HASSE, ELEANOR ENTHOVEN. Reform in Biology Education: Teachers' Implementation of a New Biology Curriculum. (Under the direction of Glenda Carter.)

*Biology: A Community Context (BACC)* (Leonard & Penick, 1998) is a National Science Foundation funded high school biology curriculum designed to meet the goals of the reform movement in science education as envisioned in the *National Science Education Standards* (National Research Council, 1996) and the *Benchmarks for Science Literacy* (American Association for the Advancement of Science (AAAS), 1993). This study of a pilot implementation of the *BACC* curriculum illustrates some of the issues that emerged for teachers as they used an inquiry curriculum in the context of a district emphasis on meeting standards. In the first paper, “Teaching biology content using an inquiry curriculum,” I discuss the issues involved with teaching biology content using this inquiry curriculum. Teachers had difficulty bridging the gaps they perceived between the content in the curriculum and the content in their district standards, they had difficulty using the inquiry activities in the curriculum to teach content, and they did not accept some aspects of the instructional strategy. Professional development for teachers implementing inquiry curricula in the context of accountability for content oriented standards needs to address these issues directly and in an on-going fashion.

In the second paper, “Is Science Education Reform Reaching the Classroom?”, I use a framework developed by the National Research Council (2002) to investigate the ways in which these teachers and their classroom practices were affected by national standards. This framework has three channels of influence: ways in which national standards might affect classroom practice and thus student learning. These channels are
curriculum, teacher development, and assessment and accountability practices. In this pilot implementation of a reform curriculum, *Biology: A Community Context (BACC)* (Leonard & Penick, 1998), all three channels had been influenced by “Standards” based reform, but the channels were not completely internally aligned nor were they completely coordinated with one another. This led to implementation issues including increased breadth of objectives, increased time pressure and inadequate resources. These issues were barriers to teachers’ full acceptance of *BACC*. Addressing alignment in more depth prior to implementation of new curricula could lead to better classroom practice.
Reform in Biology Education: Teachers' Implementation of a New Biology Curriculum

by

Eleanor Enthoven Hasse

A dissertation submitted to the Graduate Faculty of North Carolina State University in partial fulfillment of the requirements for the Degree of Doctor of Philosophy

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Approved By:

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________________________________  Chair of Advisory Committee
DEDICATION

This dissertation is dedicated to the teachers who participated in this study: Linda Carr, Leslie Chamblin, Diane Conlon, Kevin Dever, Deborah Evison, Betsy Hartnett, Virginia Johnson, and Andrea Lauricella. These dedicated teachers not only gave unstintingly to their students, but welcomed me into their classrooms, spent hours talking to me about their teaching, and filled out survey after survey in the interest of improving science education.
PERSONAL BIOGRAPHY

I was born in Los Angeles, California to Alain and Rosemary Enthoven. I was encouraged in my interest in teaching by my parents, grandparents, and aunt and uncle and I got plenty of early practice on my five long-suffering younger siblings. I attended Harvard University, graduating with a concentration in Biology. Later, I got my teaching credential and Master’s degree from Stanford University. I then taught Biology and Mathematics at Sacred Heart Preparatory School in Menlo Park California for one year before joining the Peace Corps. As a Peace Corps Volunteer, I taught science and computers in Belize, Central America for two years. I then accepted a transfer-extension of my service and worked in a teacher training program based in Kathmandu, Nepal. After completing my Peace Corps service, I returned to California, where I taught middle school science at Grange Middle School in Fairfield, California.

After just one year in California I returned to Belize and married my husband, Bill Hasse, a biologist I met while serving in the Peace Corps. I was fortunate to be hired to teach science and computers once more at the Belmopan Comprehensive School, the same school I had served as a Peace Corps Volunteer. After 4 years in Belize, Bill and I returned to the US and moved to Raleigh, North Carolina. I taught biology for 2 years at Broughton High School before beginning graduate studies in science education at NCSU.

While pursuing my doctoral degree in science education, I was fortunate to work as a research assistant first for the Scientific Visualization Curriculum Project headed by Dr. Eric Wiebe and Dr. Aaron Clark, and then as a teaching assistant to Dr. Susan Butler and Dr. Glenda Carter.
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I thank Bill, my husband, for his constant support and encouragement and for listening to me talk about biology teaching at the dinner table for years! I also wish to thank my parents for their encouragement and support.
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I. Introduction

The current reform movement in science education advocates change from a traditional transmission model of education to an inquiry model where students build their understanding from experiences, investigation and discussion. The vast majority of U.S. high school classes emphasize factual information and traditional approaches where the student is a fairly passive recipient of knowledge transmitted by the teacher or textbook (Cuban, 1982; Goodlad, 1984). This is true of most high school science classes, including biology classes (Costenson & Lawson, 1986; Hurd, Bybee, Kahle, & Yager, 1980; Leonard, Penick, & Speziale, 1996; Ogens, 1991; Penick, 1995), and does not appear to have changed much in the 20 years since Cuban and Goodlad's extensive studies, despite constant calls for reform from diverse perspectives. Even teachers using innovative curricula have continued to lecture and assign students to read and answer questions based on the textbook much of the time (Gallagher, 1967; Penick, 1995). Laboratory experiences are usually assigned after instruction in a concept and are designed to confirm the lesson rather than to investigate a phenomenon (Penick, 1995).

*National Science Education Standards (NSES)* (National Research Council, 1996) is a document containing guidelines for reform of K-12 science education. These guidelines were developed by national groups of scientists, teachers, and science education researchers over a period of several years in response to a series of studies and reports in the early 1980s decrying the poor performance of American schools and students. According to the authors (National Research Council, 1996, p. 15), *NSES* content guidelines are consistent with those explained in *Science for All Americans* (American Association for the Advancement of Science (AAAS), 1989) and *Benchmarks for Science Literacy* (AAAS, 1993) developed by
Project 2061. However, the *NSES* went beyond these earlier reform documents by detailing standards for systemic reforms in pedagogy, teacher education, professional development, assessment, and support that might allow the content standards or benchmarks to be achieved. Although the *NSES* do not use the word constructivism, they clearly call for inquiry-based classrooms in which students actively construct meaning from experiences rather than taking a more passive view of the learner. In response to the calls for reform, new science curricula have been and continue to be developed. One of these new curricula, developed with a $2.3 million National Science Foundation (NSF) grant (Leonard et al., 1996; Leonard, Speziale, & Penick, 2001), is *Biology: A Community Context (BACC)* (Leonard & Penick, 1998). In an evaluation study of *BACC*, students in *BACC* classes with teachers who received extensive training in using this curriculum showed improvement in achievement and attitudes towards science (Leonard et al., 2001). However, the design of a new curriculum and documentation of its effectiveness are just first steps in a long process which might eventually lead to widespread changes in classroom practices. Even after a new curriculum has been adopted by a teacher, school, or district, there are many factors which affect how the new curriculum is used. Therefore to plan the use of new curricula so that they will contribute effectively to the desired reforms in science education, it is necessary to study the issues that arise in implementation.

To better understand the changes in teaching practice involved in implementing a reform curriculum, I studied a pilot implementation of *BACC*, focusing on the teacher's role in implementation. The pilot implementation was carried out by eight high school biology teachers in Jacksonville, Florida, as part of the Jacksonville Urban Systemic Initiative’s use of reform curricula in science and mathematics. The purpose of this study was to investigate
how teachers implement BACC, the factors they perceive as affecting their implementation, their understanding of this curriculum, and how they see implementation affecting their classroom practice. Using these data, I then explore the interaction of teacher beliefs, factors external to the classroom, and implementation decisions. This knowledge could be used by districts and teachers to implement new science curricula more effectively; and by curriculum developers to improve their design of reform curricula and accompanying teacher support materials and professional development experiences.

Research Questions

“Perhaps the most difficult task of the researcher is to design good questions, research questions, that will direct the looking and the thinking enough and not too much” (Stake, 1995, p. 15).

For this study I chose a qualitative case study approach. Cresswell (1998, p. 17) recommends qualitative research when a topic needs to be explored and described and when the issue of interest is what occurs in the natural setting. In this context the research may shift in focus as the researcher gains greater familiarity with the case and “Emic issues emerge” (Stake, 1995, p. 20). In this case the issues arose for the teachers as they implemented the curriculum. I became aware of these issues as I observed the teachers and listened to their concerns. My initial questions were broad. Then during the analysis phase I focused on the issues that had emerged over the course of the data collection phase.

The following questions guided my initial conceptualization of the study:

- **Teacher Behaviors and Student Responses**: What teacher behaviors are exhibited in the classroom as teachers use the BACC curriculum? How do students respond
(behaviors) to these instructional strategies? What, if any, changes in teacher and student behaviors are observed over the progression of the BACC course?

- **Implementation Choices and Rationales**: What implementation choices do teachers make? Which activities/strategies do they implement? Which activities and strategies suggested in the teacher guide do they choose not to implement? In what ways do they adapt or modify the materials? How do they explain these decisions?

- **Teacher Beliefs**: How does implementation of BACC interact with teacher beliefs about learning? Do teacher beliefs about what is important to teach (major concepts, vocabulary, dissection, process skills) and how students learn (reading, listening, seeing, doing) change as they experience teaching BACC? Are initial beliefs related to their implementation choices?

- **Support**: What support is provided and available to teachers? How does support for the curriculum affect implementation? How do teachers use what they learn in workshops? What aspects of the workshop are visible in teacher behaviors and rationales (from question 1 and 2) as they implement the curriculum? What other support is needed to make the implementation more effective?

- **Problems**: What problems do teachers perceive as they implement the curriculum? How do they go about solving these problems? How do these problems affect their view of BACC and of curriculum change?

**Overview of Study**

Research to answer these questions took place in Jacksonville, Florida. It began with observation of two introductory workshops for the BACC teachers. It continued with observation of BACC classes and interviews of BACC teachers throughout the 2001-2002
school year. One issue that emerged over the course of this study was the difficulty of teaching biology content using this curriculum and its inquiry based approach. Another set of issues arose in implementation due to lack of alignment between different aspects of the curriculum, professional development, and assessment and accountability policies affecting classroom practice. In the first paper, “Teaching Content Using an Inquiry Curriculum”, I explore the issues that emerged for these teachers as they attempted to use BACC to teach biology content. In the second paper, “Is Science Education Reform Reaching the Classroom?”, I trace the influence of national standards through several intervening layers of control to describe ways in which these teachers and their classroom practices were affected by national standards during the pilot implementation of BACC.
II. Literature Review

This section begins with a brief discussion of definitions of curriculum as the term is used in this study. The ensuing literature review then encompasses five areas: biology curriculum in the context of science education reform, the teacher’s role in guiding inquiry, teacher change, curriculum change, and some recent studies of science education reform projects. The literature on biology curriculum and reform in science education provides a context for understanding the development of BACC and the choice of this curriculum as a basis for investigating the implementation of a curriculum that is consistent with the NSES. The literature on investigating teacher and curriculum change helped to form the questions I asked and my perspective for analysis. Some of the other recent studies of reform projects help to inform my discussion of recommendations and wider implications of this study.

What is Curriculum?

Student learning should be central to the educational enterprise. In addition to skills, such as reading or subtraction; facts, such as the number of states in the U.S.; and concepts, such as photosynthesis; students learn attitudes and societal expectations. But many factors influence what students do and do not learn in school. Teachers and curriculum are just two factors embedded in a social context that influences student learning. Curriculum is multifaceted with many definitions. Concurrent aspects as outlined by Posner (1995, p. 11) include the official curriculum, the operational curriculum, the hidden curriculum, the null curriculum, and the extra curriculum. Curriculum includes the state or district's prescribed course of study, the package of text and ancillary materials handed to teachers at the beginning of the year, the implicit or hidden curriculum, and even the null curriculum, what is not taught, what has been deliberately or carelessly left out. However, most important for
learning, the curriculum is what students experience in their classrooms after the bell rings and the door closes. In this analysis I will concentrate on two aspects of curriculum: (a) the curriculum as envisioned by the developers of BACC and enacted in their instructional system including their text, activities, video, supplementary resources, and teacher development workshops, and (b) the operational curriculum as enacted in the classrooms by teachers and students. I will also use the term “curriculum channel”, a more inclusive term discussed below in the section on the NRC framework for research into the effects of national standards.

Biology Curriculum and Reforms in Science Education

Historical overview. Some form of biology is a usual U.S. high school graduation requirement. The 2000 National Survey of Science and Mathematics Education reports that 96% of U.S. students have access to a first year biology course (Wood, 2002). However, what students learn once enrolled in a biology class depends on many factors internal and external to the student. There is a long tradition of calls for reform in high school biology education. The current reform movement as exemplified by the NSES and Project 2061 is only the most recent attempt. Reform in the early 1900s led to a consolidation of separate botany, zoology and physiology courses into one general biology course. In the period following this consolidation, more topics and applications of concepts to daily living (hygiene, agriculture, nutrition etc.) were added to the curriculum (Rosenthal, 1990).

The next major reform in biology education was in response to the Soviet Union launch of Sputnik in 1957, lending support to the critics of U.S. education who claimed that America was falling behind technologically. After Sputnik, scientists and the federal government combined forces to redesign science education. This movement led to the NSF
funded reform curricula of the late 1950s and 1960s: BSCS Biology, PSSC Physics, and CHEM Study. BSCS Biology was typical of the new curricula in that the content was updated and rearranged around central unifying principles. There were three versions: Blue, focused on the molecular level; Green, with an ecological perspective; and Yellow, which took a structure and function approach. All three versions were similar in that they explained the development of ideas in biology and described the classic experiments and observations, which support current biological theories. Rather than presenting biology solely as a stable body of knowledge, it was presented as an ongoing subject of investigation. All three versions were organized so that evolution, genetics, and ecology were treated as central unifying principles rather than as isolated topics. All stressed student inquiry and provided materials for the teacher to encourage an increase in laboratory instruction. By 1976, 49% of school districts were using some form of BSCS Biology (DeBoer, 1991, p. 166-167). In response, other popular biology textbooks were updated and reorganized in some of the ways evident in the BSCS books.

However, the other texts did not incorporate much of BSCS’s investigative approach either to pedagogy or in their description of the science of biology. Vocabulary and facts were stressed over experiments and evidence for competing hypotheses. Moreover, the BSCS books were generally thought by teachers to be too difficult in their reading and conceptual level for average students and have since lost market share (Leonard et al., 1996). Stake and Easley (1978) directed a large multi-site case study of science education in 11 diverse districts around the U.S. The observers for these studies found that often the inquiry materials developed in the post Sputnik reform effort were sitting in storage in the schools, rarely used.
The current call to reform science education arose as a response to a series of negative reports exemplified by *A Nation at Risk: The Imperative for Educational Reform* (National Commission on Excellence in Education, 1983) describing problems in the U.S. educational system and comparing the performance of the U.S. on student achievement measures to that of other countries. Reformers in science education were also influenced by a rich body of research on misconceptions or alternative conceptions, which were a major focus of science education research during the 1980s. Students at all levels were found to have explanations in conflict with scientific explanations for many important phenomena (Driver, Asoko, Leach, Mortimer, & Scott, 1994). Rather than being blank slates with no preconceptions about scientific phenomena, students were found to have strongly held views based on their interpretation of personal experiences. Powerful examples of the effects of these views can be seen in a series of videos from the Private Universe Project (Schneps, 1995). These videos document persistent unscientific views of such phenomena as photosynthesis, vision and the seasons of the year. Children's underlying beliefs did not change much with traditional instruction. Instead they sometimes constructed novel explanations for phenomena incorporating some new scientific information into their existing beliefs. Even Harvard and MIT graduates held misconceptions such as winter being caused by greater distance from the sun or the mass of trees coming mainly from water and nutrients in the soil. Often students like these are very successful in school because they are able to learn new information and algorithms in order to satisfy their teachers and do well on tests without incorporating these ideas into their underlying beliefs. They are unlikely to remember the scientific ideas or be able to use them in a different context (Appleton, 1993).
Since at least the 1890s, reform calls have stressed the importance of students doing laboratory work in the sciences (DeBoer, 1991). However, reform in pedagogy has been much harder to achieve than the reorganization, updating and addition of content. Traditional biology courses continue to be largely lecture and textbook based and to emphasize vocabulary and facts over inquiry and conceptual understanding. Statistics collected by the National Assessment of Educational Progress (NAEP) show that many students still report little or no laboratory experience in their science classes. Twenty-five percent of Grade 12 students surveyed by NAEP in 2000 report that they do hands on activities or investigations in science classes only once or twice a month; 21% report never or hardly ever doing such activities (National Center for Education Statistics, 2000). In an analysis of survey responses from a national sample of teachers, Supovitz and Turner (2000) found that inquiry based science teaching and practices such as having students explain concepts to one another or provide evidence for claims were less likely in high poverty schools.

The National Science Education Standards. The *National Science Education Standards* *(NSES)* (National Research Council, 1996) were developed to provide an overall framework for the renewed call to reform in science education. A central goal of this reform is “having students learn scientific knowledge with understanding” (p.21). The *NSES* content standards begin with students developing the abilities to do scientific inquiry and developing an understanding of scientific inquiry. They go on to include standards in life science as well as the physical sciences, earth and space science, science and technology, science in personal and social perspectives, and the history and nature of science. The *NSES* advocate sustained systemic reforms in pedagogy, teacher education, professional development, assessment,
programs and systems to achieve the equity and excellence they call for. Standards are laid out in each of these areas with detailed descriptions and illustrative vignettes. The vision that emerges is of inquiry based classrooms where students actively construct understanding from experiences and discussion.

**Biology: A Community Context (BACC).** BACC is a new biology curriculum designed to meet the *NSES* standards. It is different from traditional curricula in that it was designed to be more student centered, more inquiry oriented and have greater emphasis on a few central concepts rather than trying to broadly include all of biology (Leonard et al., 1996; Leonard, Speziale, & Penick, 2001). Its authors, John Penick and William Leonard, envisioned a constructivist curriculum consistent in content and pedagogy with the *NSES*, which would help teachers engage students in inquiry into important problems. It was developed in accordance with school constraints, teacher needs, and research about student learning of science (biology in particular). It approaches learners in a constructivist manner in that it assumes students need to actively build meaning from experiences and social interaction rather than passively receiving knowledge from an authority. The focus is on the students actively investigating biological phenomena and discussing their ideas.

Each BACC unit is designed around problems and inquiries. The instructional strategy for introducing new concepts is based on Karplus’ learning cycle (Leonard et al., 1996). Learning cycle strategies are often recommended (Baker & Piburn, 1997; Banet & Ayuso, 2000; Bybee & Sund, 1982; Colburn & Clough, 1997; Westbrook & Rogers, 1996) as a constructivist teaching method for increasing conceptual understanding. This method consists of three parts. In the first part, exploration, students begin with concrete experiences, ask questions, make predictions and observe phenomena. The next part, invention or explanation, is
a teacher led discussion of the findings; this should lead to introduction of new concepts. Some authors (Bybee & Sund, 1982, p. 210-211) recommend teacher-centered, direct instruction during this phase; others (Westbrook & Rogers, 1996) recommend student discussion of the data facilitated by the teacher. In the third part, called expansion or concept application, new problems are posed where students apply the concept they have just learned to help them organize and generalize the new idea. Many of the same activities are recommended in a traditional approach. The difference is, in a learning cycle, an exploratory activity comes before the concept introduction. The concept introduction, explanation and discussion are then based on student experience. A further important benefit of the learning cycle approach is that it engages students in actually doing science. Over time it may cause them to view science and scientists differently.

In BACC important biological concepts are returned to and developed in multiple inquiries. For example, the first unit is about matter and energy. The initial investigations and guided inquiries explore the problem of trash in our society. Students sort trash, study ways of disposing of waste, build and study a compost column, grow yeast and bread mold and make molecular models. As the students do the activities, the teacher should guide them in discussion of matter and energy concepts that underlie the processes they are investigating. These inquiries are a base for later units on ecosystems, population and biodiversity.

The BACC textbook is roughly half the size of other popular high school biology texts. The reading level was designed to be appropriate for average 9th and 10th grade students (Leonard in June 2001 workshop). Far fewer vocabulary words are introduced than in typical traditional biology textbooks. Text questions focus on analysis and interpretation of the activities, not factual information from the reading. Most of the inquiries use familiar,
relatively low cost materials. Many traditional biology course topics and activities, such as plant tissues and animal dissections, are not included.

**Initial studies of BACC.** Clough’s (1994) formative evaluation of two units of BACC (then called BioCom) as they were used by 12 teachers involved in field testing Units I and III showed mixed reactions of both teachers and students to the BACC approach. Teachers and students were positive about the instructional strategies, particularly the initial and guided inquiries (then called the Opening Scenarios, Class Brainstorming, and Structured Inquiries.) However, teachers were concerned about the amount of time the activities took. They tended to have students do the same inquiries at the same time rather than having different groups of students work on different inquiries and then report their results to the whole class. Teachers had varying success with the journaling aspect of BACC; Clough recommended more attention to explaining the rationale for writing and providing the teachers with an evaluation scheme. While students participated eagerly in the culminating role-playing activities they tended to emphasize the politics of the situations. “Little, if any, science was apparent in the Forum” (p. 157). Clough recommended changes in both the instructional materials and teacher in-service education to encourage the use of scientific reasoning in the Forums.

Leonard et al.’s (2001) performance assessment study of BACC involved 16 teachers who taught both BACC classes and classes using a traditional biology curriculum for an entire school year. These teachers attended a week-long training in using the BACC curriculum. Achievement was measured using tests of biology content and science process skills specifically designed for the study and validated by a group of biology teachers. A pretest-posttest research design was used. Although the researchers had wanted matched
classes, counselors sometimes assigned “students of perceived lower ability” to BACC classes (p. 313). Therefore it was especially positive that students in the BACC classes scored significantly better on the posttests in both concept achievement and scientific process skills than students in the traditional classes. Observations of the teachers showed that these teachers were indeed using the BACC instructional strategies and taking a different role in their BACC classes.

The Teacher’s Role in Guiding Inquiry

The teacher’s role in the BACC curriculum is to create a classroom climate where students experiment, communicate and think (Leonard & Penick, 1998, Teacher’s guide). The teacher must provide the materials and context for investigations, lead classroom discussion, question and encourage students as they work, assess students in a variety of ways, and teach students to assess themselves. This is not an easy role. The research record shows that this role has been difficult for teachers using many different inquiry curricula. Costenson and Lawson (1986) reviewed evidence that despite a variety of studies showing that inquiry based pedagogy is more effective for biology instruction, teachers continued to use traditional methods of instruction. They then interviewed teachers to find out why this was the case. Some of the top reasons teachers gave for not using inquiry were the amount of time it took to develop materials, the amount of time it takes to cover the curriculum using inquiry, the difficulty of the inquiry based materials available, the expense of inquiry based materials, and their discomfort with the changes in classroom culture and control. The authors conclude that teachers would need a different type of preparation for teaching to overcome these factors. Cultural factors may also play a role. The changes in teacher and student roles required for inquiry teaching may even be regarded as "deviant" by other
teachers, particularly in low wealth urban schools serving low income and minority students (Kahle, Meece, & Scantlebury, 2000, quoting Haberman (1991). Phi Delta Kappan, p. 291). Thus, other teachers and school culture may discourage individual teachers from changing from traditional to more inquiry based teaching.

Tilburg, Verloop, & Vermunt (1999) found in a two year study of teachers working to incorporate inquiry into their teaching that teachers did not know how to guide inquiry and grew less confident and less enthusiastic about teaching scientific inquiry skills over the course of their study. An explicit goal of BACC and the NSES is for students to engage in scientific discourse, to use evidence to support arguments, and to consider alternative explanations. Therefore, an important part of the teacher’s role in guiding inquiry is to create a classroom climate conducive to this type of discussion and to teach students how to engage in it. However this has also been problematic: "Attempting to establish scientific dialogue in the classroom is more than an issue of awareness of how to scaffold students' learning to talk [science] but also an issue of how to impact a long standing tradition" (Carter, Westbrook, Dawkins, & Reid, 2000, p.4). In their study of an honors ninth grade physical science class Carter et al. found that, although students were able to learn to engage in scientific discourse, they resisted this change in roles. The students were very anxious to be successful but they defined successful in terms of knowing correct answers. They wanted the teacher to be the dispenser of knowledge and right answers to be clearly defined for them.

Yerrick (2000) found that lower track students also strongly resist changes in their classroom roles. Only over a long period of time was he able to develop a willingness in his students to engage in scientific discourse. “The 'just-the-basics' mentality and compromising science by watering down the curriculum for lower track students continue to perpetuate a
learned helplessness for these students regarding scientific knowledge" (p. 831). He found that these students had learned to see the teacher and text as authorities whose ideas must be reproduced; their own ideas seemed worthless in the school context.

Clough’s (1994) detailed descriptions of implementation of the field test version of two units of BACC indicate that teachers varied widely in their level of implementation, choice of implementation strategies, and skills in guiding students in inquiry. He concluded that extensive professional development addressing both teacher skills and the rationale for BACC would be needed to implement the curriculum appropriately.

Perspectives on Teacher Change

Teaching the BACC curriculum as envisioned by its developers requires teachers, especially those used to teaching in a more traditional mode, to make significant changes in their practice. They must give up teaching by telling or lecturing, and they must omit many topics to allow time for students to explore the activities and build understanding.

Teacher conceptual change. Feldman's (2000) practical conceptual change model, based on Posner's conceptual change model (Posner, Strike, Hewson, & Gertzog, 1982), is a way of understanding the conditions needed for teachers to make major changes in their teaching practice. These models in turn are based on Kuhn's analysis of paradigm shifts in science and Piaget's model of cognitive development. According to Feldman, teachers have practical theories that guide their daily decisions in such domains as lesson planning, grading and classroom management. The conditions for change are analogous to those needed in Posner's model. For a practical conceptual change to occur, teachers need to be dissatisfied with their current practice, and a new theory must be available which makes sense, appears beneficial, and is enlightening or helpful in understanding practice. If these conditions are
not met the teacher may incorporate, assimilate or adapt various aspects of the new curriculum into his or her existing teaching practice rather than making a practical conceptual change.

**Teacher growth, professional development and change.** A different perspective on changes in teacher practice comes from research on teacher professional development and growth. Joyce and Showers (1995) found in a meta analysis of teacher development programs that only when peer coaching was added to staff development programs was there significant long term transfer of new teaching methods to the classroom. A short workshop might be able to introduce a new laboratory activity, but would not affect the pattern of teaching behaviors exhibited by teachers. A synthesized model developed by Sprinthall, Reiman and Thies-Sprinthall (1993) and further supported by several studies (Reiman & Oja, 2001; Reiman & Peace, 2002; Reiman & Watson, 1999) proposes that for teachers to grow and develop they need to take on a new, more complex role, and regularly reflect on this new experience, over a long-term period of at least one semester. Further, teachers need balance between role taking action and reflection and they need to be both supported and challenged in their new role. According to this model, peer coaching would work to change teaching practice because doing peer coaching allows teachers to provide each other with support and challenge and a context for extended reflection on practice. In this view, adopting new teaching practices such as those required to teach *BACC* would be a new, growth-promoting role. The other conditions needed for growth might or might not be provided by the school district’s implementation plan.

Supovitz and Turner (2000) provide additional quantitative support for long-term, high quality professional development being related to teacher use of inquiry in science
instruction. In their study many factors were shown to play a role in science teachers’ use of inquiry and practices designed to promote an investigative classroom culture. These factors included individual teacher and school characteristics. Only teachers receiving more than 80 hours of professional development in science education reform practices reported more than average use of inquiry practices in their science teaching.

Phases of teacher concerns as they adopt innovations have also been extensively studied. The Concerns Based Adoption Model (CBAM) based on Fuller’s (1969) work describes how teachers move through levels of concern when faced with a new situation or challenge. They start with a focus on self and personal concerns, may move on to management of the task concerns, and finally move to concern about the impact on student learning. Some teachers remain stuck on personal concerns; others move quickly to impact concerns. This may be related to the teacher’s conceptual level and to other factors, such as stress and support (Reiman & Thies-Sprinthall, 1998).

Teacher beliefs and change. Richardson (1996) reviewed numerous studies showing that teacher beliefs related to subject matter and student learning affected practice and in some cases could be changed by staff development interventions (p. 112). The teachers’ implementation of new practices depended on congruence between their beliefs and the new practices. Tilburg, Verloop, and Vermunt (1999) found in a study following teachers implementing a new inquiry skills curriculum that experience changed the teachers’ beliefs. In this case difficulties with teaching the curriculum seemed to affect their beliefs about students learning through inquiry in a negative fashion. They became more pessimistic about the possibility of doing inquiry based instruction. Clough (1994, p. 188) recommended that
future studies of BACC include research into the teacher’s beliefs to better understand implementation problems.

School culture and teacher change. Other studies of teacher’s adopting new practices come from a sociocultural perspective as exemplified by Hepburn and Gaskell's 1998 case study of two physics teachers adopting a new curriculum. They found that teachers operate within a larger community of other teachers, administrators, parents, students and the wider community outside the school. The values, historical practices, and relationships within the community were important determinants of how the new curriculum was implemented and resulted in two very different implementations, both successful in their own context. In a study of elementary school science reform (Vesilind & Jones, 1998) found that aspects of school culture, particularly norms of egalitarianism and teacher isolation, led to difficulties for lead teachers in introducing new teaching practices. These studies show that the culture of particular schools and districts will influence teacher’s adoption of new practices.

Full understanding of how teachers come to make major changes in their practice and how they adapt new curricula may require the use of multiple models and perspectives to incorporate all of these factors.

Theoretical Perspectives for Investigating Curriculum Change

Mutual adaptation. In the first paper developed from this project I focus on the difficulties teachers experienced using an inquiry curriculum in a context where content was highly valued. For this study I chose to use a mutual adaptation perspective. Snyder, Bolin and Zumwalt (1992), in their review of curriculum implementation research, describe three broad perspectives: fidelity, mutual adaptation and enactment. The fidelity perspective comes from a top down view of curriculum development. In this model the teacher’s role is
to implement new materials as planned by their developers. To determine whether the new curricula are having an effect, it is necessary to measure effects on students. But, because adoption of a new curriculum does not necessarily mean implementation as planned, it is also necessary to measure level of implementation. Studies undertaken from this perspective generally used quantitative measures to compare the intended practices to the actual implementation. Many studies found that actual implementation as intended was low. Researchers then became interested in studying change as a process and the effects of the local context. As researchers realized that successful implementations of curricular innovations involved adaptations of the curriculum to the local context as well as changes on the part of teachers and schools, this perspective became known as the mutual adaptation perspective. In contrast to the mutual adaptation and fidelity perspectives, the enactment perspective begins with the curriculum as created by teachers and students in the classroom as the central feature of study. This perspective is more suited to studying the development of new curricular materials in cases where the teachers themselves are the developers and so was not appropriate to this study. Since mutual adaptation studies explore the change process and seek to understand the factors underlying changes made to the curriculum as well as the changes in teaching practices, this seemed to be the most appropriate perspective for this study.

The NRC framework for investigating curriculum change. In the second paper I take a broader look at the influences of national standards on the teachers and classrooms in this study. The National Research Council published a framework (National Research Council, 2002) for investigation of the influence of national standards on mathematics, science and technology education. Their intention was to lay out a model of how national standards in
mathematics, science and technology might influence learning for students. In order for national standards to make a difference for individual students they must affect classroom practices. The model lays out three complex and interacting channels of influence whereby standards might directly and indirectly influence classroom practice: curriculum, teacher development, and assessment and accountability. In most cases each channel traverses multiple interwoven layers of control and influence at the federal, state and local levels to reach the classroom. This control includes financial and regulatory control. The curriculum channel includes three different ways of influencing classroom practice. In many states, including Florida, there are both state and local standards which include course descriptions and objectives. The curriculum channel also includes the development of instructional materials, textbooks, lab manuals, films etc. Finally the curriculum channel includes the selection of instructional materials. The teacher development channel includes pre-service teacher preparation programs, certification requirements, and in-service teacher development. Finally the assessment and accountability channel includes how students, schools and districts are assessed, the accountability systems used and the ways in which higher education systems select and place students. The authors of this framework recommend that an analysis of the influence of standards in creating reform in science education be situated in this framework. In this way researchers may be able to trace the influence of standards to actual changes in teaching practice and then assess whether the desired changes in student learning are taking place.

Recent Studies of Reform in Science Education

Many recent studies have examined different aspects of the reform movement in science education and the effects of national standards. Some of these have addressed
coordination and alignment issues, and others have addressed the effects of specific aspects of reform.

**Alignment and coordination.** Alignment of curriculum, professional development and assessment is stressed in the *NSES*, particularly in the program and system standards. A recent study (Webb, 1999) investigating alignment between state mathematics and science standards and 14 tests in four states revealed that alignment was inconsistent. Some tests were well aligned with the standards they were supposed to assess, but many were not. The analysis showed that assessment of depth and range of knowledge was weak overall. Questions were asked at a lower level of complexity than stated in the standards - stressing recall and skills rather than the extended or strategic thinking called for in the standards. The full analysis for one eighth grade science test shown was illustrative. The alignment between assessment and standards for planning and conducting investigations and application was worse than for other areas of the curriculum, such as living things. This type of finding is consistent with teacher beliefs about the most important content to teach for high stakes assessment.

Urban Systemic Initiatives (USIs) are National Science Foundation (NSF) funded projects to increase math and science achievement by implementing standards based reforms in high poverty urban areas. The Jacksonville Urban Systemic Initiative (JUSI) was initially funded in 1997 and will be funded through August 2003. JUSI’s reform initiatives include partnership with local colleges, universities, and the business community, adopting standards based curricula and supporting teachers with inquiry based professional development (Barnes, Girardeau, Senftleber, & Kerlin, 2002). JUSI’s Year 3 Report (Fryer, Cline, & Girardeau, 2001) reports increases in enrollment and course completion in mathematics,
science and technology courses, some increases in student achievement and an increase in teachers receiving standards based professional development. Continuing challenges identified in this report include finding time for teacher development, eliminating the achievement gap while maintaining high standards for all students, and continuation of JUSI efforts despite a lack of sufficient funding. Studies of other USI projects around the country (Borman, Lee, & Boydston, 2002; Kersaint, Borman, Boydston, & Sadler, 2001a; Kersaint, Borman, Lee, & Boydston, 2001b) have also found issues with (a) lack of alignment between national standards and high stakes state assessments, (b) finding time for recommended teacher professional development, (c) teacher beliefs that are inconsistent with recommended teaching strategies, and (d) lack of funding for reform.

**Achievement and Reform.** Several recent studies of the use of teaching practices in science classes consistent with the *NSES* support the assertion that these methods will lead to measurable increases in student achievement. Sawada and Piburn (2002) carried out an extensive analysis of teaching practices and student achievement. They developed a classroom observation instrument to score the teacher’s use of “reformed” teaching practices centered on an inquiry orientation in the classroom. They found that higher scores on their reformed teaching observation protocol correlated with larger gains in student concept attainment over the course of a semester in physical science, physics, and mathematics classes. Kahle et al. (2000) found in their study of schools involved in a science education reform project in Ohio that African American students whose teachers used more standards based teaching practices scored higher on science achievement tests than similar students whose teachers used fewer standards based practices. Scamblebury, Boone, Kahle, & Fraser (2001) in a study of 3,429 middle school students in 191 classes (part of a large scale
evaluation of Ohio’s systemic reform initiative) found that standards based teaching practices correlated with statistically significant positive differences in student science achievement and attitudes.
III. Teaching Biology Content Using an Inquiry Curriculum

ABSTRACT

*Biology: A Community Context (BACC)* (Leonard & Penick, 1998) is a National Science Foundation funded high school biology curriculum designed to meet the goals of the reform movement in science education as envisioned in the *National Science Education Standards* (National Research Council, 1996) and the *Benchmarks for Science Literacy* (American Association for the Advancement of Science (AAAS), 1993). This study of a pilot implementation of the BACC curriculum illustrates some of the issues that emerged for teachers as they used an inquiry curriculum in the context of a district emphasis on meeting standards. The issues that emerged for teachers as they began to implement BACC were (a) difficulty bridging the gap they perceived between the content in the curriculum and the content in their district standards, (b) difficulty using the inquiry activities in the curriculum to teach content, and (c) difficulty accepting some aspects of the instructional strategy. Professional development for teachers implementing inquiry curricula in the context of accountability for content oriented standards should address these issues directly and in an on-going fashion to increase the acceptance and effectiveness of reform curricula.
The vast majority of U.S. high school classes emphasize factual information and traditional approaches where the student is a fairly passive recipient of knowledge transmitted by the teacher or textbook (Cuban, 1982; Goodlad, 1984). This traditional approach is used in biology classes (Costenson & Lawson, 1986; Hurd, Bybee, Kahle, & Yager, 1980; Leonard, Penick, & Speziale, 1996; Ogens, 1991; Penick, 1995), and does not appear to have changed much in the 20 years since Cuban and Goodlad's extensive studies, despite constant calls for reform from diverse perspectives. Even teachers using innovative curricula have tended to lecture and assign students to read and answer questions based on the text much of the time (Gallagher, 1967; Penick, 1995). Many science teachers include little or no laboratory investigation in their classes. For example, 25% percent of Grade 12 students surveyed by the National Assessment of Educational Progress (NAEP) in 2000 report that they do hands on activities or investigations in science classes only once or twice a month and 21% report never or hardly ever doing such activities (National Center for Education Statistics). Laboratory experiences, when included, usually come after instruction in the concept and are designed to confirm the lesson rather than to investigate a phenomenon (Penick, 1995). Supovitz and Turner (2000) found that teachers in higher poverty schools, as defined by the number of students on free and reduced lunch, reported lower use of inquiry based science teaching and less use of practices designed to foster an investigative classroom culture.

The *National Science Education Standards (NSES)* (National Research Council, 1996) call for a different kind of science education based on active student involvement in science inquiry:
Emphasizing active science learning means shifting emphasis away from teachers presenting information and covering science topics. The perceived need to include all the topics, vocabulary, and information in textbooks is in direct conflict with the central goal of having students learn scientific knowledge with understanding (pp. 20 - 21).

According to the *NSES* (National Research Council, 1996, p. 15) its content guidelines are consistent with *Science for All Americans* (American Association for the Advancement of Science (AAAS), 1989) and *Benchmarks for Science Literacy* (AAAS, 1993) developed by Project 2061. However, the *NSES* goes beyond these documents by detailing standards for systemic reform in pedagogy, teacher education, professional development, assessment, programs and systems. Although the *NSES* do not use the word constructivism, these standards clearly call for inquiry-based classrooms in which students actively construct meaning from experiences.

In response to this reform movement, new science curricula have been and are being developed. One of these new curricula, developed with a $2.3 million NSF grant (Leonard et al., 1996), is *Biology: A Community Context (BACC)* (Leonard & Penick, 1998). Students in *BACC* classes with teachers who received training in using this curriculum showed improvement in biology concept achievement, science process skills, and attitudes towards science (Leonard et al., 2001). While *BACC* was demonstrated to be effective in this study, adoption and implementation of reform curricula, in general, is a slow and difficult process requiring teachers to adopt new roles. As McInerney (1986) suggested in his analysis of biology textbooks, traditional curricula have enormous staying power. Past curriculum reform efforts have not been widely successful in incorporating inquiry methods into science education.
Stake and Easley (1978) found in an extensive multi-site case study that “despite considerable contact with legacies of the NSF-sponsored curriculum projects and with inservice programs dedicated to the promotion of student inquiry, very little inquiry teaching was occurring” (ch. 12, p. 4). Curricula promoting inquiry may be developed and adopted, but then not used in the way intended by their developers. Therefore it is necessary to study the actual use of new curricula in diverse settings to understand how teachers use them and what hinders their more widespread and effective use.

To better understand this implementation process, I chose to study a pilot implementation of BACC in Duval County (Jacksonville), Florida. This study investigated how teachers implemented BACC, the factors they perceived as affecting their implementation, their understanding of this curriculum, how they saw implementation affecting their classroom practice, and then explored the interaction of teacher beliefs, factors external to the classroom, and implementation decisions. The resulting knowledge could be used by districts and teachers to implement new science curricula more effectively and by curriculum developers as they design classroom materials, teacher support materials and professional development experiences. Money spent on curriculum research and development is wasted without adequate attention to the implementation process.

Theoretical Framework

Snyder, Bolin and Zumwalt (1992) outline three different perspectives in curriculum implementation research: fidelity, enactment and mutual adaptation. The first of these, the fidelity perspective, developed as an attempt to discover why new curricula often failed to result in the desired improvements in student achievement. Before the effects of new curricula could be measured it was necessary to determine the extent to which they have
actually been implemented. The role of the teacher from this perspective was to adhere faithfully to the new materials being implemented. This perspective is mostly concerned with measuring how closely a new implementation matches the intended implementation and with “identifying the factors which facilitate or hinder implementation as planned” (p. 404). However, this perspective does not provide a robust description of the implementation process nor does it take into account the teacher’s role in creating a successful implementation by adapting the innovation to his or her local context.

The curriculum enactment perspective takes the position that curriculum does not exist until it is created by the classroom experiences of teachers and students. If there is an outside curricular innovation to be studied, it is a resource rather than a standard against which to measure the teacher’s performance. In this perspective the focus is on the classroom and not on comparisons with the intended curriculum. Because this perspective takes the enacted curriculum as its starting point, the enactment perspective did not seem suitable for this particular case. Understanding the issues that developed for teachers in implementing a particular example of a reform curriculum requires a perspective that considers the teachers’ interpretations and modifications of the intended curriculum.

The mutual adaptation perspective on curriculum implementation views the implementation process itself as more complex than strict adherence to the curriculum materials. From this perspective the researcher’s goal is to understand the implementation process and how teachers adapt new materials and approaches to their own goals and local context. If we are to understand the complicated process of changing science instruction to match the vision articulated in the NSES, we need to examine the issues of implementation from the teacher’s perspective as well as from the reformer’s perspective. We need to study
the role of the teacher in creating an enactment of a reform curriculum in his or her own local context. Therefore, I chose to study this case of curricular change from a mutual adaptation perspective.

This mutual adaptation perspective was somewhat problematic in Jacksonville as the teachers were bound by their agreement with the Jacksonville Urban Systemic Initiative (JUSI) and were encouraged by the JUSI personnel “to implement the curriculum as written.” The JUSI personnel and the teachers saw fidelity as necessary to test the curriculum for effectiveness. At the same time several factors made the mutual adaptation perspective more realistic: (a) Teachers did not always have a clear understanding of the intended curriculum; (b) the curriculum was not written as a script, but instead necessitates many teacher choices as well as changes in practice for teachers; (c) the teachers found that they had to adapt the materials to the resources available and to meet their goals for the course; and (d) the teachers were encouraged to express how they thought the curriculum needed to change to fit their students’ needs. Using a mutual adaptation perspective allows analysis of the curriculum as the teachers interpreted and adapted it within their context.

Description of BACC

The BACC text and curriculum materials are quite different from the traditional textbook, Biology: The Dynamics of Life (Biggs, Kapicka, & Lundgren, 1994), used in Duval County. The BACC materials are designed in a constructivist manner in that they assume students need to actively build meaning from experiences and social interaction rather than passively receiving knowledge from an authority. The focus is on students actively investigating biological phenomena and discussing their ideas rather than on introducing facts and vocabulary.
The student text is divided into eight units designed around themes, problems and inquiries. Important biological concepts are returned to and developed in multiple inquiries, often in several units. Unit organization is illustrated in Table 1.

Table 1

**Activities in Typical BACC Unit**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Inquiry (with video)</td>
<td>Designed to promote discussion of a problem or issue.</td>
</tr>
<tr>
<td>Guided Inquiries (4 to 8)</td>
<td>Includes both inquiry activities with data collection and modeling activities. Questions focus on analysis and interpretation of the activity, not factual information from the text.</td>
</tr>
<tr>
<td>Readings</td>
<td>Each inquiry is followed by a reading with related content information.</td>
</tr>
<tr>
<td>Self Check 1</td>
<td>Questions to develop some of the main concepts embedded in the inquiries. Students work on these in small groups.</td>
</tr>
<tr>
<td>Conference</td>
<td>Students develop scientific communication skills by writing abstracts of their investigations and sharing knowledge and questions.</td>
</tr>
</tbody>
</table>
Table 1 (continued)

Extended Inquiries (4 to 8)  An opportunity for further and possibly more independent investigations.

Self Check 2  Again students work on these in groups. The questions are designed to promote discussion of the problems explored in the unit as well as nature of science issues.

Congress /Forum  Students take a role in a simulation of a public forum related to the initial problem posed in the unit. (In some units the Congress is preparatory to the Forum; in others it is a separate activity). This activity is designed to help students connect science to social issues and to construct and evaluate arguments from evidence.

Unit Test  Multiple Choice Test for each unit.

Each unit begins with a video introducing a problem that is then developed in an initial inquiry. The first unit, “Matter and Energy for Life” begins with a video about problems of trash disposal. This is followed by activities exploring the problem of waste disposal in our society while introducing concepts of matter and energy. Students sort trash, study ways of disposing of waste, build and study a compost column, grow yeast and bread mold to study respiration and decomposition, and build models to help visualize these
processes at the molecular level. Each activity is followed by a reading with related content information. Questions focus on analysis and interpretation of the activities, not on factual information from the reading. The first set of self check questions, actually designed to be worked on in groups, further develop the concepts. The conferences focus on scientific communication. For the first conference students write and present an abstract of one of their investigations. The first unit’s extended inquires include further study of compost and yeast respiration as well as more in depth study of societal waste disposal issues. The second set of self check questions in the first unit includes more analysis of waste disposal problems as well as questions about the role of science and scientists in society. The Congress/Forum is a town hall meeting to decide on a municipal waste disposal plan. Each group of students is assigned a role to research and play in the simulation. Rubrics for the various activities in addition to the multiple choice unit test are provided for assessment.

In accordance with NSES recommendations, Leonard and Penick deliberately chose to reduce the number of concepts introduced in BACC so that students could experience inquiry (Leonard et al., 1996). BACC does not include some traditional biology content and omits much of the detail found in more traditional high school texts. For example, BACC does not include discussions of electron configuration, specific information about different kinds of chemical bonds, discussion of condensation and hydrolysis reactions or detailed information about the structure and function of cell organelles, all of which were required by specific Duval County biology performance standards. BACC also omits plant and animal dissections and much of the detailed knowledge of taxonomy, anatomy and physiology included in traditional biology courses. Leonard and Penick chose instead to focus on studying fewer concepts with more investigations and student centered activities. There is
far more emphasis in *BACC* on doing and discussing investigations and on the nature and process of science than in traditional curriculum and far less emphasis on vocabulary and factual material.

**Method**

This study examined how teachers struggled with defining their role and their concept of high school biology as they began implementing a new “reform” curriculum. A case study approach (Creswell, 1998) was chosen because it allowed me to look at a variety of different aspects of the implementation while focusing on the teacher’s role and perspective. The following questions guided my initial conceptualization of the study:

- What teacher behaviors are exhibited in the classroom as teachers use the *Biology: A Community Context* curriculum?
- How does implementation of *BACC* interact with teacher beliefs about content and student learning?
- What problems do teachers perceive as they begin to implement the curriculum?

**The District and the USI**

Jacksonville and Duval County, located in the northeastern corner of Florida, have a consolidated government including the school system. Duval County Public Schools is the fifteenth largest district in the U.S. with 129,000 students in 2002. Duval County is attempting to introduce reform curricula at all levels in math and science through its National Science Foundation (NSF) funded Jacksonville Urban Systemic Initiative (JUSI). The JUSI’s mission is to increase mathematics and science achievement, to decrease achievement
gaps, and to implement reform in K-12 mathematics, science and technology education. At the high school level JUSI has supported the introduction of three reform curricula: *Active Physics* (Eisenkraft, 1998), *Chem Com* (American Chemical Society, 1998) and *BACC*. These curricula are categorized as research curricula in Duval County. Teachers and principals must sign a special agreement with the county to use these curricula instead of the standard materials. JUSI and the district provide some support with workshops, materials and a resource teacher.

**BACC Pilot Implementation**

The Duval County implementation of *BACC* began with three Duval County teachers who piloted *BACC* during the 2000-2001 school year. These teachers received little *BACC* specific professional development or support during that year. In the spring of 2001, *BACC* co-author and principal investigator, Dr. William Leonard was invited to do a one day workshop to recruit teachers for the pilot implementation project. Biology teachers from around the district were invited to attend. This workshop was attended by 23 teachers including four district resource teachers and three teachers already piloting the curriculum. Most of these teachers expressed interest in finding out more about the *BACC* curriculum. The JUSI staff then worked with teachers and school administrators to identify appropriate sites for the pilot implementation project. The March workshop was followed by a week long summer workshop, also led by Dr. Leonard, and attended by 11 teachers and one student teacher. Seven of these teachers plus two others who were unable to attend the summer work (including one from the initial pilot group) agreed to implement *BACC* in all of their biology classes during the 2001-2002 school year. All nine teachers implementing *BACC* during 2001-2002 were initially included in this study; one was later dropped at her
request. The eight teachers remaining in the study taught at five different high schools. These five schools represent some of the geographic, economic and ethnic diversity of Duval County’s high schools. However, as the district and JUSI focus is on improving lower performing schools, none of the district’s higher performing magnet schools was included in the pilot implementation project. Florida has a school accountability system in place which grades schools on an A to F scale. This grade is based largely on scores on the Florida Comprehensive Assessment Test (FCAT). The schools in this study all had C or D ratings in the three years prior to the study. In all of the pilot implementation schools biology is primarily a ninth grade course, although many observed classes included some students from higher grade levels. Both BACC and traditional biology classes were taught in all of these schools. Students were assigned to classes without reference to which curriculum would be taught. Twenty-five regular track (academic) sections and 11 honors classes were included in the pilot implementation. Three of the schools used block scheduling with four 90 minute instructional blocks each day. In these schools biology was a one semester course. The other two schools had more traditional year long courses. Class sizes observed ranged from 20 to 44 students. Five of the teachers had science rooms with flat lab tables, sinks, counters, and electrical outlets. The other three teachers had more makeshift accommodations; one of these teachers had no sink and very limited flat table space. More information about the characteristics of the schools is shown in Table 2.
Table 2

School Characteristics

<table>
<thead>
<tr>
<th>School</th>
<th>Schedule</th>
<th>Enrollment</th>
<th>% Black</th>
<th>Number of BACC teachers</th>
<th>Number of BACC sections</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>full year</td>
<td>1597</td>
<td>34</td>
<td>3</td>
<td>13</td>
</tr>
<tr>
<td>2</td>
<td>block</td>
<td>1857</td>
<td>42</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>full year</td>
<td>2188</td>
<td>16</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>block</td>
<td>1298</td>
<td>57</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>block</td>
<td>2174</td>
<td>42</td>
<td>2</td>
<td>12</td>
</tr>
</tbody>
</table>

\(^{a,b}\)(Duval County Schools, 2001)

Research Participants

The teachers involved in the pilot implementation were a diverse group in terms of experience. The district initially planned to include only experienced teachers interested in reform curricula in the pilot implementation. However, teachers who did not meet these criteria were included because of their own or their school administrators’ desire for the program. The group included a new teacher without formal teacher education in her second semester of teaching (lateral entry), two second year teachers, one of whom also had college teaching experience, two veteran teachers each with more than 30 years of experience, and three teachers with five to 14 years of teaching experience. All of the teachers had a science background; however, the lateral entry teacher was a geologist with little experience in
Two of the teachers served as cooperating teachers for student teachers during the fall semester. Both of the student teachers agreed to be observed and interviewed with their cooperating teachers. One of the teachers was male, the rest were female. One of the teachers was African-American; the others were European-American. In addition to the classroom teachers, JUSI assigned a resource teacher to support the reform curricula by providing staff development and technical assistance. This person served as a helper during the summer workshop.

**Data Sources**

Fieldwork for this study focused on the 2001-2002 school year implementation, and began with observation of the introductory workshop for teachers in March 2001 and subsequent summer workshop. The main sources of data for this project were interviews with the teachers implementing the BACC curriculum and observations of their classes. A total of 39 taped interviews and 58 observations were made. Each teacher was observed and interviewed at least three times over the course of the school year.

Classroom observation involved several kinds of data collection. Field notes recording lesson topics, activities, and teacher and student behaviors were taken. In addition, each teacher was observed at least three times using the Training and Assessment System (TAS) program (Bonnstetter & Bonnstetter, 1986). The TAS system allows the observer to enter codes into a laptop computer as student and teacher behaviors occur. At the end of the observed class the observer has a list of each behavior in sequence and the amount of time spent. Then the program can provide summary statistics and find repeated patterns in interactions. The TAS system was originally developed to allow pattern analysis (Shymansky, 1978) of classroom interactions using the SATIC coding system developed by Abraham and Schlitt (1972).
Bonnstetter then created other coding options to allow different coding systems and additional user generated codes to be entered and analyzed in the same way that the TAS system worked for SATIC. For this study, I used a coding system based on Flanders’ (1970) system but with some modifications to capture additional activities common in BACC classrooms (See Appendix A). Two teachers were video taped while teaching, to allow an inter-rater reliability check of my coding. Ninety minutes of video tape were coded by another graduate student trained to use the same coding system.

Teachers also completed surveys indicating which activities they had chosen to implement and allowing them another opportunity to comment on the activities and modifications they had made or thought should be made to the activities. Several of the teachers made detailed comments and suggestions for many of the activities.

In addition to the observations, interviews and surveys, samples of teacher made materials such as lab handouts and worksheets used in the BACC classrooms were collected. Other sources included interviews with the district science coordinator and JUSI resource teacher, interviews with the curriculum authors, John Penick and William Leonard, and the curriculum materials including the BACC student text, video, Teacher's Guide, Instructional Resource, and Student Resource.

Data Analysis

The observation field notes enabled a detailed description of each teacher’s implementation of the curriculum. The interviews gave a window into teachers’ thoughts as they used the BACC materials in their classrooms. Concerns and rationales for implementation choices were explored. Instances of match and mismatch with the BACC curriculum as written in the student text and teacher guide were noted and teachers were probed for rationales during
interviews. The surveys were used to analyze the extent and pattern of implementation of different aspects of the BACC curriculum as well as offering another window into teachers’ thinking about implementation choices. Field notes from the two introductory workshops and discussion of support issues in teacher and JUSI personnel interviews allowed me to explore the role of teacher professional development in supporting the teachers as they implemented the new curriculum.

The TAS program enabled coding and analysis of how time was spent in the BACC classroom. The program allowed me to enter a new code every time the classroom interaction changed (e.g. from teacher question to student response). During whole class instruction teacher behaviors and teacher student interactions were coded. Time spent doing group work was given a single code. Teacher activities during this time were recorded in field notes. Then the percentage of time spent in different modes of instruction was determined.

At several points during the analysis period, but after the data collection was complete results were shared with the participants to check whether I was portraying an accurate representation of their implementation and views.

Researcher Perspective

My role in this project was to be an observer of the district’s implementation project. I did not play an active role in disseminating information about the curriculum or how to use it. My own perspective is that of a biology teacher. I have 13 years of experience teaching science in several different contexts. However, my high school biology teaching experience was in the traditional mode, using traditional texts. Blending in with the teachers at the workshop and sharing their perspective during interviews were not problems; observing as an outsider, stepping outside of my teacher self, and refraining from helping students during
investigations was difficult. It was also extremely difficult to refrain from offering opinions, advice or help to teachers in the study.

**Findings**

In light of findings that new curricula are often not actually implemented as desired (Cuban, 1992; Stake & Easley, 1978), I begin this section by reporting the extent of *BACC* implementation in the classrooms studied and describing some of the implementation choices teachers made.

**Doing *BACC* Activities**

A narrow quantitative measure of implementation is how many of the *BACC* activities were used. Implementation in terms of doing *BACC* initial and guided inquiries was very high in most of the *BACC* classes, particularly for the early units. Table 3 presents a summary of the number of teachers implementing each of the main activities for two of the eight units.
Table 3

Number of Teachers Implementing *BACC* Activities in Units One and Five

<table>
<thead>
<tr>
<th>Activity</th>
<th>Unit One</th>
<th>no. of teachers</th>
<th>Unit Five</th>
<th>no. of teachers</th>
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<tbody>
<tr>
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<td>5</td>
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<tr>
<td>Guided Inquiries</td>
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<td>4</td>
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<td>6</td>
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<td>1.3</td>
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<td>6</td>
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<tr>
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<td>0</td>
</tr>
<tr>
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<td>3</td>
</tr>
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<td>4</td>
</tr>
<tr>
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<td>1</td>
<td></td>
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<tr>
<td>Test</td>
<td></td>
<td>8</td>
<td>Test</td>
<td>5</td>
</tr>
</tbody>
</table>

<sup>a</sup>The Congress was a planning activity for the Forum in Unit 1, but a separate activity in Unit 5.
These results were fairly typical of units one through five where teachers used most of the initial and guided inquiries. Typically teachers assigned only a few of the extended inquiries. Only two teachers used the conferences in the first unit and none did after that. Although they commented that the congresses and forums went very well, few of the teachers chose to use these after Unit 2. They used selected questions from the self checks and unit tests. After Unit 5 the number of activities implemented dropped sharply. In interviews teachers reported feeling more and more behind both in completing the BACC units and in covering the district objectives. Therefore, they explained that they had to omit many activities. Some of the teachers said that they thought that much of the Unit 6 content (Behavior and the Nervous System) did not fit the state and county curriculum objectives. Five of the eight teachers ran out of time and included little or nothing from Units 7 and 8.

A cross check on implementation was obtained by observation. Each classroom observation of one or more periods of instruction was categorized as BACC, mixed or non-BACC. Observations were categorized as BACC only if the primary instructional activities for the entire period came from the BACC text or resources. Out of 58 classroom observations 33 were classed as BACC lessons, 11 were mixed and 14 were non-BACC. In addition to the classroom instruction observed, a general idea of each teacher’s level of implementation could be inferred from looking at examples of student work and ongoing experiments in the classroom. These observations in conjunction with the surveys support the conclusion that all of the teachers used some aspects of the BACC curriculum throughout the school year.

In the final interview most teachers said that they had increased the amount of time spent in hands on and student centered activities compared to previous years. Further
evidence of teacher commitment to trying the *BACC* curriculum could be found in the fact that they spent an average of $330 of their own money to furnish supplies to do *BACC* activities and in the time teachers put into adaptations to make the activities work in their classrooms.

**Course Organization**

Another way to look at implementation level of *BACC* is to examine how teachers organized their courses. Seven out of the eight teachers followed the order of the *BACC* units. They used the *BACC* textbook, video and activities as the primary source and supplemented with other resources. Their students were observed to regularly use biologs, a key feature of the *BACC* curriculum. The biolog is a journal where students record their observations and thoughts as they do the *BACC* activities. The remaining teacher continued to organize her course to cover material from every chapter of *Biology: The Dynamics of Life* (Biggs, 1994). She made this choice at the beginning of the year when she had not yet received *BACC* textbooks. She said parents expected students to have textbooks and homework from the beginning of the school year. When the *BACC* texts arrived midway through the first quarter she began to use them as a supplementary resource.

**Description of Implementation**

There was a great deal of variation in the implementation of *BACC*. Teachers varied in their reliance on *BACC* as a primary source of the curriculum, their modifications of particular activities and the extent to which their skills and resources matched those needed to implement *BACC*. However, some generalizations can be made. In contrast to the picture of traditional biology teaching painted in the literature, none of the teachers was noted to use lecture as a primary teaching method. Very little traditional direct instruction with the
teacher standing at the overhead while the students took extensive notes was recorded in any of the observed classes regardless of whether the day’s lesson was a BACC lesson or not. In some classes students spent time doing fact and vocabulary oriented worksheets from non BACC sources, but this did not appear to be the main mode of instruction in any class. Instead, the main modes of instruction observed were group work on investigations or preparing for student presentations, interactive teacher led recitations, and individual work.

When a BACC activity was observed a typical pattern was seen. First the teacher introduced the activity focusing on giving directions, then students carried out the activity and began answering the questions for the activity in the BACC text. Generally they cleaned up just before the end of the period and were assigned to finishing the questions for homework. Students were rarely observed to present their results to the class and little whole class discussion of student data took place.

Implementation Issues.

These findings show that all eight of these teachers implemented many aspects of the BACC curriculum throughout the year. Yet, as they used the curriculum they struggled with making it fit the context of their goals and perceived classroom needs. This difficulty went beyond the lack of appropriate resources and in some cases lack of classroom management skills needed to implement the curriculum. The issue that emerged for these teachers over the course of the year was the difficulty of teaching content using an inquiry curriculum. This problem had three sources. Teachers did not believe the content included in BACC was adequate, they had difficulty using the BACC guided inquiries to teach content, and they did not accept important aspects of the overall instructional strategy. These issues came up repeatedly in interviews throughout the year.
Assertion 1. Teachers did not believe the content included in BACC was adequate.

Teachers struggled with the issue of giving up traditional content. Rationales for studying fewer concepts in Biology class were discussed during the summer workshop and teachers debated this issue with themselves all year. In answer to a question mid year about her evaluation of student learning with BACC one teacher said:

Teacher A: I’ve been struggling with that really. Because I know the way I was teaching before, they had more content knowledge. They were far better off with content knowledge than what they’ve been getting with BACC. But how important is content knowledge I don’t know. I don’t know if we’re… its going to take awhile to figure that out.

(December 6, line 229)

The teachers had strong beliefs about what content was important for students to learn in biology class. Most of them responded to initial questions at the beginning of the year about what was important to teach with goals compatible with BACC.

Teacher A: The most important thing is for them to learn in biology class is how to think for themselves and to solve problems, that’s the primary, my primary concern. And then they, if they learn basically how all living things are dependent on each other and interrelated and the fact that if we start harming some life forms it tends to [inaudible] to harm human life forms and I believe I’ve done my job. (August 24, line 18)

Teacher C: My most important goal is for them to be able to take care of their body. That’s their number one goal. And then second would be the
surroundings which would be the environment. You know, to be able
to take care of those things. (August 22, line 318)

Teacher E: I think that it is important that students are aware of their
environment as well as themselves so they should be able to relate the
two, the environment with living things and living things with their
environment. … I think that it is important that students learn to, not
only be aware, but be able to evaluate and interpret the issues and
concepts that are biological. (October 3, line 88)

Teacher B: …that most of life is interconnected in some way. There is very
little life that is an entity unto itself, without being influenced by the
environment or other life. And I think for me it is for them to come
away with a sense of awe that, that so much goes on, that they are
totally unaware of on such a regular basis, that makes them who they
are, that makes life what it is. (August 24, line 343)

However, follow up questions, observation of classes and interview questions about
particular lesson objectives led to a more complex picture. It was evident as the year
progressed that the teachers were reluctant to give up and continued to feel responsible for
student learning of some content not included in BACC or included with less detail than in
the previous text. This included concepts from local performance standards (electron
configuration, types of bonding, hydrolysis/ condensation), traditional topics and activities
not specifically included in the Duval standards (plant and animal systems, dissections) and
more detailed knowledge of facts and vocabulary (steps of photosynthesis, cell organelle
structure and function) related to the concepts included in BACC. Their beliefs about
appropriate content were supported by district standards, their own experiences as students, their previous experience as teachers, and the expectations of other staff members and students. These beliefs were challenged by the BACC workshops, causing teachers to struggle with thinking about which content was really important for their students.

These teachers taught in a local context where performance standards were emphasized. Meeting Duval County’s local performance standards and Florida’s Sunshine State Standards was a major concern for all teachers in the study. Teachers were supposed to post student performance standards in the classroom. High stakes testing was about to be implemented in science and would include all of the students who would be 10th graders in the year following the study. Teachers were uncertain about the focus of the tests but thought it essential to cover the content of the standards. Although the Sunshine State Standards include a nature of science strand with inquiry benchmarks, the concerns expressed by most teachers centered on whether students were learning the other content in the standards. To these teachers, “meeting the standards” usually meant knowing concepts, facts and vocabulary, not process skills or understanding the nature of science. Only one teacher noted that BACC was full of laboratory activities with charts, tables and graphs that would help students do better on the FCAT. Although the amount of material required by the Duval standards but not in BACC was small, this issue led teachers to doubt the BACC strategy and effectiveness.

Beyond concern for standards and test scores, most of the teachers thought that the traditional content and vocabulary deemphasized in BACC was needed for their students’ future success. Some of the teachers cited their own experiences in college, others the
experiences of their children and former students in defending their belief that students would need this content to be successful.

Teacher C: Sometimes I worry about that and I’m going to kind of have to do a little bit of adding, you know, because unfortunately I’m still a real content based person and when they go to college, and these kids are, the content is going to be there. You know. I mean my daughter just took biology in college and believe me they had to know all the little details. (Aug 22, line 248)

Teacher H: And when we went to a workshop this summer, I was really excited. I’m like oh yeah this is the way BACC, I mean this is the way biology should be, just like BACC. This is the stuff that really pertains to their life, but then you know then there’s a part of me now that’s kind of like what if they really need this stuff, to be aware it for college. Am I doing a disservice for them? Should they have this background of biology before they go to take that biology course in college? Should they already have this? What if they wanted to take AP Biology? Am I not, you know…are the kids in my class, are they not going to be able to keep up because they haven't learned all this vocabulary? Or would that be something that they would have to relearn anyway? These are questions I ask myself. (May 2, line 355)

Teachers understood that students did not retain much of this content but believed it was still important to teach it. One talked about teaching AP students who had totally forgotten about photosynthesis and respiration which she knew they had learned in ninth
grade. She wondered whether the BACC students would remember more. Another repeatedly said she knew students forgot the details but it would be easier for them in the future if they had seen it before. Teachers were concerned about depriving those few students who were interested in going on in science of the opportunity to learn what the teachers were sure the students would need to be successful. These concerns were often reinforced by other experienced teachers not teaching BACC. One of the second year teachers said that other more experienced teachers in her school were very negative about BACC. She was worried because her students had not learned all the steps of the light and dark reactions of photosynthesis. She thought that while they talked about these topics in her BACC class she hadn’t emphasized them the way other teachers did.

Student experiences were another influence on teacher thinking. One teacher had a student who was inspired by the BACC trash unit to start an environmental club to do recycling at school. This teacher saw that as an example of the success of the BACC approach in motivating student involvement but continued to struggle with her belief that the students needed more structure, more worksheets and more memorization to learn biology. She was inspired by the vision offered by the summer workshop, but was unable to get most of her students to engage deeply in the activities in the way she wanted them to. And her new vision struggled against the picture of biology class created by her own experiences as a student. Similarly another teacher thought that students at her school looked forward to the traditional frog dissection lab. She recalled the dissections in her own high school biology class and felt she would be depriving her students if she did not include frog dissection.

Because of the perceived lacks in BACC content, teachers supplemented BACC with content reinforcing activities to meet their objectives. Time was a major issue for all of the
teachers. None comfortably finished all of the material that they had hoped to. Time was often the rationale for choosing not to do certain BACC inquiries, as well as the conferences, congresses and forums. However, teachers found time to use a variety of non BACC activities to reinforce content learning. For example, three teachers used projects (model building, skits) and one used a jeopardy type game to reinforce learning of cell organelle names, structures and functions. Most used a variety of review worksheets in conjunction with other textbooks. Teachers reported that students found these worksheets relaxing after BACC activities and questions; students were uncomfortable with the more challenging work involved with uncertainty in BACC. Several teachers supplemented BACC’s inheritance unit with genetics problem sets. Teachers also used content oriented videos (for example on protein synthesis) to supplement. One included a series of animal dissections. Teachers thought that they would plan to do even more of this type of supplementation once they were free from the restrictions imposed by their agreement with JUSI.

Teacher H: (talking about plans for next year) I think I would supplement all of BACC a little bit more with my own notes and practice worksheets and stuff because I just, maybe its my own insecurities as far as not feeling like they've actually learned the standards, but that's something I feel like I haven't…. Okay this is what you need to know, now do you know it? That's one thing that I want to change. I might have to cut out more labs and put in more of my own stuff but that's something that I would have to do for BACC…(May 2, line 8)

For these teachers adapting the curriculum to their context included adding back in what they saw as important elements of the traditional curriculum missing from BACC. But
by replacing \textit{BACC} activities with traditional, fact and vocabulary oriented activities they lost some of \textit{BACC}’s intended focus on student construction of understanding from experiences and discussion.

\textbf{Assertion 2. The teachers had difficulty using the \textit{BACC} inquiry activities to teach concepts.}

Teacher F: It’s [\textit{BACC}] great, it’s a great book of labs, but tying it all in together with the concepts that they really need to learn, I don’t know if it does such a great job. (December 4, line 110)

The difficulty with giving up traditional content was exacerbated by the teachers’ difficulty with connecting the \textit{BACC} activities they did use to the concepts and content in the text following the inquiry. In many cases the \textit{BACC} materials explored concepts with a laboratory activity but did not have the detailed concept explanations for students that teachers were accustomed to in their previous text. In some cases more detailed material was in the teacher background knowledge sections of the Teacher’s Guide, but teachers were not sure how to incorporate this material or relate it to the activities.

Teacher A: I think a lot of the information in the teacher background is in the textbook, is very valuable information, but it never comes up in the text. There’s never like anything in there that says the teacher should expose the kids to some of this stuff, and we were trying to go by the teacher’s manual to have a realistic trial of the curriculum…( Dec 6, line 353)

Students often did the inquiries enthusiastically but did not engage with the interpretation and analysis questions. Answers to these questions in biologs tended to be
short and shallow. Little class time was spent discussing these questions either in small
groups or in whole class discussion. Students’ answers to questions often indicated a very
superficial understanding. Some of these problems arose because the connections between
some BACC activities and the underlying science concepts were unclear to some of the
teachers.

Teacher F: I just think that there needs to be a little bit more continuity as far
as what it is that experiment is supposed to be showing them. It's great
they sit there and they do an experiment but what have they learned from
it? What are they supposed to retain from doing that? What is it they were
supposed to learn by doing that? (October 3, line 391)

Several teachers suggested that it would be helpful if each activity had the learning objectives
explicitly stated. One of the more experienced and knowledgeable teachers described trying
to determine the objectives from the questions, surrounding content and unit exams. When
asked about the objectives of observed lessons, teachers sometimes stated a broad related
objective, but missed connections to specific biology concepts or the underlying unit
concepts. For example, when asked about the first unit, most of the teachers talked about the
objectives related to society’s problems with waste disposal and did not mention
conservation of matter in chemical reactions.

Even when the teachers saw these connections themselves they were unsure about
how to help students make them.

Teacher F: Tying it all in. I guess that’s what I mean. I don’t think it does a
good job of just tying it all in and I’m not sure if that’s just, I am
supposed to be doing that more or if they are supposed to be getting
that out of the book or … (December 4, line 140)

Teacher H: [In answer to a question of what she needed from professional
development.] An actual example of how he [Dr. Leonard] would go
about giving us the information that we’re supposed to be getting from
the guided inquiries. From the initial, the actual like lecturing kind of
concept. How he would make sure that the students are getting that
information. Does he just plan on going over the initial inquiry? I
mean the interpretation, application questions or does he supplement it
or exactly…. just questions… How do other people do it? How is it
supposed to be done? Is it supposed to be done just as readings and
labs, readings, labs, readings, labs? I don’t know. (May 2, line 699)

Teachers rarely led class discussions of the data from the activities or gave teacher
explanations linking the activity just completed to the related content. TAS records and field
notes show that in most cases where a BACC activity was observed, classes began with the
introduction of a new activity and ended with students working on activities until a few
minutes before the bell. The teachers’ introductions were mainly in the form of directions
rather than centering on the purpose of the activity. The last several minutes of class
included cleanup and announcements about homework. Little sharing of student data or
discussion of results was observed. These discussions, when they did take place, were short
and usually centered on answering particular questions in the BACC student book. Teachers
seemed to think that the student-centered nature of the curriculum precluded their taking a
role in directing interpretation and analysis of the activity.
The text readings following each guided inquiry are designed to introduce related concepts and vocabulary. Very little lecture on or discussion of readings was observed in most classes.

Teacher A: Right, I’d probably develop some more of the activities. I think one of the things that is missing in BACC is after they do the inquiry they are not really getting the important stuff from the textbook. Like today I was going over the self check questions and the answers were horrible. Either they are not understanding what they are reading or the text isn’t giving the answers clear enough for the kids to get them. So I plan on, … see[ing] what is not developing well enough and take a few minutes each day and develop it. You know, maybe give them a couple of short notes on the overhead and a brief lecture discussion because there is really not a lot of that in the BACC curriculum which is fine because I am not one to stand up there and yada yada yada for an hour but there needs to be some… (Dec 6, line 333)

When direct content instruction was observed, the teachers did not make explicit connections between the content and the related BACC activities. Although the teachers expressed frustration that the students didn’t seem to be making the desired connections, they were very reluctant to use whole class direct instruction with teacher led questioning and discussion to help students make the connections. They thought that following the BACC curriculum required a much more indirect approach where students would make these connections on their own. They seemed to hear Dr. Leonard’s emphasis on doing the activity first as an admonition to do the activity without other instruction and felt that they were breaking their
agreement with the district to implement the curriculum as written when they did teacher led discussion of the activities.

Teacher B: And maybe it’s my, my, naïveté on how to use the curriculum, but I’m not used to my students reading and doing something and reading and doing something. I’m used to us talking and doing. (August 24, line 175)

Teacher A: He [Dr Leonard] seemed to more or less emphasize . . . the kids and their own discovery of the information and I know it is not very content based but I think there needs to be more. I think you go by the teacher’s manual and what it wants you to do and when to do it because that’s what we were trying to do this first time… (Dec 6, line 345)

As the year progressed the teachers continued to experience difficulty teaching biology concepts through the BACC inquiries. In the context of a district focus on achieving standards, many of which were content oriented, these difficulties were a major impediment to the effectiveness of inquiry instruction and acceptance of the BACC instructional strategy.

Assertion 3. The teachers did not accept important aspects of the overall instructional strategy.

Teaching biology using BACC as the primary curriculum meant major changes in instructional strategy for these teachers. The BACC curriculum organization required teachers to restructure their courses from a familiar structure of the discipline approach to one based on problems. The strategy requires beginning with concrete experiences, helping students construct their understanding through discussion of those experiences, students
learning to communicate their findings, and application of the science concepts learned to societal problems. These changes also meant changes in evaluation and grading methods. The teachers used many of the laboratory activities which seemed familiar to them but were more uncomfortable with other aspects of BACC.

Because the organization of material is very different in BACC than in the curricula these teachers had used previously, teachers were unsure which concepts would really be covered. Most teachers initially saw this as a short term difficulty which would be overcome as they worked through the curriculum. However, as they used the curriculum some teachers experienced the problem-based rather than topical approach as jumping around. They saw this as confusing to students. And this may have reinforced their uneasy feelings about inadequate content.

The BACC materials are designed so that student experiences come before explanations. In the student text, readings come after the inquiries. Students are supposed to begin to construct their understanding of concepts by discussing their observations and experiences; then these can be used to help students develop and understand scientific explanations. Dr. Leonard emphasized in the workshops that it was important for students to work from the concrete to the abstract and that explanation would make more sense and be more interesting to students after a concrete experience. He frequently said, “Do the activity first.” While this approach initially seemed logical and appealing to teachers, they had difficulty with it in the context of their practice. For some activities teachers thought students didn’t have enough prior knowledge to make sense out of the activity. Teachers were used to using activities to prove or illustrate material they had already explained so they were unclear about how to use activities to develop understanding. The activity first
approach also required a change in thinking about evaluation and grading for both teachers and students. These problems contributed to the teachers’ sense that the curriculum was not adequate for teaching content and concepts.

Some of the teachers thought that without a scientific explanation of the concept ahead of time the students would not learn from doing the activity. For example, in an activity where students build model molecules, teachers thought that without a scientific explanation of bonding ahead of time the students would be “just playing” and would not benefit from the model building (Teacher G: - Field notes: Sept 13, line 117). Other teachers found that the students just did not get what the teachers thought they should from the activities if they had not been given a science concept explanation first.

Teacher H: I have to talk about it a little bit first. Because otherwise they don't see what the concepts that they're getting when they're doing it and it's kind of like okay they did all this and they didn't get anything. They had no direction. They had no idea what the concept they are trying to get is. But if I tell them a little bit about you know what we're doing first. Sometimes I do go through the procedure because they don’t read the book too. But, sometimes if I give them a little bit more background about the thing we're going into rather than having the background afterwards. If I do it a little bit before, you know, briefly, but so they know what they are looking for. And they can go ‘ah ha’ rather than just you know ‘la la la [humming] what did we just do? I have no idea.’ (May 2, line 150)
Teachers also found it much more difficult to evaluate answers based on student experiences rather than an authoritative explanation.

Teacher A: How I used to teach…well the major difference between now and before is before I would have a tendency to give all of the information, you know, I would give everything they need to know and then I would turn them loose on doing an activity and I would expect them to use the information that I have already provided for them. So if a question would come, oh, well how does this affect this? Well, remember when we spoke before class, go back to your notes and see how this might affect… The answer, maybe not point blank, was there but the information I gave them prepared them to answer all the questions that they were given whereas the BACC when you do the activity ahead of time you don’t get as… its more difficult to evaluate because the kids are coming up with their answers based on their experiences rather than based on particular facts that you have given them prior to the activity. So there’s the big difference. (December 6, line 219)

The post laboratory activity “interpretations and applications” questions were generally supposed to be answered by students based on their laboratory experiences. These questions came before the readings in the book with content information. Student answers to these questions were often shallow and did not reflect much understanding of scientific content. Teachers reasoned that if they followed the “do the activity first” guideline, they could not grade student answers expecting content knowledge that students had not yet been taught, but
teachers were unsure of how or when to teach the content. The teachers sometimes addressed this issue by inserting concept explanations or readings before the activities. However, in many cases the inquiry activities seemed to be unrelated to content instruction. Thus teachers did not take advantage of a key research based feature of the curriculum.

Teachers also struggled with using the text readings. Teachers and students were used to readings with vocabulary words in bold, definitions in the glossary, and worksheets to lead the students through the text. Teachers found that the BACC format required more thought and independence from the students. They were generally very positive about this feature, but found they had to teach students the skills to learn from this format. They developed a variety of strategies to ensure that students read and learned from the text. Two teachers at one school assigned students to take notes on the readings using a structured format. They then discussed and graded these notes. Another teacher picked out and assigned vocabulary from the reading; she also had students read aloud in class. Teachers thought it was important to have assessment of the content in the readings before the self check at the end of all the guided inquiries. This provided a signal to students that reading and studying content were important and allowed the teachers to evaluate whether students were learning the content before moving on. Some of the teachers used graded notes and or quizzes for this purpose.

The conferences, congresses and forums are an important part of the BACC strategy. They are intended to help students understand and model scientific communication and the application of science to societal issues and problems, learn to support positions with evidence, discuss what counts as evidence, and experience science as more personally relevant. In this strategy students learn through developing and talking through their
arguments. A teacher or book may be an important knowledge resource but the learning comes from the students’ thoughts and discussion. However, the teachers did not see these activities as helping to meet their course objectives. The following excerpt from an interview was typical of teachers’ thinking about these activities.

Teacher H:  It [first forum] went really great and I wasn't expecting it to be… just like the kids would be too cool for it. I just thought they were not going to be into at all but they were really into it.

Researcher:  They were into it. Did you do the next one?

Teacher H:  No, I just have not had time to do any of the other ones really. It's unfortunate but I just have had to keep moving on with the curriculum. I haven’t actually…. I wish I had. I don't know if we'll do this one. That might be fun to do… like the one at the end of this chapter, Unit 5. (May 2, line 813)

Although the teachers expressed surprise at how well the initial forums went and how much students seemed to enjoy them, they did not continue to use them throughout the course. They said they did not have time to do these activities and were not sure of their value. Even when they did these activities they saw them more as “play” and an opportunity to practice public speaking than as an opportunity to explore science concepts or scientific argument. For example, in one class observed the students were given only 25 minutes to research the issues and their roles before the class began to role play the town council meeting in the unit one forum. Nevertheless these students entered into the role playing with gusto. Their portrayal of the different community roles indicated that students understood the dilemmas posed by the initial inquiries but did not portray much in-depth understanding gained from
doing the other activities. The recycling group suggested that all municipal waste could be
safely and economically composted or recycled, neglecting any discussion of other important
issues. The students paid far more attention to developing slogans and rhetoric than to
explaining the science. This teacher stopped using the congress and forum after Unit 2
explaining that they just took too much time for what the students got out of them.

None of the teachers continued to use the conference step of the curriculum. They
said time pressure precluded use of conferences. They seemed to see the conference
component as a review, not as an opportunity to help the students synthesize the various
inquiries and relate them to the overall unit, nor as an opportunity to practice scientific
writing and communication. One teacher explained:

Teacher A: Well so far we haven't done them because we spend so much time
on each individual lab that the kids really don't want to go back and
review any one particular lab. And quite honestly after you’ve spent so
much time on each one, I don't even want to go back and rehash and
drag it back up. I might try one this half of the year just to see if there
really is any value in it, but if they didn’t put their heart and soul in it
the first time I don't see how they're going to get any more out of it the
second time. . . . With my experience with these kids if you are not
doing it right now it never happened. . . . I mean you ask them to think
back what they did last weekend and they’re clueless. I can’t imagine
going back two weeks prior they wouldn’t, maybe it would be valuable
for them to go back and revisit it but I just don’t see them getting a lot
out of it. (Feb 25, line 10, line 32)
Discussion/Implications

Teaching biology using the BACC curriculum required these teachers, even those already using inquiry activities, to make major changes in their teaching practice. Content significant to these teachers would have to be omitted. While teachers were comfortable with doing most of the activities, in many cases they were not able to use the activities to teach important biology concepts. Teaching concepts through inquiry activities meant that teachers needed to have students do the activities and then find ways to explore the concepts through discussion of the students’ data and experiences. While these teachers were eager to try BACC and demonstrated their commitment by doing many of the activities as well as paying for needed materials from their own money, they were unable to get the results they wanted from the curriculum because they had difficulty using the activities in this way. Furthermore, teachers were not convinced of the important role of student discussion in developing understanding or had difficulty promoting the desired type of discussion so they omitted most activities designed to promote discussion.

Support in terms of initial and on-going in-service education emerges as an important factor in much of the literature related to teacher growth and development as well as in Clough’s (1994) formative evaluation of BACC. There is a body of research that suggests teachers do not make significant changes in their practice without ongoing professional development. For example, Joyce and Showers (1995) found that changes in actual teaching practice required practice with feedback; an on-going in class coaching component was more effective than practice in the workshop setting alone. Supovitz and Turner (2000) found that increased amounts of teacher professional development were associated with increased use of inquiry-based teaching practices. However, teachers’ use of investigative practices did not
increase above average unless teachers had more than 80 hours of professional development. Establishing an investigative classroom culture (which is needed for BACC) was not found until teachers had more than 160 hours of professional development. School resources for inquiry based instruction and administrative support also played a significant positive role while student poverty decreased the use of inquiry oriented practices. Furthermore, secondary school teachers are situated in a community of practice, their own departments, which have significant influence on the change process (Anderson & Helms, 2001).

Some of the Duval County teachers had significant workshop exposure and commitment to inquiry methods before the BACC project; others had less, or, in the case of one of the beginning teachers, none. Initially JUSI planned to include on-going support and professional development for the BACC teachers, but money for materials dried up in the post September 11 budget situation, and no further BACC workshops were provided. At the beginning of the school year the JUSI resource person provided some support, but he left to go back to classroom teaching mid year. There was little contact between teachers at different schools and teachers did not use the BACC web forum provided by one of the teachers. At no school was the department chairperson a BACC teacher nor did department chairpersons seem to be involved in supporting the BACC effort. Without administrative support teachers never formed a collegial group to address the difficulties they had with the curriculum. In addition to helping each other with understanding how to manage the laboratory activities, teachers might have discussed their perception of how the curriculum was to be taught and their problems with linking content to the activities. A moderator might have addressed some of their misconceptions about the role of the teacher in helping students make connections between the activities and related concepts and content.
This study shows the need for teacher professional development to address content issues explicitly and in the context of local content standards. Explaining research which supports teaching less breadth and more depth of content is important but not sufficient in the context of demanding local content standards. Teachers need to discuss what content is included in a new curriculum, how to teach this content through the particular activities provided and what to do when this content does not completely match the specific objectives in the district’s standards. Since most high school and college science classes do not teach content through inquiry activities, teachers will rarely, if ever, have experienced learning science in this way. Therefore teachers need explicit instruction and modeling in how to lead a class discussion of an activity, how to use student data in the discussion and how to connect or bring out the underlying science content in the discussion. Because teachers have little or no experience with this kind of instruction either as students or teachers, they would benefit from seeing videotapes of outstanding implementation with students similar to those they teach. The professional development must continue as teachers experience using the curriculum so that they can collaborate in planning and reflect on student work. Issues can then be addressed as they emerge.

Curriculum developers, understanding the content issues for teachers, need to do a better job of describing what content is to be taught through particular activities as well as making concrete suggestions for how teachers could integrate these concepts into a student discussion of the activity. A list of specific content objectives for each inquiry should be in the teacher’s guide, followed by a discussion of how each of these objectives can be developed from the activity by teacher questioning and discussion. Teachers need suggestions of how to introduce activities to focus students on the purpose of the activity.
Typical misconceptions for important concepts should be included in the teacher guide along with suggestions for how the teacher can help students overcome these. Both student and teacher materials need to make more explicit ties between the activities and the content and concepts being taught. This can be done by using the student inquiries to a greater extent in the content readings following the inquiries. Greater attention also needs to be paid to how activities are framed, what prior knowledge is needed and how and when concepts are to be assessed so that the “activity first” rationale makes more sense to teachers and students. This could be done by listing questions the teacher can use to assess prior knowledge needed to understand the activity as the activity is introduced. This should be followed by suggestions for how to modify the approach to the activity when students do not have this knowledge.
References


Clough, M. P. (1994). *A formative evaluation of Biology in the Community (Biocom)*, University of Iowa.


Available: http://nces.ed.gov/nationsreportcard


Appendix A

Codes Used for TAS observations

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Code</th>
<th>Category</th>
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<tbody>
<tr>
<td>Accepts feelings</td>
<td>1</td>
<td>Teacher indirect</td>
</tr>
<tr>
<td>Praises or encourages</td>
<td>2</td>
<td>Teacher indirect</td>
</tr>
<tr>
<td>Accepts uses student idea</td>
<td>3</td>
<td>Teacher indirect</td>
</tr>
<tr>
<td>Asks a question</td>
<td>4</td>
<td>Teacher indirect</td>
</tr>
<tr>
<td>Lectures</td>
<td>5</td>
<td>Teacher direct</td>
</tr>
<tr>
<td>Gives directions</td>
<td>6</td>
<td>Teacher direct</td>
</tr>
<tr>
<td>Corrects or criticizes</td>
<td>7</td>
<td>Teacher direct</td>
</tr>
<tr>
<td>Student responds</td>
<td>8</td>
<td>Student talk</td>
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<tr>
<td>Student initiates</td>
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<td>Student talk</td>
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<td>E</td>
<td>Group work</td>
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<td>Individual writing and reading</td>
<td>W</td>
<td>Individual work</td>
</tr>
<tr>
<td>Teacher demonstrates - equipment</td>
<td>R</td>
<td>Teacher direct</td>
</tr>
<tr>
<td>Teacher demonstration - concept</td>
<td>T</td>
<td>Teacher direct</td>
</tr>
<tr>
<td>Uncodeable or other</td>
<td>Y</td>
<td>Other</td>
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### Appendix A (continued)

<table>
<thead>
<tr>
<th>Student Presentation</th>
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</thead>
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<td>Wait time</td>
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IV. Is Science Education Reform Reaching the Classroom?

Abstract: In *Investigating the Influence of Standards: A Framework for Research in Mathematics, Science and Technology Education*, the National Research Council (2002) lays out a framework for investigating the influence of national standards including the *National Science Education Standards (NSES)* (National Research Council, 1996) on student learning. This framework has three complex and interacting channels of influence: ways in which national standards might directly and indirectly affect actual classroom practice and thus student learning. These channels are curriculum, teacher development, and assessment and accountability practices. In a pilot implementation of a reform curriculum, *Biology: A Community Context (BACC)* (Leonard & Penick, 1998), all three channels had been influenced by “Standards” based reform, but the channels were not completely internally aligned nor were they completely coordinated with one another. This led to issues including increased breadth of objectives, increased time pressure and inadequate resources. These issues were barriers to teachers’ full acceptance of *BACC*. Addressing alignment in more depth prior to implementation of new curricula could lead to better classroom practice.
How are national standards affecting science teachers in their classrooms as they attempt to teach new national standards based curricula? The *National Science Education Standards (NSES)* (National Research Council, 1996) and the efforts to reform science education reach classroom teachers in a variety of complex and interacting ways. In *Investigating the Influence of Standards: A Framework for Research in Mathematics, Science and Technology Education*, the National Research Council (NRC) (2002) lays out a framework for investigating the influence of national standards on student learning. This framework organizes all of the ways in which the national standards might influence student learning into three categories: three channels by which national standards might directly and indirectly affect actual classroom practices and thus student learning. These three channels are curriculum, teacher development, and assessment/accountability practices. The NRC model notes that these channels are interacting. For example: changes in curriculum expectations may require changes in assessment practices and new teacher development programs; teacher professional development may lead to new assessment practices in the classroom. Therefore studies of the effects of national standards must take into account interactions between channels.

Because education in the U.S. is decentralized, each of the three channels, curriculum, teacher development, and assessment/accountability practices traverse multiple intervening layers of control including federal, state and local government to affect classroom practice. This is illustrated by Figure 1.

*Insert Figure 1 here*

At each level of control national standards may be interpreted in different ways by different people, and thus a variety of interpretations may be incorporated into educational
Figure 1. “The Layers of Education Governance and Channels Through Which Reform Might Flow” (NRC, 2002, p. 32).

planning, policies and programs. These channels also operate within a larger context of political and economic forces which have their own effects on teachers and classroom practices. Documenting the effects of the standards requires tracing paths of influence from the national standards recommendations through changes at the state and local levels to actual changes in teaching practice and then studying the effects of those changed practices on student learning.

The NRC framework is offered as an organizing model for situating research on the influence of standards. In addition to the organizing model the framework offers two key questions:

- “How has the [overall educational] system responded to the introduction of nationally developed standards?
- What are the consequences for student learning?” (p. 34 and repeated through document)

The organizing model and key questions are illustrated in Figure 2.

Insert Figure 2 here.

This paper addresses the question of how one educational system has responded to the introduction of national standards by considering the influences of the NSES as experienced by teachers participating in a pilot implementation of a reform curriculum designed to be consistent with NSES recommendations for pedagogy and content. The influences of the NSES are traced through several intervening layers of control to describe ways in which these teachers were affected. A case study approach (Creswell, 1998) was chosen because it allowed me to look at different aspects of the implementation process.
Figure 2. The National Research Council’s organizing model for situating research on standards (NRC, 2002, p. 114).

The NRC Framework for Research on Standards and the *NSES*

This section describes in more detail each of the three channels whereby the NRC committee members thought national standards might influence classroom practice and the specific *NSES* recommendations for that channel. Following this description of the individual channels is a brief description of the *NSES* recommendations regarding alignment of policies and coordination of reform efforts.

The Curriculum Channel

The NRC curriculum channel encompasses many aspects of curriculum development and implementation including:

- standards and frameworks that define what is to be taught
- graduation requirements that influence which courses students take
- course offerings
- development of instructional materials
- the choice of instructional materials
- the provision of resources for the classroom

The *NSES* content, teaching, program and system standards specifically address all of these aspects of curriculum. The content standards go far beyond a list of important science concepts to stress the importance of inquiry, the nature of science and the connection of science to society and other areas of study. The teaching, program and system standards explain the overall reforms needed to achieve the content standards. These standards may influence classroom practices in different ways. For example, the content standards may encourage state curriculum frameworks to include inquiry and cause changes in graduation requirements such as the addition of an Earth Science requirement. The *NSES* content and
teaching standards may influence curriculum developers and textbook publishers in their choice of and approach to content.

The Teacher Development Channel

The second channel as defined by the NRC framework is teacher development. This channel includes initial teacher preparation, certification and licensure requirements, as well as professional development requirements and opportunities for the practicing teacher. The NSES include standards for professional development for both pre and in-service science teachers. These standards emphasize that teachers must have opportunities to learn science content through inquiry and that professional development should be an on-going, lifelong, collaborative process. The NSES recommends a shift from current practices in which teachers are often seen as the targets of change, to increased reliance on teachers as agents of change, a change in emphasis away from short skill-based workshops towards longer, more reflective learning opportunities. According to the NSES, professional development programs should “focus on the vision of science education presented by the Standards” (p. 71). Collaboration, support and collegial relationships are recognized as essential to developing a school climate that supports teacher growth and Standards based changes in practice.

The Assessment and Accountability Channel

The third NRC channel is comprised of both assessment and accountability practices. This includes all types and purposes of assessment of student learning from teachers’ formative assessments of daily class work to high stakes state testing. The NSES assessment standards address this channel. But, in addition to assessing student learning the NSES stress the importance of assessing “opportunity to learn” (p. 79). These standards call for equal
attention to assessing the science education system through measurement of opportunity to learn and measurement of student learning. Opportunity to learn indicators include such factors as the qualifications of the teacher, the time allocated to science instruction, and the availability of instructional materials and resources. Careful assessment of opportunity to learn helps with appropriate interpretation of student achievement and allows assessment and improvement of science education programs and systems. In discussing assessment of student achievement, the *NSES* emphasize the importance of assessing “the science content that is most important for students to learn” (p. 79). Their definition of most important content includes inquiry, scientific reasoning, and scientific communication. The *NSES* also stress the importance of matching the type of assessment to the purposes of the assessment and of designing assessments that will be fair to all students.

**Alignment and Coordination**

The program and system standards of the *NSES* emphasize the necessity of alignment and coordination of all elements of reform to most effectively move towards the goals of reform. For example, teaching practices and assessment must be aligned with the goals and expectations for students. Instructional materials, resources and professional development must support the recommended teaching practices. However, achieving this alignment is difficult because interventions take place at multiple levels and are sponsored by different organizations. Different aspects of the standards are emphasized by different interventions. By the time the reform effort actually reaches the classroom, the alignment within and between channels may no longer be clear, leading to confusion and frustration.

Using the NRC model I analyze *NSES* influences on each of the three channels as experienced by the high school biology teachers in this study as they implemented a *NSES*
based reform curriculum. Then I examine some aspects of the alignment between and within
canals as experienced by the teachers in this study and analyze the effects of misalignment
on the implementation of the reform curriculum.

Context

Setting

This study traced the experiences of eight teachers during a pilot implementation of
*Biography: A community context (BACC)* (Leonard & Penick, 1998) as part of an Urban
Systemic Initiative project in Jacksonville, Florida. Jacksonville and Duval County, located
in the northeastern corner of Florida, have a consolidated government, including the school
system. Duval County Public Schools is the fifteenth largest district in the U.S. with 129,000
students in 2002. Duval County is experimenting with the introduction of reform curricula at
all levels in math and science through its National Science Foundation (NSF) funded
Jacksonville Urban Systemic Initiative (JUSI) begun in 1997. The JUSI mission is to
increase mathematics and science achievement, to decrease achievement gaps, and to
implement reform in K-12 mathematics, science and technology education. New reform
curricula are chosen and introduced as “research” curricula to help achieve this mission. The
teacher, school, district and JUSI enter into a cooperative agreement to implement these new
curricula. The teacher, with the support of his or her school administration, agrees to
implement the curriculum as written, while JUSI agrees to provide professional development
and support. In addition to teacher in-service workshops, JUSI provides resource teachers
who visit classrooms and assist with implementation issues for these curricula. One of these
new reform curricula is *BACC*. In the 2000-2001 school year JUSI began a limited pilot
implementation of BACC with three teachers, but provided little curriculum specific professional development. A larger pilot project was planned for the 2001-2002 school year.

I began my study of this pilot implementation with observations of the introductory teacher workshops in spring and summer of 2001 and then with classroom observations and teacher interviews throughout the 2001-2002 school year. Teachers also filled out a series of surveys recording which BACC activities they had used, their rationales for choosing which activities to use, comments on the activities, and a list of supplemental materials they had used.

Research Participants

The eight teachers in this study were a diverse group in terms of professional preparation and years of teaching experience. The group included seven women and one man, seven European Americans and one African American. Two were 30 year veteran science teachers. Three others had been teaching from five to fifteen years. Three were new teachers in their first and second years of teaching. Of these three, one had completed a teacher education program, one had experience teaching college microbiology and was taking graduate level courses in science education, and one, with extensive background in earth science but no teacher education coursework or experience in teaching science, had just become a teacher during the previous semester. The eight teachers taught in five different high schools representing some of the geographic and ethnic diversity of Jacksonville's schools. However, as the district and JUSI focus is on improving the lower performing schools, the district’s higher-performing magnet schools were not included in the pilot implementation project.
Reform Curriculum: *Biology A Community Context*

According to a national survey of biology teachers (Wood, 2002), the three most commonly used biology textbooks in the U.S. are *Modern Biology* (Holt, Rinehart and Winston, Inc.), *Biology: The Dynamics of Life* (McGraw-Hill/Merrill Co.) and *Prentice Hall Biology* (Prentice Hall, Inc.). *BACC* is a new biology textbook with associated curriculum materials designed to be very different from these more traditional programs. *BACC* was designed to promote student inquiry and understanding of the nature of science. The units are designed around problems, issues, and inquiries. Students keep a biolog, which includes their thoughts and impressions as well as the record of their laboratory investigations. The initial inquiry for each unit is introduced with a short video designed to promote interest in and discussion of an issue or problem. Topics are generally introduced with a guided inquiry giving students concrete experiences with concepts before there is an explanation in the text. The guided inquiries include fairly structured modeling activities and investigations as well as more open-ended inquiries. Important concepts are often explored in several different inquiries. In each unit a conference where students prepare abstracts of their work and share their results follows the set of guided inquiries. Extended inquiries follow the conferences and allow students to work more independently. Although there are questions labeled “self check”, students are instructed to work on these in cooperative groups. This promotes further discussion of concepts. Each unit ends with a congress and a forum. These are culminating activities where students use concepts learned from the unit to participate in the discussion of a related social issue. For example, Unit One, “Matter and Energy for Life”, ends with a simulation of a town council meeting discussing how to dispose of the town’s wastes; Unit Five, “Inheritance” ends with a congress on the further funding of human genome research.
and a forum debating whether automobile insurance companies should be allowed to use genetic information in setting rates. *BACC* also follows *NSES* research based recommendations to include less content in greater depth. Therefore *BACC* contains significantly fewer concepts than traditional high school biology textbooks but promotes active involvement of students in doing science and connecting biological concepts to societal issues.

**Tracing the Influence of National Standards**

To trace the effects of the *NSES* on the teachers in this study, I first examine each of the three channels as defined by the NRC to see what effects the *NSES* may have had (or not have had) as they were interpreted at the federal, state, and local level. I identify which levels of government are making the decisions that ultimately affect curriculum implementation in the classroom. I then look at these effects as they were experienced by the teachers in the study and discuss the issue of alignment. Figure 3 traces some of the paths through which the national standards influenced the classrooms in this study. Each path is then discussed in the sections that follow.

*Insert Figure 3 here*

**The Curriculum Channel**

The curriculum channel as defined by the NRC includes three components that were critical to the Jacksonville teachers’ implementation of *BACC*. These were: (a) the state and local performance standards, (b) the *BACC* materials, and (c) the resources in terms of laboratory facilities, equipment and materials.
Figure 3. Tracing the influence of the National Science Education Standards
State and local performance standards. The influence of the NSES on local standards was indirect and came through several different routes. Florida adopted state standards for students called the Sunshine State Standards in 1996. A major goal of their development was alignment of curriculum, instruction, professional development and assessment to provide a basis for accountability and thereby improve student achievement. These standards, developed simultaneously with the NSES, were based on an earlier 1993 Florida framework influenced by Science for All Americans (AAAS, 1989) and emerging science curriculum frameworks from around the U.S. The 1996 revision of Florida’s standards, which took place as the NSES were being developed, was influenced by Benchmarks for Science Literacy (AAAS, 1993) as well as NSES drafts (Marianne Barnes, personal communication, Sept 12, 2002). The Sunshine State Standards are similar to the NSES in some ways. They include a nature of science strand with standards related to inquiry and knowing how science is done and used in our society as well as strands for specific content areas including Earth and Space Science. They are intended to promote inquiry throughout the science curriculum. However, the benchmarks within the Sunshine State Standards are generally stated in a format of knowing about or understanding science rather than doing science. For example, while the first standard in the Sunshine State Standards nature of science strand is “The student uses the scientific processes and habits of mind to solve problems,” the first benchmark for this standard is: “Knows that investigations are conducted to explore new phenomena, to check on previous results, to test how well a theory predicts, and to compare different theories.” By contrast the standards defined by the NSES for inquiry and nature of science are consistently stated in an active format: “design and conduct scientific investigations” and “formulate and revise scientific explanations and models using logic and evidence” (p. 175).
Using the Sunshine State Standards, Florida’s Department of Education also developed course descriptions for middle and high school courses describing the overall content and purpose of the course and detailing which of the Sunshine State Standards should be included in each course. The biology course description includes a statement that “laboratory investigations, which include the use of scientific research, measurement, laboratory technologies, and safety procedures, are an integral part of this course” (Florida Department of Education, 1998, p. 1). This document also recommends that the nature of science strand be integrated into the overall course rather than being taught as a separate component.

In addition to the state standards, Duval County has adopted the “New Standards” from the National Center on Education and the Economy (NCEE) in an effort to increase achievement. These are performance standards designed to help students, parents, educators and community members understand what standards mean and recognize when a standard has been met. They do this by not only describing the type of student work expected but by including samples of student work with commentaries. The NCEE Standards for science were designed using the NSES and the Project 2061 benchmarks as guidelines for the appropriate content and level of performance (National Center on Education and the Economy, 1997). The NCEE standards are more specific and detailed in their expectations for student performance of scientific inquiry than the Florida standards. They require students to demonstrate inquiry, problem solving and communication in a variety of ways consistent with what is described in the NSES content standard for inquiry.

Using the Sunshine State Standards, the Florida Department of Education course description for biology, and the NCEE standards, Duval County developed local performance
standards for their biology course. Because some of the Sunshine State Standards for science are designated by the state for annual assessment, these standards were included in the local biology standards in addition to Florida’s required standards for biology, even when they were more related to physical science than life science. The end result was 90 specific local performance standards. Although the National Standards call for “more emphasis on studying a few fundamental science concepts” and “less emphasis on covering many science topics” (National Research Council, 1996, p. 113), the Duval County Biology Performance Standards required detailed knowledge of a broad range of topics.

Teachers in Duval County were very aware of state and local standards. District policy requires teachers to base their lesson plans on standards and to post standards in their classrooms for students to see. When asked about goals and course planning, teachers often defined their responsibility in terms of standards:

Teacher A: My primary role is to make sure the students can understand the performance standards . . . that have been written from the Sunshine State standards, and I basically look at what do they need to learn, what is the best way to get them to learn those particular standards, and then I usually have some kind of quiz or test to measure, or activity to measure, have they learned it or not. And if they haven’t, then it is back to square one where I look and see, ok, what else can I do to get them to learn this. (August 24, line 105)

Teacher B: My job is to take what has been given me, the requirements by the state and Duval and make sure that those objectives, those standards
are taught. Hopefully in a way that’s interesting and that will stick.

(August 24, line 444)

But while the standards include inquiry and nature of science strands, some of the teachers seemed to think more about the other strands in the context of choosing content and preparing students for assessments. The following quotes were typical:

Teacher B: [explaining why teachers chose to omit BACC body system labs]

A lot of those labs . . . are not done, because of our limited time and because it is not in our scope and sequence or in our performance standards. (May 4, line 346)

Teacher D: [explaining how she chose which inquiries to do from the BACC population unit] At this point I’m selecting only what we can move through with some sort of efficiency that are directly relevant to the state standards and that’s it. (May 1, line 16) I did assign that for those students for this unit three, but it really isn’t relevant . . . to the Sunshine State Standards. I’m not so sure how important it is for the exam that I see there, and it’s too abstract and so I thought, why did I even assign this reading . . . this is way too high level for them to get. (May 1, line 304)

Teacher H: [explaining why BACC’s lack of emphasis on vocabulary is a problem] In the standards you are supposed to learn the difference between this and that and you haven’t even learned [intercom interruption] what either word means. So it's hard for you to compare and contrast. (May 2, line 178)
Teachers were also very aware of inquiry as an instructional goal, in some cases because of the emphasis on inquiry in JUSI workshops and in some cases because of emphasis in university coursework and professional conferences. However, most teachers seemed to associate inquiry goals with JUSI, BACC or their own goals rather than with meeting standards.

**BACC Materials.** Another part of the curriculum channel as defined by the NRC framework is the development of instructional materials. Leonard and Penick designed BACC to be consistent with NSES recommendations to increase depth and reduce breadth (Leonard et al., 2001). They purposefully chose key biological concepts to emphasize in BACC while reducing the overall number of topics and amount of factual material. At the same time they increased the emphasis on students doing investigations and communicating their understandings. Further, they organized the content and concepts around problems and investigations. Important concepts such as trophic levels, energy flow and biodiversity appear in multiple contexts thus helping to deepen understanding. In the opinion of the developers “all of the [National] Standards for both Science as Inquiry and for Life Sciences are met by this curriculum” (Instructional Resource, p.181, italics in the original).

The choice of instructional materials is also part of the NRC defined curriculum channel. The BACC materials were chosen for a pilot implementation in Duval County because they were inquiry based, consistent with national standards, and had an ecological emphasis consistent with this emphasis in the Sunshine State Standards. Thus the NSES had a direct and significant effect on both the development of BACC and the choice of this curriculum in Jacksonville.
The BACC materials in turn did affect classroom practice. Seven out of the eight teachers reorganized their course to follow the BACC curriculum’s organization and had their students use some form of journaling to record their labs and responses to readings. All of the teachers used the BACC videos to promote discussion of issues and relate science to societal problems. They used many of the guided inquiries and tried some of the extended inquiries and forums. At the end of the year, six of the eight teachers reported that use of BACC had increased the amount of time their students spent doing hands on activities significantly. The two teachers who did not think they had increased the amount of time spent on laboratory activities already had their students doing laboratory activities several times each week. Those teachers who had previously used a fairly high level of inquiry found some of the BACC guided inquiries to be more structured with less student input than some of their previous inquiries. However, other teachers reported that the level of inquiry in the laboratory activities that they were doing using BACC was more student directed than their previous lab activities:

Teacher G: No comparison from what it used to [be]. I mean it’s totally, it’s 180 degrees different. Like before they hardly did any thought about why they are doing it . . . and now they are doing all of it. I mean you actually pretty much have given them, [inaudible] you give them the direction and now they are wanting to know why it did this or what happens if I do this instead. It’s their project, it’s their life, they control it. (May 3, line 101)

Other teachers reported that although BACC inquiries were more student directed than those they had used previously, many of their students were not able to handle this level of inquiry
and self direction or that there wasn’t enough time to allow the students to develop their own procedures. Those teachers reported and were observed adding structure and directions to enable students to do the labs.

**Resources.** A third part of the curriculum channel addresses the resources available to implement the intended curriculum. This includes the class size, the laboratory facilities and equipment, and the materials available. *BACC* is an active laboratory curriculum. Students are intended to be doing active investigations about 75% of the time (Teacher’s Guide, p.3). In some of the investigations students need to decide on appropriate materials and procedures. This requires more teacher supervision and preparation than activities where the whole class is following the same predetermined procedure. That means class size and facilities need to be appropriate for the activities. However, in the Duval County schools, as in most school districts, decisions about facilities and schedules are made by the school level administration. No special provisions could be made by JUSI for the teachers involved in the pilot implementation projects and indeed none were made for *BACC* teachers. While some of the classrooms were spacious and well equipped with class sizes ranging from 20 to 27 students, other classrooms were inadequate to carry out the intended curriculum. Class sizes of over 40 were observed in one school and classrooms without lab facilities were observed in two other schools. One of these classrooms did not have flat tables or sinks; the other had only one sink for class sizes of up to 37 students and the room was so cramped that students could not move around. Teachers overcame these conditions to some extent by sending students to get water, setting up trays and carts with materials, doing activities outside etc. but were unable to do some of the recommended laboratory activities.
Materials were also a problem. If students are to design their own investigations, the teacher needs to have a variety of materials and equipment available for students to choose from. Far from being easily available to students as envisioned by the developers (BACC Teachers’ Guide, p. 5), equipment was often unavailable or not easily accessible and the budget for materials at most of the schools was quite limited.

Beyond laboratory facilities, to do BACC as it is envisioned by the developers, students and teachers need other information resources: In a personal interview with one of the curriculum developers, Penick stated:

The text was clearly designed to be a stimulus not a compendium, an encyclopedic something. There's actually very little information in the text in the classical sense. If you were to compare the number of factual bits of information in BACC versus the bestselling books, it would be minuscule.

The idea was that BACC would have what was needed to stimulate the students to get started, but they needed to supplement with other things. The intention fully was that they would be reading from other materials. (May 21, line 210)

Most of the classrooms had some supplementary information resources in the form of a few computers with internet connections and some science magazines. In some of the classrooms the computers were occasionally used; in others technical problems, problems with classroom management and the large ratio of students to computers led teachers to forgo their use. Some teachers arranged for class use of the school media centers to have students do projects that required internet and other resources for research. All of the teachers had other biology textbooks as resources, although these were more frequently used for supplementary
worksheet assignments than as references for BACC activities. Overall the availability of resources appropriate for student research as envisioned by BACC was low.

In terms of materials, BACC is a low-cost curriculum; it is not a no-cost curriculum. The teachers reported paying from $50 to $600 with an average of $330 of their own money to buy supplies. Most of the teachers had the impression at the beginning of the year that supply costs would be paid for by the district or USI. After Florida’s tourism revenues declined post September 11, Duval County revised its budget for materials and whatever money might have been available disappeared. Most of the teachers continued to spend their own money for both BACC and other classroom materials because they saw value in the hands-on activities afforded by the materials. Several teachers explained that while BACC was not more expensive than a traditional laboratory biology course, more supplies were best purchased fresh from local grocery, pet, and hardware stores, rather than ordered through scientific supply houses. (The materials teachers wanted to purchase fresh locally included bread, yeast, sugar, gum drops, potting soil, seeds, eggs, vinegar, toothpicks, plastic bags, crickets, goldfish, worms, screen, etc.) Most of the schools did science ordering for the whole department at the beginning of the year from scientific supply houses and had no mechanism in place for these types of purchases. Some schools were willing to work with teachers to pay for these supplies; in other schools the teachers purchased supplies, but were never reimbursed.

Teachers also need sufficient planning time to prepare for a new curriculum, gather extensive materials and set up their classrooms for the various activities. However, no provisions were made for extra planning time and some of the teachers had even less than the typical one planning period per day. In one school the teacher had no planning period
second semester: She taught all four blocks. In another school teachers were frequently (more than once a week) required to do other activities such as attend meetings and substitute teach during their planning period.

**The Teacher Development Channel**

The second channel whereby National Standards might influence classroom teaching according to the NRC model is teacher professional development. In Jacksonville, JUSI was responsible for initiating the use of *BACC* and providing appropriate professional development. The JUSI model for professional development is based on an inquiry approach consistent with *NSES* recommendations. Prior to the pilot implementation of *BACC* all of the experienced teachers in the study had attended some JUSI professional development workshops. The teachers described this professional development as stressing the importance of student inquiry and providing them with hands-on activities to do in class.

To prepare teachers for implementing *BACC*, two workshops were provided: a one day introductory workshop in March and a week-long summer workshop. Both workshops were led by Dr. William Leonard, co-author and principal investigator for the *BACC* curriculum development. In these workshops the main emphasis was on doing the activities. Dr. Leonard described research (i.e. Orlich, 2000) and an educational philosophy supporting the need for learning to start with concrete experiences rather than lecture. Teachers participated in several of the curriculum activities on each of the six workshop days. Dr. Leonard’s focus was on the need for students to do the activities to construct knowledge from active experience and in this way was consistent with *NSES* recommendations.
Teacher D: I thought his main message was for us to give students an opportunity to direct themselves within an experimental or scientific setting. (May 1, line 399)

Although the workshops were standards based in that they focused on teaching a curriculum consistent with the NSES and on inquiry based pedagogies, the overall professional development experienced by these teachers over the course of the 2001-2002 school year was not consistent with the NSES standards for professional development. In particular the vision of on-going collaborative, reflective professional development set out in these standards was not realized. Neither the district nor JUSI provided the on going support to BACC teachers called for by NSES and which their own (JUSI) reports suggest is necessary for successful implementation of reform curricula. Support meetings were talked about but did not take place during the 2001-2002 school year. Some sharing did take place between BACC teachers at the same school, but three teachers had no other teacher in their schools using BACC. More sharing would have been particularly valuable for the less experienced teachers in the group, for teachers in schools with block scheduling between the first and second semesters, and as some teachers began to question whether BACC was appropriate for their students and the district standards.

Teacher H: I really liked the workshop. I wish we as teachers, we could have, we had said then that we would want to get back together more and more. . . . I never got back together with them. (May 2, line 577)

A lot of things I've just had to do the best I could with what I have.

(May 2, line 656)
Beyond sharing strategies and support, the NSES vision for professional development involves teachers collaborating in examining and reflecting on their own and student work. Without an on going component to the professional development there was no structure to develop this collegial reflection. In class coaching was also planned for during the study year but in practice was minimal. The JUSI resource teacher for BACC, who had many other responsibilities, spent most of his BACC time trying to procure sufficient BACC textbooks and other resources and little time was available for in class assistance or coaching. He left JUSI to go back to classroom teaching mid year and was not replaced for several months.

The Assessment and Accountability Channel

The third channel by which National Standards might affect teachers’ classroom practice is assessment and accountability practices. Florida has a high stakes accountability system in place to assess student learning of the Sunshine State Standards and compare student achievement to national achievement. Thus it has both criterion and norm referenced subtests. It also includes both multiple choice and open response types of items. The tests, known as FCATs (Florida Comprehensive Assessment Tests), are used to grade schools in an accountability system that involves publication of scores and sanctions for low scoring schools. The test is also used as a gateway for student performance. Students must pass the 10th grade FCAT to be eligible for high school graduation. Reading and mathematics have been assessed at grades 3-10 since 1998. An FCAT in science for grades 5, 8 and 10 is being developed. It was field-tested in the spring of 2002 and will be operational in the spring of 2003; thus it will apply to the students who were 9th graders during the 2001-2002 pilot implementation of BACC. Duval County is also using the SAT 9 (Stanford Achievement Test 9) to assess the progress of the Jacksonville Urban Systemic Initiative (JUSI). Duval County
had not decided how to assess student learning of biology with BACC when the pilot implementation began. At the end of the first semester block, a 33 item multiple choice test using the BACC Teacher’s Guide Unit Tests as a source of items was created. The items were selected based on correlation with the Sunshine Standards and used by the district as part of their assessment of the research curriculum.

The BACC teachers were very concerned about state mandated assessments and accountability. At the time of the study, teachers had not yet seen the science FCAT and did not have a clear idea about how it would be aligned with science standards. Some teachers were concerned that it might require students to have extensive factual knowledge; others thought it was likely to concentrate on the interpretation of data and thus be more consistent with the reform curricula. The science FCAT will have a bigger impact on classroom practice in future years as teachers become more familiar with this test.

Assessment and accountability in other subject areas reduced the amount of time spent on science during the study year. Beyond preparing for the new science FCAT, preparing for the reading and math FCAT was part of every teacher’s responsibilities and regularly took time away from science instruction. At some schools specific materials and methods were mandated, preventing teachers from using science materials for FCAT practice. At one school all class periods were shortened to create a reading period every day in which students did a variety of required reading activities. Another school required all teachers to schedule a reading activity each period on Wednesdays and sometimes had weeks when a different period each day was devoted to sustained silent reading of the student’s book of choice. At two other schools extra homeroom periods and special assemblies devoted to test taking skills were scheduled. All of the teachers were encouraged to embed
FCAT skills in all instruction. The new science FCAT may reduce demands on science instructors to spend science class time doing review activities for other areas or increase interest in instruction which integrates material from different subject areas.

The assessment channel also includes the teacher’s own formative and summative assessments of student achievement. The NSES recommend the use of a variety of assessment tasks. The BACC curriculum materials include familiar multiple choice unit tests; they also include rubrics for assessment of other kinds of student work including inquiry investigations, student journal writing, and student participation in class forums. This type of assessment is aligned with NSES recommendations for developing self-directed learners. However, the rubrics provided were difficult for teachers and students to use. Some of the teachers suggested modifications to the rubrics or developed new rubrics for their own use. Several of the teachers listed learning more about how to use BACC’s assessment tools as an area of need for further professional development.

**Alignment**

The three NRC channels may be separated as they traverse the federal, state and local agencies which set educational goals, policies, and programs but they converge again in the classroom in the teacher’s experience of and response to these goals, policies and programs (See Figure 2, p. 76). While the teachers in this study were affected by national standards in all three channels of influence, lack of alignment within and between channels led to problems during the study year.

**Within the curriculum channel.**

The lack of alignment among the BACC materials, Duval’s local performance standards and the resources allocated for teaching BACC emerged as a problem for nearly all
of the teachers. The content of the Duval standards was aligned with the NSES and included inquiry and the nature of science so it appeared to be well aligned with BACC. However, the number of standards and breadth of the requirements made it difficult to teach all of these standards using the student inquiry approach of BACC. The inquiry approach may develop a deeper student understanding but teachers believed the inquiry approach required more time to cover content than a more traditional expository approach.

The large number of Duval standards not only created time pressures but also included very specific and detailed knowledge of concepts not included or not covered in depth in the BACC materials. Most of these were standards Duval added to the Florida Biology course description because they were to be assessed annually. Teachers thought that ensuring student understanding of these concepts was an essential responsibility because these standards would be assessed on the high stakes FCAT test. Some of the teachers were comfortable with supplementing BACC with other materials when they thought it was necessary. Other teachers were troubled by this issue, because of their interpretation of their agreement with the district to implement the BACC curriculum as intended, their interpretation of BACC and their perception of their students’ needs relative to understanding material required by the standards.

The issue of whether local standards would be met using BACC materials came up in the beginning of the year with BACC “Guided Inquiry 1.5: Modeling Molecules”. In this activity students build molecular models and simulate respiration and photosynthesis. The main concepts addressed are the carbon cycle and the Law of Conservation of Matter. The Duval County Standards for biology included atoms, electronic configuration and bonding. Teachers were accustomed to teaching these standards by teaching students about atomic
mass, atomic number, electron orbitals and different types of chemical bonds. The BACC materials never explicitly address these standards. Bonding is modeled, not explained. The activity has students build molecular models but does not provide any information on electronic configuration or why particular atoms form particular numbers of bonds. Most of the teachers supplemented BACC at this point with lecture, recitation, readings and worksheets from their previous text. One teacher with an honors class thought this material was mostly review for her students, but other teachers began to question whether the BACC materials really matched their standards.

Teacher D: If we relied solely on BACC where would the information come from? There is no mention of bonds, ionic, covalent or hydrogen bonds in the BACC index. The . . . book or some other source of info + practice must be used, located, modified. (note written to the researcher, 12/05/01)

Similar issues arose with other objectives. A lack of guidance on how to handle these conflicts and the teachers’ interpretations of what it meant to implement the curriculum as written left some of the teachers feeling frustrated and led most of the teachers to supplement BACC with more traditional materials.

The lack of alignment between the BACC materials and the resources available for implementation was also frustrating for many teachers. The expectation of JUSI seemed to be that teachers would implement the BACC curriculum despite the lack of appropriate conditions for doing laboratory activities in some of their classrooms. This included problems of class size, lack of laboratory facilities, and inadequate funding for expendable supplies. Teachers were particularly frustrated by the lack of funding for BACC supplies
because they saw this as a JUSI responsibility and had expected that JUSI would help in
arranging funding for the needed supplies.

Teacher F: Actually I thought USI would reimburse me because this is part of
their whole urban systemic initiative thing, this new . . . whole new
program that they are trying out and . . . since they are the ones
spearheading this project, this program, I thought they would be the
ones that would actually make sure that . . . we got everything we
need. (May 30, line 764)

Supplies for BACC might have been inexpensive, but the teachers needed flexibility to
purchase fresh supplies locally as needed, which was not afforded by the accounting systems
at some of the schools. Class size and teacher room assignment was a school level
administration responsibility and at most of the schools was not coordinated with the choice
of a more laboratory intensive curriculum. Teachers bought supplies with their own money,
modified activities, used larger group sizes to reduce the need for materials, and used a
variety of methods to compensate for lacking equipment. Despite these strategies, some still
reported that their students’ opportunities to do some of the inquiries were limited by large
class sizes, lack of appropriate equipment and lack of funding for materials.

Between channels

Besides the lack of alignment within the curriculum channel there were problems
due to mismatch between channels. The professional development that teachers received
was not adequately aligned with either the curriculum or the assessment channels. The lack
of a continuing component to the development plan and the lack of attention to developing a
collaborative group meant there was no forum for dealing with teachers’ concerns as they
arose. The summer workshop addressed using the BACC instructional materials, particularly how to do the different activities. However, the teachers’ concerns about misalignment between the local performance standards and the BACC instructional materials and difficulties with using the materials to teach content did not arise until they experienced using the curriculum. This concern was then heightened by uncertainty about the new science FCAT and by district emphasis on teaching to the standards. Two other concerns, classroom assessment of student work and modifying the activities to fit the available resources, became more specific as teachers experienced teaching BACC. Teachers needed the opportunity to share strategies for adjusting activities. They needed to see and reflect on student work samples from different classrooms and discuss strategies for assessment and improvement. Professional development could not adequately address these issues prior to the teachers’ experiencing the curriculum with their students.

Assessment and accountability practices were also misaligned with the curriculum and teacher development channels in that they were creating pressures to teach in ways inconsistent with methods advocated by JUSI professional development and the BACC materials. High stakes state testing in mathematics and reading was leading to an emphasis at some schools on mathematics and reading test preparation activities, which did not integrate science instruction and which took instructional time away from science. Furthermore, teachers in some of the schools did not have the autonomy to choose activities consistent with reform initiatives to improve math and reading.

Discussion/Recommendations

Alignment issues are not isolated to Jacksonville. Although they do not use the NRC framework as an organizing model, other researchers have reported similar problems with
lack of alignment within and between channels. A recent study (Webb, 1999) investigating alignment between state math and science standards and 14 tests in four states revealed that alignment between standards and assessments was inconsistent. Studies of other USI projects around the country (Borman, Lee, & Boydston, 2002; Kersaint, Borman, Boydston, & Sadler, 2001a; Kersaint, Borman, Lee, & Boydston, 2001b) have found similar issues including mis-alignment between national standards and high stakes state assessments, lack of time for recommended teacher professional development, and lack of adequate funding for reform strategies.

Designing professional development to meet NSES standards is an important part of the solution to this problem. This professional development must address issues of coordination and alignment openly: Teachers need clear and consistent messages about how to address misalignment within and between channels. Professional development must be long term and address the classroom context of the teachers. Research in staff development supports collaborative relationships focused on planning instruction and peer coaching as an important way to support teachers in making changes in their practice (Gartin & Digby, 1993; Joyce & Showers, 1995). Ishler, Johnson, and Johnson (1998) found that the most significant predictor of long term use of cooperative learning after its introduction at staff development workshops “was membership in collegial teaching teams that discussed implementation problems and engaged in peer coaching” (p. 280). A design for developing this despite the difficulties in scheduling peer observation might include teachers’ videotaping their own classes for later discussion. Because teachers rarely have had extensive experience with inquiry in their own science education, professional development for implementing inquiry based science curricula must provide a variety of experiences and
models for this type of instruction. Teachers’ doing the laboratory activities at workshops is not enough; they need to observe implementation including the post activity discussion with students similar to their own. They need opportunities to discuss and reflect on their experiences as they begin to implement new curricula.

Administrative leadership is another part of the solution. As the NSES recommend, professional development should also include the administrators who make decisions that affect science classrooms. Administrators at the state level need to be sure that high stakes assessment of student achievement is aligned with standards and focuses on assessing inquiry as well as important concepts. Administrators at the district level need to be sure that teachers are not getting contradictory messages. They need to be sure resources are in place to support reform. Administrators at the school level need to understand and support the changes their teachers are being asked to make. This support can take a variety of forms including encouraging rotation of access to science laboratories if there are not enough for all classes, protection of science class time for science teaching, encouraging rather than forbidding field trips and outdoor field work, and directing bookkeepers to modify purchasing regulations so that teachers can buy fresh materials as needed.

The dilemmas and frustrations caused by the lack of coordination within and between channels are barriers to teachers’ acceptance of reform strategies. Coordination is difficult as different aspects of the system are controlled by different people and organizations. Although the NSES include standards beyond the content and teaching standards, these standards seem to be getting less attention in systemic reform. The focus seems to be more on reforming the teachers and students than on reforming the system to provide the support that teachers and students need. The NSES standards for professional development,
assessment, programs and systems emphasize the importance of providing appropriate resources and support for the changes at the classroom level. In a complex system there may be a variety of barriers to coordinating reform efforts, but without coordination and attention to all of the *NSES* standards, the implementation of reform will be less effective than it could be.
References


V. References


http://nces.ed.gov/nationsreportcard  


