned-complex activity students were shown DNA data that was useful in demonstrating relatedness of primate species. Returning to their groups students talked about the various justifications for differences in evolutionary trees in light of the DNA data. A second tree was assembled and students were again asked to write out explicit reasons for arrangements of their evolutionary trees, especially if they had changes. This final diagram concluded the teacher-centered inquiry activity. Students then began a student-centered inquiry into the advantages of opposable thumbs and stereoscopic vision. All totaled, students spent 45 minutes on the teacher-centered inquiry activity, with no more than 20 minutes for each step. James, Arthur, and the students then completed a survey about the effectiveness of the various sections of the lesson in constructing an understanding of primate evolution. They answered three questions.

1. What part of today's lesson did you learn the most from?

2. What part of today's lesson did you learn the least from?

3. Complete this sentence: Today I learned (insert response).

James and Arthur answered modified versions of questions 1 and 2, identifying parts of the lesson in which students learned the most and least from, respectively.

During the lesson Arthur moved around the room and interacted with students on an informal basis and also recorded in his journal observations he made of students during the teacher-centered lesson. The overall atmosphere of the room, Arthur noted, was initially discomforting and confusing, especially when students were asked to document the reasons they assembled the primate tree the way they did. One student constructed his tree based on increasing 'uprightness'. Another student thought that decreasing amounts of hair was a sign of evolutionary progress. Still other students looked to their classmates for ideas on how to start constructing their tree. On no less than seven different occasions, Arthur recalled, he and James were asked by a student if the work was correct. Understandably, students confused this phylogenetic tree lesson with a pedigree chart. Some students found it unsettling that James refused to provide immediate confirmation of the quality of their work. Arthur heard one student say to another, 'Close that book—from your own mind!' Once James provided DNA data students constructed evolutionary trees with more confidence in their arrangement. According to Arthur, it would have been nice to have another go at teacher-centered inquiry so students would gain confidence thinking on their own, but time didn't permit it. Perhaps presenting primate brain size would have resulted in yet another change in students' evolutionary trees. Even without the addition of other information to consider, students produced a four-page 'book' that documented their individual learning during the day's lesson. At the end of the lesson students seemed in awe of their ability to write what they learned and were amazed that they had 'discovered' some of the criteria used by scientists to construct an evolutionary tree.

Arthur and James reflected on what they had learned from their inquiry. They reported they were unsure what they 'had on their hands'. According to Arthur,

We certainly hadn't found the 'silver bullet.' But, we would like to think teacher-centered inquiry was a 'copper bullet' for us—useful in slaying some beasts, but by no means a magical solution to any educational problem.

James and Arthur provided insights about what they had learned from their collaboration. For Arthur the CAR process seemed laboriously slow at times (e.g., problematizing practice and examining the literature for relevant insights) and too fast at other times (e.g., implementing a plan and observing the outcomes). More importantly, Arthur now holds the opinion that 'by examining ourselves, other experts in education, and effective change in the school environment, we can systematically address problems that make us feel like prisoners in our own classrooms'. Moreover, Arthur became perplexed by what 'really' took place.

After observing the activities take place, I question whether there is such a creature as 'teacher-centered inquiry activity.' From a certain perspective, what occurred is an increased amount of student-centered activities with shorter [time] spans for each leading to one teacher-centered activity at the end of the day (notes). As far as I can tell, the best teacher-centered inquiry gets is simply 'sneaky' student centered inquiry.

James too provided keen insights into the outcomes of the collaborative inquiry. For him inquiry had become somewhat more ill-defined, contextualized, yet powerful in its effects on students. Here is what James concluded.

Inquiry is such a broad term. How does one go about defining where inquiry begins and another type of learning such as teacher-centered [lecture] begins? To me, I can see inquiry as any type of challenging, thought provoking method of teaching that stimulates

a student's mind to wonder about the subject. It has been my experience that students will only remain on task as long as their attention span will allow. Having varied types of teaching methods is much more effective than a routine, especially since the students will know what to expect in a routine and it then becomes monotonous. Along the same line, I have used the same [evolutionary tree] lesson with other classes and have seen totally different results. This makes me believe that teaching is immediate and spontaneous, and a teacher must respond to what works and does not work at that particular time.

Findings-Deconstruction of James' Discourses-Practices.

The problem that Arthur and James decided to resolve was '… the lack of involvement associated with lecture/discussion sessions'. The words that constitute the problem to be investigated can be deconstructed and their meaning examined to determine what ultimate goal Arthur and James sought. Arthur and James seek to promote 'student involvement,' which means for students to be 'included in, brought into contact with, or to be attentive to the lecture/discussion'. As Arthur and James describe it, attentive means to observe carefully, to give thoughtful consideration to, or to think meditatively about the lecture/discussion. Lecture is an informative talk to a class or giving information to a class. So, according to Arthur and James, James' lectures contain 'notes on the chapter, given in a way that draws meaningful ties between vocabulary words'. What James does in the lecture, apparently, is present vocabulary words to students, define what these words mean, and explain the interrelationships among these vocabulary terms. By defining for students what he considers to be the meaningful ties rather than allow them to do so, however, James deprives his students of the opportunity to 'give thoughtful consideration to or think meditatively about the information'. As a result, what students actually do during this presentation is described in the observations Arthur presented

regarding one specific lesson. In this lesson, 12 of 17 students 'check out' (i.e., slept or had their heads on the desk) of the lesson and had 'disengaged completely' within 15 minutes after James had begun the lecture/discussion. As a result, James 'becomes increasingly distant from the majority [and] attends to the questions and comments of a few vocal, outgoing students'. What James wants from students during the lecture/discussion, he denies them the opportunity to do. In fact, during the discussion that follows the lecture James 'nails down the details', then in step 3, he 'provides them with a study guide to help students remember key concepts taken from their textbook and covered in the lecture'. In response, students become bored and 'check out'. Perhaps students have learned by now that lecture information will be summarized for them and they will be given study guides, which provide exact readings on information that they are expected to know. Unknowingly then, James is subverting the stated intention of the lecture and follow-up discussion part (step 2) of the 6-step teaching strategy.

Arthur and James set out to develop a plan that will be 'sustainable, work within existing time and resources, and involve all students'. What they decide to do is to introduce teacher-centered inquiry to step 2 and to capitalize on past successes of the inquiry method. James regularly uses student-centered inquiry, according to Arthur, in step 4 of the 6-step instructional strategy. Instead of allowing students to direct the inquiry (i.e., student-centered) as he does in step 4, Arthur and James develop a 'teacher-centered' lesson, the pace of which is set by the teacher more than by students. What leads Arthur and James to believe the teacher-centered lesson will be a success is that it would 'bring a lab feel to lectures'. As Arthur and James report, all students participated in the teacher-centered inquiry on the topic of primates, designing and redesigning an evolutionary tree with each new piece of information they were given. As a result, students were 'in awe of their ability to write what they learned and were amazed that they

had discovered some of the criteria used by scientists to construct an evolutionary tree'. When commenting on the lesson's effectiveness, James notes the importance of the use of a variety of teaching methods, as a routine soon becomes monotonous and students quickly learn what to expect. From his comment, James appears to be more interested in avoiding boredom and inattention than engaging all students in a thoughtful consideration of the lesson's topic, as Arthur indicated that James continued to make use of the 6-step instructional strategy and because of time considerations discontinued use of teacher-centered inquiry in place of lecture/discussion during step 2.

James' Discourses-Practices as Political Productions

What is the source of knowledge in James' class? An examination of the case study provides clues as to the hierarchy of knowledge sources for James' lessons. From Arthur's description of the instructional routine, it is seen that James' role is central to the teaching process. During only one of the six steps in the two-day, 'highly structured instructional sequence' does James place students in the position of constructing their own understanding of the key concepts contained in the chapter included in the biology textbook. During this step students engage in 'authentic science', which James sees to be the 'high point in the 6-step instructional cycle'. During this part of the instructional cycle, '…everyone is engaged in self-directed learning while James acts as a resource person to resolve any confusion that may arise'. During the three steps preceding step 4, James takes on the role of textbook interpreter. First, he reviews vocabulary and definitions for key biology concepts to be covered in the chapter/unit. James defines which biological concepts are important to remember. During step 2, he lectures and leads a discussion in which he provided notes on the chapter, given in a way that draws meaningful ties between vocabulary words. In doing so, James provides an overview for students of the information

contained in the textbook and the interrelationships among key concepts, presumably in a condensed form rather than repeat the more lengthy textbook presentation. Next, he provides students with a study guide, which helps them 'remember key concepts' taken from the textbook and covered in the preceding lecture. Steps 1-3 have been somewhat repetitious but they establish James' authority and expertise in matters of interpreting the biology textbook, which serves as the ultimate source of 'truth' concerning biology concepts. Only in step 4 do students have an opportunity to make sense for themselves of the key biology concepts by engaging in a teacher-designed inquiry. During step 5, James uses concept maps and other forms of 'critical thinking activities' to help students reflect on past lessons, in preparation for the test, which concludes the 6-step highly structured instructional cycle. On tests, James expects students to 'recall information and apply what they have learned', presumably in much the same way that they have practiced when the teacher constructed concepts maps for them in step 5.

The political production of knowledge in James' classroom can be determined by examining Arthur's and James' case study report. The textbook serves as the ultimate authority for James' instruction, and he plans the 6-step instructional cycle so that he covers key biology concepts that students will be tested on at the lessons' conclusion. Throughout instruction, James serves as the source of knowledge and expertise for students. He expects students to ask him questions; he provides students with his interpretation of the textbook information; he decides what's to be included in the guide given to students for study purposes; and he constructs the end-of-chapter/unit tests. The knowledge hierarchy flows from the textbook, to James, to the study guide, and finally to the students. Missing from the presentation of this case study is any mention of times during the 6-step instructional cycle when students are asked to consult their textbook and read and interpret information for themselves.

Conclusions

Arthur and James examined student engagement in a teacher-centered biology leson. Based on this action-research case study (and their action research), they learned that students take a more active role in learning and believe students' learn more from teacher-centered instruction when the teacher first engages them in an exploration of their own understanding prior to the introduction of a new biology concept. When deconstructing James' discourses-practices, however, we find ambiguous, oftentimes contradictory meanings contained in the teacher knowledge developed by the teacher-researcher team, as well as an extant hierarchy evident with clear, distinct boundaries established for who gets to produce biological content knowledge. For example, James deprives students of the opportunity to give thoughtful consideration to or think meditatively about information and, instead, provides them with his interpretation and understanding of key biology concepts. James, at times, appears to be subverting (unknowingly) the stated intention of the lecture and the follow-up discussions and is more interested in avoiding boredom and inattention than engaging all students in a thoughtful consideration of key concepts. Even though there is an attempt to empower James through action research, he is reluctant to alter the established 6-step lesson cycle in ways that engage his students. Instead, James remains the source of knowledge and expertise for his students. The textbook retains its prominent position as the source of biology knowledge and James interprets its contents for students. James retains his authority and control rather than share it with students and gain their attention and involvement in learning.

What can be concluded as a result of this collaborative action research case study? First, James appears to hold a common 'theory-in-use' that inhibits change of any magnitude in his existing teaching practice, namely the belief that students must first be well behaved then self-

motivated before they can learn. The tenacity with which the teacher in this study holds this belief results from years of an 'apprenticeship of observation' (Lortie, 1975) as a student and now as a teacher in public schools. Second, the science teacher in this study oftentimes failed to see that he helped to create the classroom ecology. Thus, James attributed to students the sole responsibility for the learning problems that, unknowingly, he has helped to create—a 'blame-the-victim' mentality. As a result of his educational history and the expectations established for him by school administrators to establish power and authority over students, James has created discourses-practices that he enacts in his classroom and will not readily relinquish despite evidence that his beliefs, intentions, and values are counterproductive.

In summary, it is apparent that poststructuralism, adult learning theory and, action science/learning/research have offered very productive frameworks for engaging in and understanding teacher collaborative action research. Furthermore, viewing James' teaching practice through the poststructualist lens we get a foreshadowing of the difficulty that lies ahead for well-intentioned science teachers and teacher educators to bring about the kinds of sweeping change in teaching practices needed to achieve the goal of universal scientific literacy.

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