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A CASE STUDY OF SYSTEMIC CURRICULAR REFORM: A FORTY-YEAR HISTORY

A Dissertation APPROVED FOR THE
DEPARTMENT OF INSTRUCTIONAL LEADERSHIP
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Introduction

Educational reform efforts continue their ephemeral and precarious journey through our American educational school systems. From elementary schools to colleges and universities, reform movements have cyclically inundated our educational systems for over 150 years. To keep from replicating futile reform efforts and to understand successful reform efforts, it is imperative to determine characteristics of successful educational reforms and perhaps, more importantly, how these reforms were sustained.

What follows is a description of the development of a particular inquiry-based elementary school science curriculum program and how its theoretical underpinnings positively influenced a school district's (K-12) science program and also impacted district- and state-wide curriculum reform initiatives. The district's science program has evolved since the inception of the inquiry-based elementary school science curriculum reform forty years ago. Therefore, a historical case study, which incorporated grounded theory methodology, was used to convey the forty-year development of a science curriculum reform effort and its systemic influences.

History indicates that educational reform is a recurring issue and its intentions and focus tend to be cyclical in nature (Ansah, 1986). Writing as a visionary, Goodlad (1975a) penned,

> There will be several interesting cycles of educational change before 2001; there will be an excess of claims and counterclaims. Careers will be made of both kinds of excess. At close range, nothing will seem to be changing except the appearance of change itself(p. 28).

Accordingly, the majority of American educational reform efforts eventually failed under their own presuppositions. A few reformshave "incorporated bits of themselves into the fabric of contemporary schooling" (Ravitch, 1983, p. 58) while others have been renamed and are being recycled as innovative reform movements. A thorough investigation into the cyclical nature of educational reform will lead to a realization that achieving educational reform is a difficult and often times unattainable task.

In spite of the difficulties either initiating and/or sustaining reform efforts, it seems that educators, policy makers, and laypersons are extremely eager for educational reform to occur. However, Fullan and Stiegelbauer (1991) cautioned those who hastily seek reform without first developing the meaning of educational change, "One of the most fundamental problems in education today is that people do not have a clear, coherent sense of meaning about what educational change is for, what it is, and how it proceeds" (p. 4). Fullan and Stiegelbauer suggested that for change efforts to be deemed successful meaning must be found concerning *what* should change and *how* change should be achieved. Even when a coherent sense of meaning has been established, it does not lead directly to an unambiguous, successful reform. Fullan (1993) recognized that successful educational reform efforts are usually clear after they work, not in advance, hence "the meaning of change will rarely be clear at the outset, and ambivalence will pervade the transition" (p. 31).

This ambivalence or uncertainty along with the euphoria of mastery are fundamental to what Fullan (1993) identified as the "subjective meaning of educational change" and to the success or failure of the attempted change. Therefore, in order to understand what both successful and unproductive reform efforts necessitate, it is essential that a definition of reform be established as a framework for this particular study.

Although the language of reform will be employed throughout this study, Goodlad (1999) cautioned those who use the rhetoric of reform in educational settings,

> Reform carries with it much negative baggage, primarily of bad people to be reformed from doing bad things. What schools need are processes of renewal essential to their continuing good health, just as all individuals, institutions, and our habit need such (p. 98).

Wagner (2001) also believed that reform implies negative connotations, "We must 'reinvent' the entire system" (p. 381) not reform it. Even though Goodlad and Wagner employed a changing rhetoric of reform in terms of renewal, the concept of reform continues to be the center of most educational improvement strategies.

Educational reform is broad in scope yielding much opportunity for interpretation. All attempts at educational reform involve some mode of change, but as Fullan (1993) argued, "Change is everywhere, progress is not" (p. 345). Progress, therefore, is a fundamental component of all successful reforms. Palestini (2000) contended, "Humans seem to prefer the status quo. However, we all seem to realize that to progress, we need to experience change. For any institution to survive, continuous improvement is absolutely [*sic*] necessary. Continual improvement implies change" (p. 1). It is apparent from Palestini's description of reform that an associated change is paramount in any successful reform effort. Fullan also expounded that a change is considered successful only if progress results from the change or reform. Approaching reform from a practical perspective, Fullan (1982) provided his understanding of the purpose of educational change as the endeavor ". . . to help schools accomplish their goals more effectively by replacing some programs or practices with better ones" (p. 11).

A historical dictionary definition of reform as taken from the era of the incipient stage of the science curriculum reform under investigation (1963) is*to improve what is wrong, corrupt, or unsatisfactory* (Stein, 1966). An equidistant definition of reform, in terms of time, is*to make better by introducing better procedures* (McKechnie, 1983). Moreover, a more current description of reform is *to change to a better state or form* (Webster's, 2003). A thorough examination of the literature of reform, leads me to deem that reform, in the context of education and the realm of this historical case study, could be described as *any effort that improves the quality of schooling in its present state.* Thus, the latter description of reform will serve as the premise of this research.

Purposes of the Study

The purposes of this study were to provide a better understanding of *how a particular school district has been able to sustain and continue a theory-based program of inquiry science for more than forty years* and *how this science program has been able to influence district- and state-wide curriculum reform initiatives*. The aforementioned description of reform that serves as the premise of this research is *reform is any effort that improves the quality of schooling in its present state*.

Historically, educational reform has been a short-lived process for many schools and/or school districts that choose to undertake it. Sarason (1995) argued that educational reform and its resulting change is oftentimes demonstrated in an isolated classroom or school but never is represented by an entire school system. Sarason stated, “What is demonstrated in a single classroom or school never spreads. Indeed, even in the original site, the spirit of the demonstration sometimes gets extinguished as participants leave or new administrators arrive on the scene” (p. 84). Furthermore, research on the roles of the school district during times of reform indicates that school districts have not focused on instructional improvement (Fuhrman & Massell, 1992).

Significance of the Study

To address the deficiency of school system success made by Fullan and others, I will describe the evolution of a curriculum reform effort that began during the 1962-1963 school year within the classroom of an elementary school teacher in theHudson (pseudonym) Public Schools, Hudson (pseudonym), Oklahoma. The incipient stage of this elementary school science curriculum reform has emerged over a forty-year span into a district-wide science curriculum program that has influenced district- and state-level curriculum reform initiatives. The longevity of this successful reform contributed to the significance of this study.

Fullan (2000) claimed that there is a problem with those that study successful reform efforts. Successful schools were examined *after* they were running effectively. Fullan added, “We know nothing about how these particular schools got that way, let alone how to go about producing more of them” (p. 582). Fullan continued that, “Each group must build its own model and develop local ownership through its own process”

(p. 582). Moreover, Fullan urged that emphases should shift from successful individual schools to successful school systems, “We know a great deal about individual school success; we know far less about school system success—how large numbers of schools in the same system can improve” (p.583).

Successful reform at the elementary school level requires about three years and successful reform at the secondary school level requires about six years (Fullan, 2000). Changing teacher beliefs and pedagogical practices takes more than seven years of committed effort (Varrella, 2000). Unfortunately,m any of the innovations in schools and classrooms frequently encounter problems after adoption and terminate a short time later—often within the first 2 years—without achieving full implementation (Gold, 1999). I have identified a *rare success story* of curriculum reform that has sustained for four decades. Therefore, this study is significant because of the duration (forty years), extent (district- and state-wide influence), and quality of the distinctive curriculum reform effort.

Research Questions

The primary research question guiding this study is *how is a school district able to sustain and continue a curriculum reform effort (a theory-based program of inquiry science) for more than forty years*? A secondary research question guiding this study is *how is the science program able to influence district- and state-wide curriculum reform initiatives*? For those who are interested in studying successful reform innovations, Fullan (1993) cautioned that, “The uniqueness of the individualsetting is a critical factor —what works in one situation may or may not work in another” (p. 47).

A History of Science Curriculum Reform

Science education reform in America can be traced back to the early 1900s. Given this, a historical context of reform, specifically contemporary (1960s to present) curriculum reform, is provided to better understand the significance of this study. In order to address more thoroughly the progression of reform, three major periods of science curriculum reform are presented: (a) early 1960s to the mid 1970s, (b) mid 1970s through the 1980s, and (c) 1990s to the present.

Early 1960s to the Mid 1970s

The decade of the 1960s symbolized the most extensive period of educational reform innovations to date. Many, if not all, reform efforts during this period were focused on curriculum development and implementation, mainly within secondary and elementary school mathematics and sciences. Thus, this period is referred to as the "Curriculum Reform Era" (Klein, 1989); "The Education Decade" (Goodlad, 1975b); and "The Golden Age of Science Education" (Shymansky & Kyle, 1992a).

Historical accounts indicate a small number of curriculum programs were under development as a result of the perceived crises that followed the end of World War II (September 2, 1945). Many advocates of reform, at that time, were calling for a return to the basics of education (the basics referred to an increase in development of reading, writing, and arithmetic skills). Moreover, the launching of Sputnik by the Russians (October 4, 1957) provided the impetus for large scale federal and private funding and monumental public support for the imminent curriculum reform efforts. Yager (2000) reported that the forty years following Sputnik resulted in $2 billion expenditures of K-12 science and mathematics education.

Welch (1979) claimed that there was a twenty year period of intensive science and mathematics curriculum development funded by the National Science Foundation (NSF) beginning in 1954 and temporarily ending in 1975. The first summer institute designed to prepare classroom teachers on the implementation of the new curricular materials began in 1954 with a $10,000 budget. Soon after the launching of Sputnik, an increased emphasis in spending toward curriculum development and implementation was observed in 1960 when $30 million were used to support an estimated 320 summer institutes. Welch reported that the NSF appropriated more than $130 million toward course content improvement projects as well as an additional $565 million for teacher education activities that prepared teachers for the implementation of these newly developed curriculum programs.

The National Defense Education Act (NDEA), which was passed in 1958, also served as a significant source of funding for elementary and secondary school education. Between 1958 and 1961, an estimated $136 million were contributed toward education with at least 75% of NDEA funds used for science education (Dede & Hardin, 1973).

By 1977, over 500 curriculum projects were either being developed and/or being implemented. These projects and their related curriculum programs were regarded as the “alphabet soup” curricula referring to the acronym used for each program (e.g., BSCS, CHEM study, ESCP, ESS, HPP, IPS, ISCS, MNNEMAST, PSSC, SAPA, SCIS, TSM, USMES, and so on). Of these curricular programs, the Elementary Science Study (ESS), Science—A Process Approach (SAPA), and the Science Curriculum Improvement Study (SCIS) were a select few programs thatattempted to develop scientific literacy, specifically at the elementary school level. The developers of these few curricular programs incorporated intellectual development (as it was concurrently being discovered and examined) with thenature and/or processes of science using discovery or inquiry approaches.

One example of teacher education activities comes from an elementary school science curriculum reform program named the Science Curriculum Improvement Study (SCIS) (Karplus & Thier, 1967). The inservice program that preceded SCIS implementation consisted of the following activities:

1. Teachers were to develop an understanding of the theoretical foundations of the SCIS approach. In other words, teachers needed to know the relationship of the SCIS program as it related to the nature and structure of science and to the cognitive development of children.
2. Teachers were shown how SCIS fit into the historical development of elementary school science.
3. Teachers were acquainted with ways of working with children that were of special importance to SCIS, such as laboratory type experiences and questioning strategies.
4. Teachers were made aware of the research and development of the SCIS materials and to the teacher's role in the importance of SCIS.
5. Teachers were involved in professionalized science experiences that closely related to the SCIS program and that helped them develop a better understanding of the nature and structure of the program.

Upon review of these activities, it is evident that a considerable amount of time and financial support was necessary to carry out teacher education in-service endeavors.

Never before had there been this much effort devoted toward improving education, specifically science and mathematics education. Concomitantly with the positive atmosphere accompanying this educational reform movement between 1954 and 1975, there also were unfortunate events or “countervailing forces” (Bybee, 1997) that eventually overshadowed this optimistic wave of reform[6] . Angus and Mirel (1999) considered this period an “unraveling” or “fragmenting” of America. Such events as the assassinations of political and societal figures; involvement in and subsequent protests of the Vietnam War; civil rights movements; riots; Watergate scandal; and the resignation of the President allcontributed to America’s political and social unrest during this period of time. Public attention gradually shifted from educational to societal issues. Unfortunately, a negative sentiment was associated with the broad-scale, nationwide movement of curriculum reform.

Accompanying these countervailing forces were the perceived shortcomings of the large-scale curriculum reform efforts. Welch (1979) believed that even though there was an enormous investment from the federal government in developing *new* curricula, little broad-scale change occurred over the twenty-year period of development. Due to the perceived failings of the curriculum reform efforts, NSF ceased funding curriculum development and suspended inservice-related workshops and activities designed for educating teachers between 1975 and 1976. Yager (1984) referred to this period as the “year of crisis.” Welch (1979) claimed that evaluation efforts measuring the curriculum projects’ impact “tapered without any conclusive evidence that the Golden age of Science Education had produced any substantial gains besides updating the subject matter” (p. 390).

Therefore, in 1976, NSF requested a large-scale evaluation to assess the impact of the elementary and secondary school science curriculum projects, which they sponsored (see Helgeson, Blosser, & Howe, 1977; Stake & Easley, 1978; Weiss, 1978). Harms and Yager (1981), at the request of NSF, combined the three aforementioned studies with a National Association of Educational Progress study and then summarized these findings into a meta-analysis evaluation report known as *Project Synthesis*. Shymansky and Kyle (1992b) concluded from these documents that, "The meta-analysis findings of the curriculum movement of the 1960s and 1970s indicate that change is possible, true reform is difficult to achieve, schooling process is affected by social forces, and quick fixes to curriculum reform are 'doomed to fail"' (p. 754).

A common feeling toward curriculum development projects of this era was reflected in a statement by Welch (1979), "While there may be new books on the shelves and clever gadgets in the storage cabinets, the day-to-day operation of the class remains largely unchanged" (p. 303). Stake and Easley (1978) found that 90-95% of the teachers investigated in their broad-scale study used the textbook 90% of the time. Although the science curriculum programs corroborated the implementation of inquiry related activities in classrooms, textbooks were still used as the main curriculum source.

Classroom observations lead Goodlad (1966; 1970) and Eisner (1969) to call for a shift in planning curriculum reform from a *top-down* approach, where the curriculum was designed for students at the high school level with no correlation to elementary curriculum, to a *bottom-up* approach where the "knowledge of students and their achievement was built into the sequence of subject matter in the curriculum design" (p.98). Goodlad foresaw a problem with these curriculum reform efforts, in that these programs were focusing attention toward classroom materials and curricula but giving little consideration of the student and classroom teacher. Likewise, Dede and Hardin (1973) claimed that a weakness of the broad-scale curriculum reform era was the oversight of how students learn and how teachers teach. Goodlad and Klein (1974) observed that if classroom teachers were not active participants in the curriculum reform innovations, then the reforms would lose their intensity. In addition, Rutherford (1971) strongly believed that changing the curriculum alone was not enough; he believed the intention of any curriculum development effort “is to change instruction” (p. 555). Thus, Rutherford urged that teachers must become aware of the curriculum program’s goal when they implement the program in their classroom.

Hopkins, Ainscow, and West (1994) believed that the lack of teacher involvement in curriculum development resulted in four types of change during this *Golden Age* era. These changes are: (a) high quality with poor implementation, (b) high quality and high implementation, (c) low quality and low implementation, and (d) low quality and high implementation. Unfortunately, a high quality curriculum with poor implementation (change “a”) and a low quality curriculum with high implementation (change “d”) were the most common types of change that were observed during this era of implementation. The framework of many curriculum programs required the classroom teacher to change his/her method of teaching, which for many teachers, was contrary to their primary teaching approach of exposition. Therefore, a conflict ensued for these teachers who were required to use inquiry-based activities as they attempted to implement these innovative curriculum programs. Where these conflicts arose, the programs were either abandoned a short time after implementation, or classroom teachers reverted to their previous style of teaching as they continued “implementing” these inquiry-based programs. Anderson, et al. (1994) supplied the following list of reasons why the curriculum reform programs of the 1960s were *abandoned*: the curriculum programs were considered too difficult for most students; teachers did not understand the conceptual structure of the programs; or teachers could not master the inquiry or discovery style of teaching necessary to use the programs as designed.

Welch (1979) summarized the barriers that were evident in the first decade (late 50s to early 60s) of curriculum reform. These barriers were challenges of unprepared and insecure teachers, specifically at the elementary and junior high school levels; the inherent difficulty of change; the lack of federal policy for innovations; the natural conservatism of schools; and the threat of a national curriculum. The second decade of reform (late 60s to mid 70s) provided additional barriers to reform. These were declining enrollments in secondary school science courses; inflation; student unrest; fading public image of science; environmental concerns; competing demands, specifically societal; and the back-to-basics movement.

In summary, the curriculum reform movement of the late 1950s and early 1960s was in response to perceived crises in American society. Pre-crises curricula were characterized as child centered, an attribute of the Progressive movement of the 1920s. However, the perceived crises initiated a shift from the then current student-centered curriculum to a subject- or content-centered curriculum. In other words, the reform pendulum swung in the direction of a back-to-basics education that preceded the Progressive movement. A possible reason for this focus on content was that specialists leading these reform efforts were scientists in the academic field not educators. Renner and Marek (1988) believed that the NSF–funded curriculum projects of the 1960s failed because of this narrow focus.

Unlike its counterparts, the SCIS, which was designed for elementary school children, addressed content but also, how content should be delivered and what elementary aged students could learn. A main objective of the SCIS program was to develop science curriculum that was developmentally appropriate for the learner. The teaching approach was based primarily on Piagetian theory of how people construct knowledge. In their earlier work, Karplus and Thier (1967) implied that the teaching approach in the SCIS contained “cycles” of preliminary explorations, inventions, and discoveries. This “cyclical” teaching approach and curriculum development model was later referred to as the learning cycle (Lawson, Abraham, & Renner, 1989). Succinctly stated, the learning cycle is an organizational tool for teachers that closely follows how children learn; it is based primarily on the cognitive development work of Jean Piaget. More information regarding the learning cycle will be provided later in this dissertation.

In spite of the perceived failures of these curriculum development projects, vis-à-vis teacher behavior, many of the elementary and secondary school science curriculum reform efforts significantly developed student process skills and thinking skills (Bredderman, 1983; Shymansky, Hedges, & Woodworth, 1990; Shymansky, Kyle, & Alport, 1983; Walberg, 1980). Even though positive results of these projects were reported, many, if not most, science teachers at the elementary and secondary school levels reverted to their conventional teaching methodologies using a textbook-centered curriculum and an expositional approach.

Mid 1970s through the 1980s

The years between 1978 and 1983 were referred to as a period for rethinking the goals of American education. The nation as a whole had a change of mind about broad-scale curriculum reform. Rutherford (1997) referred to the fifteen years following the Sputnik era of reform as a period of inaction, "A critical mass of change had not had time to become institutionalized, and the long hiatus allowed us to slip back to earlier practices and materials—and gave the doubters reason to claim failure" (p. 6). Thus, the back-to-basics movement was being recycled as it once was advocated following World War II.

Augmenting this back-to-basics movement in education was the report, *A Nation at Risk: The Imperative for Educational Reform* (National Commission on Excellence in Education, 1983). This document described the current state of the American educational system. At that time there was a perceived gap between the scientific elite (scientists) and the scientific illiterate (non-scientists). Hurd (1986) recognized a similar gap between the existing school curriculum in science and the demands of living in a scientifically and technologically driven society. *A Nation at Risk* proved to be the first publicly accepted document demanding educational reform. As a result, there were more than 300 reports addressing needs for educational reform (Bybee & DeBoer in Gabel, 1994). Many of these reports proved to be catalysts for the desire and demand for improving science education (see Boyer, 1983; Goodlad, 1983; Sizer, 1984). However, germane suggestions for educational improvement were nonexistent in most of these reform documents.

Hurd (1985) believed two contrasting science educational reform efforts stemmed from these national reports. These were a *renewal* of science education and a *reform* of science education. According to Hurd, a *renewa*l entailed requiring more science courses for graduation; higher test scores; more challenging textbooks; longer school days; increased amounts of homework; more rigorous courses; additional teacher in-service requirements; raising grading standards; increasing technology; rewarding effective schools and teachers and embarrassing poor ones; defining quality as a return to traditional textbooks and curricula; forming networks; and enforcing student absenteeism, nonconformity, and lack of civility.

A *reform* in science education, according to Hurd (1985), referred to qualitative changes in goals, curriculum, and learning. These changes were based upon “the changing nature and ethos of science and technology; cultural shifts; forces modifying our society and economic systems; and the likely influence of each on how people in America will live and work in the near and distant future” (p. 92). Although these changes are more general, as opposed to science education renewal, they were based upon data and logic and therefore are essential for improving science education. Furthermore, Hurd (1986) claimed that the “educational issues embedded in the reform of science education are profound, complex, and multidimensional, lying deep in the changing nature of science, as well as in the history and culture of U.S. society” (pp. 353-354).

Several factors helped explain this shifting emphasis toward the basics of education during this era. These factors include: U.S. students were falling behind academically in the global marketplace; declining enrollments in science courses would lead to a decrease in supply of scientists; scientific literacy as defined was broad in range; funding for research and innovations began to wane; inquiry curriculum development and implementation required increased funding; and time allotted for science teaching in elementary schools was decreasing. Additional concerns were low achievement scores; quality teacher shortages; low priority of science by parents; failure of science education to regard Science, Technology, and Society; and confusion about goals of science education (Hurd, 1984).

Renner (1979a) questioned the back-to-basics movement of that day and asked "What are the basics of science?". By referring to a quote taken from science historian Duane H. Roller, Renner stated that the *basic* of science was the “quest for knowledge” (p. xxii) about “natural phenomena” (p. xxiv). This quest for knowledge, otherwise referred to as scientific inquiry, was the premise of Renner and others as they called for science education reform before and during this era. Feldman (1983) quoted Renner as stating, “I’m afraid we’re doing to science education just what we did after Sputnik. Crash programs will get students involved, [and] then comes another letdown. If we don’t change the way the kids learn, [then] science education will crash again” (pp. 10-11).

Sealey (1985) compared the new science curriculum of the *Golden Age* to the science curriculum of the mid-1980s. She concluded that the era preceding the Golden Age (where the science curriculum was based upon textbooks and the memorization of scientific laws, theories, and facts) was being reimplemented by the schools in the 1980s. Many educationalists (Renner in Feldman, 1983; Yager, 1980; 1984; Yager, Bybee, Gallagher, & Renner, 1982) believed this return to a more traditional manner of teaching and learning in science education was leading to another crisis.

1990s to the Present

The decade of the 1990s proved to be a monumental era in the revitalization of science curriculum reform. The science educational reforms of this decade are comparable to the reforms that occurred as a result of Sputnik. However, Dow (1997) cited one difference between these two reform movements; the origin of the Sputnik reforms stemmed from the technological and military competition with the former Soviet Union while the most recent reform was initiated by the competition seen on the global marketplace. Unlike the Sputnik reforms which were intended for those students labeled as educational elite, the current reform is designed for “all students regardless of age, gender, cultural or ethnic background, disabilities, aspirations, or interest and motivation in science” (National Research Council [NRC], 1996, p. 2).

In response to the perceived crisis in education, NSF once again contributed millions of dollars in support of curriculum reform efforts. Large scale curriculum reform efforts were undertaken by the American Chemical Society (ACS), the Biological Sciences Curriculum Study (BSCS), the Education Development Center (EDC), the Lawrence Hall of Science—Berkeley, and the National Science Resources Center (NSRC). These agencies were committed to the development of curricula that were relevant to the technological society of this era. Other agencies, such as, the American Association for the Advancement of Science (AAAS) through their reform Project 2061, published *Science for all Americans* (1989) and *Benchmarks for Science Literacy* (1993); The National Science Teachers Association published *Scope, Sequence, and Coordination of Secondary School Science* (1992); and The National Academy of Sciences, through the NRC, published the *National Science Education Standards* (1996) which also contributed to the promotion of science education reform. Although these reform documents differ in their objectives, they share a common goal that all students could and should achieve scientific literacy.

In each of these reform initiatives, the primary means of achieving this common goal in science education is the implementation of inquiry teaching and learning practices. As written in the *National Science Education Standards* (NRC, 1996), the teaching and learning practices of science "rest on the premise that science is an active process. Learning science is something that students do, not something that is done to them. 'Hands'-on activities, while essential, are not enough. Students must have 'minds-on' experiences as well" (p. 2). The minds-on approach is regarded as scientific inquiry where students, through an active approach of experiencing science, develop scientific knowledge as well as reasoning and thinking skills.

Implementation of national standards and subsequent state standardsare among the leading approaches to school and curriculum reform, but in isolation are insufficient for educational reform. According to Goodlad (1990), the*re newed* interest of reform in the 1990s focused on the individual school as the unit of center of change; this underlying message was also prevalent in the late 1960s and early 1970s. Goodlad believed that successful reform requires the coordination of three related agendas: (a) the school system as a whole, (b) the individual schools that make up the system, and (c) teacher education. It is this notion of a system-wide or systemic approach that is inherent if not explicit in most current documents advocating science education reform.

Systemic Reform

State Level

Systemic reform is a concept that has emerged nationally over the last fifteen years. Components of systemic reform have been practiced in a few states for many years. For example, the state of Oklahoma has a long history of what can currently be described as attempts of systemic reform. In June 1958, the Oklahoma Curriculum Improvement Commission of the State Department of Education created the State Committee on the Improvement of Science Instruction in Oklahoma, Grades K through 12. As a result of the organization of committees and subcommittees, basic principles and procedures for systemic curriculum reform were outlined resulting in a published bulletin in August 1960, titled, *The Improvement of Science Instruction in Oklahoma, Grades K-12* (Oklahoma State Department of Education [OSDE], 1960).

The educational emphasis of the preliminary statewide document largely focused on two recommendations. The first recommendation proposed a science curriculum throughout the entire public school system, grades K-12, while the second recommendation proposed modifications of the teacher certification program. The underlying guidelines in the aforementioned document focused only on the products of science. In other words, the State Committee recommended scientific objectives and concepts, or *what* science should be taught. Between the years 1960 to 1965, the State Science Committee was inactive.

The Committee reconvened in January 1965 and decided that the elementary school science program was in dire need of revision to meet the current expectations in science education. Additional members were added to replace members who resigned their positions on the Committee while subcommittees were disbanded. At this point, attention was being directed toward addressing the products of science *and* the processes of science, or *how* science should be taught. The newly formed State Science Committee unanimously agreed that the inquiry approach of instruction was irrefutably the philosophical approach that should be recommended to the elementary school teachers of science in the state of Oklahoma (OSDE, 1968).

Therefore, in 1968, the State Committee published a bulletin that described the inquiry approach, discussed materials that were available to implement and supplement the inquiry approach, and indicated how programs could be organized in area schools. Additionally, it was recommended that the goal for all science programs should be to achieve the central purpose of education (Educational Policies Commission, 1961), which is to develop in students the ability to think. The state-wide emphasis directed toward inquiry science teaching at the elementary school level proved to be ground-breaking, "Oklahoma [was] one of the first states in the nation to attempt to initiate 'inquiry' teaching of science on a statewide basis" (Stafford & Renner, 1968). The changes that were recommended for the elementary science program proved to be successful for many elementary school teachers of science.

The successfulcurriculum changes suggested for the elementary school science program were also recommended for the secondary school science program and published in a 1970 bulletin titled, *TheImprovement of Science Instruction in Oklahoma, Grades 7-12* (OSDE, 1970). Revisions were frequently suggested and incorporated in subsequent bulletins for grades K-6 (OSDE, 1971) and for grades K-12 (OSDE, 1978).

Consequently, by 1978, the OSDE had in place a recommendation for the articulation and coordination of K-12 science curricular programs.

The OSDE 1978 bulletin continued to serve as the state-adopted systemic reform initiative until 1990. In 1990, the Oklahoma Curriculum Committee of the State Department of Education published *Recommendation: Learner Outcomes: State Competencies Grades 1-5* (1990a) and *Grades 6, 7-8, & 9-12* (1990b) as a set of statewide initiatives for curriculum reform. These reform documents recommended that the science philosophy for all science programs should emphasize the processes and products of science. Additionally, it was recommended that the goal for allscience programs should be to achieve the central purpose of education, which is to develop in students the ability to think. The authors of these reform documents agreed that science is a natural vehicle to foster this development. Accompanying the overarching philosophy and program goals for science education, the reform documents provided specific program goals and science learner outcomes for each grade level.

The two *Recommendations* documents (OSDE, 1990a, 1990b) led to the development of the current statewide curriculum framework for Oklahoma, the *Priority Academic Student Skills*(PASS) , which was initially published in September 1993. The original PASS document (OSDE, 1993) identified science process skills (observing and measuring, classifying, experimenting, interpreting, communicating, and safety in the classroom) that Oklahoma students should demonstrate at specified grade levels in science (grades 1-3 followed by each succeeding grade). Science content standards were not provided; Oklahoma educators were expected to "include the science processes with content-based instruction to develop a complete science curriculum" (p. 55). Achieving scientific literacy through inquiry was the suggested teaching methodology. State law (70 O.S. Section 11-103.6a) requires the Oklahoma State Board of Education to review thoroughly this curriculum document every three years.

In response to the exclusion of science content in the incipient PASS document, subsequent revisions of PASS (OSDE, 1997, 2000) included science content standard areas, which were designed to facilitate the development of scientific concepts. The revised PASS documents at the K-8 grade levels were then organized into four broad areas: Science Processes and Inquiry, Physical Science, Life Science, and Earth/Space Science. The PASS was now arranged by grade cluster groups (Grades K, 1-3, 4-5, 6-8, and 9-12) to facilitate flexible use of instructional resources at the district level. This integrated approach was designed "to provide students with a coordinated, coherent understanding of the necessary skills and knowledge of scientifically literate citizens" (p. 165). Direct, inquiry-oriented learning experiences that emphasized the processes of science and major science concepts continued to be advocated in subsequent revisions of the PASS document.

Currently, the PASS document is in its fourth revision (OSDE, 2002). The skills and content standards are arranged by grade level at Grades K-8 and by course subject area (physical science, biology, chemistry, and physics) at the high school level. Scientific literacy continues to be the primary objective of this curriculum framework, and inquiry remains as the suggested method of instruction: "Inquiry builds conceptual bridges between process and scientific knowledge. Relevant use of developmentally appropriate technology facilities the inquiry process" (p. 177). To date, the PASS document is the State of Oklahoma's attempt to initiate systemic reform in all subject areas.

National Level

Thompson (1993) believed that the origins of systemic reform at the national level could be traced back to 1989, when the National Governors' Association insisted that the states play a key role in educational change. Similarly, to the broader concept of educational reform, systemic reform has many meanings and interpretations. Fuhrman and Massell (1992) provided two broad themes describing systemic reform: (a) a comprehensive change that is focused on many aspects of the system and (b) a policy integration, coordination or coherence around a set of clear outcomes. According to Goertz, Floden, and O'Day (1996), systemic reform represents three fundamental components: (a) the promotion of ambitious student outcomes for all students; (b) the alignment of policy approaches and the actions of various policy institutions to promote such outcomes; and (c) the restructuring of the governance system to support improved achievement.

Systemic reform predominates most if not all fundamental, current reform efforts in science education. Some contemporary examples of systemic reform documents in science education are *Science for All Americans* (AAAS, 1989), *Benchmarks for Scientific Literacy* (AAAS, 1993), and *National Science Education Standards* (NRC, 1996). Integral to these documents is the increased emphasis on educational accountability of achieving scientific literacy for all. A critical component in these systemic efforts is that all systems ranging from the classroom to the school to the school district to the community to the state and ultimately to the nation must be part of the change process. The NRC (1996) believed that, “Coordination of action among the systems serve as a powerful force for change” (p. 228). These cooperative interactions influence the success level of educational reform efforts.

Anderson, et al. (1994) stated that to understand reform requires a systemic approach. According to Anderson, et al., “Systems thinking is a way of thinking that must be applied to the situation to begin to understand it well before even suggesting means of bringing about change” (p. 103). Furthermore, a systematic approach to educational reform requires both a structure and a process. Bushnell (in Bushnell, 1971) explained, “The structure or ‘system’ requires a network of communication links between teachers and students, teachers and administrators, administrators and taxpayers—a network which, ideally, satisfies learning needs, conveys information, and helps pass bond issues” (p. 9).

The place of initiation for systemic reform is disputable. There are researchers who reason that systemic reform begins at the school level (Fullan, 2000; Schlechty, 1997). Schlechty (1997) believed that systemic reform at the school level involves changing the systemic properties of schools. Stated more methodically, Fullan (2000) described systemic or large-scale school change as the equation $E = MCA^2$, where E is the rate of efficacy of the system, M is the motivation for reform, C is the capacity for reform, and A^2 is the assistance times the accountability. Fullan believed that sustained reform could only occur when internal school development (defined as the process of developing professional learning communities within the school) is successfully combined with a connectedness to those forces outside the school and united with an external infrastructure.

Although systemic reform is advocated by many reformers, there are those who believe that changing the system *directly* does not work (Fullan, 1996). Fullan elaborated,

> ‘Systems’ have a better track record of maintaining status quo than they have of changing themselves. This is why attempting to change the system directly, through regulation and structural reform, does not work. It is people who change systems, through the development of new critical masses. Once a critical mass becomes a majority, we begin to see the system change. The lesson of systemic reform is to look for those strategies that are most likely to mobilize large numbers of people in new directions (p. 423).

It is apparent in the excerpt taken from Fullan, that in order to effectively initiate and sustain systemic reform, those seeking reform must first procure a committed network of people who when working together can possibly change or reform the system.

As previously addressed, systemic reform is a concept that has emerged nationally over the last fifteen years. A working definition of systemic reform for the current study is defined as *any effort (reform) that influences subordinate entities in a top down manner and superordinate entities in a bottom up approach.* The understanding of systemic reform provided impetus for this study of a particular inquiry-based elementary school science curriculum program and its philosophical underpinnings, its positive influence on a school district’s science program, and its impact on district- and state-wide curriculum reform initiatives. The school district’s decision to adopt and implement a science curriculum program and its inquiry teaching approach in the early 1960s, prior to any then current national curriculum reform initiatives, is significant. Furthermore, the district’s capacity to sustain a successful reform effort for more than four decades is worthy of study. It is this sustained systemic success that resulted in the fruition of this investigation. Therefore, a historical case study, which utilized grounded theory research approach, was conducted to communicate the understanding of how one particular school district initiated and sustained a curriculum reform movement for more than forty years.

Method

A qualitative research approach that combined historical case study and grounded theory techniques was chosen for this study. A historical case study by definition is a detailed examination that concentrates on a particular setting, subject, or event tracing the particular development over time (Bogdan & Biklen, 1998). This historical case study involved a chronological history of the K-12 science program within the Hudson Public School district from 1962 to 2002. A chronological examination is necessary to address the research questions of this study.

Qualitative research methods used for this study included purposeful sampling, open-ended or informal interviewing techniques, and systematic and concurrent data collection and data analysis procedures. Specifically, grounded theory or constant comparative method (Glaser & Strauss, 1967) was used to analyze the data and discover how a school district has been able to sustain and continue a curriculum reform effort for more than forty years. In accordance with Stake (1995), "[I] seek greater understanding of [this] case. [I] want to appreciate the uniqueness and complexity of [the case], its embeddedness and interaction with its contexts" (p. 16).

Merriam (1998) concluded after many years of conducting qualitative research that, "The single most defining characteristic of case study research lies in delimiting the object of study, the case" (p.27). Merriam accentuated the essential component of this type of research is maintaining a bounded system where there are specific boundaries that cause the topic of study to be unique. Borrowing from Merriam (1998), the *outer edge* of this historical case study will be the development and modification of the teaching procedure and curriculum development modelembedded in a 1960s curriculum reform effort while the *heart* of this study will be the evolution and continuation of a systemic, curricular reform as seen in the Hudson Public Schools (HPS)

The HPS science program has undergone a transformation of educational philosophy as first seen in the 1960s. This philosophy has accommodated to the changing society, yet the underlying principles have sustained for forty years while other educational ideas and/or philosophies in other schools and districts have diminished. For that reason, attention will be directed to the actions thatwere taken at the elementary, middle, and high school levels, but also the school district's decisions to maintain and sustain a commitment to the aforementioned inquiry teaching approach and curriculum development model.

Sample

The HPS are located in a mid-sized city in Oklahoma. When the first instance of an educational reform at the elementary school level was implemented during the 1962-1963 academic year, the city of Hudson (pseudonym) had a population of approximately 33,000 people (See Table 1). Forty years later, Hudson's populatin has increased to approximately 96,000 residents.

Table 1

Historic population growth for the city of Hudson

Year	Total Population	Total Increase	Percent Increase
1960	33412	6406	23.72
1970	52177	18705	55.98
1980	68020	15903	30.51
1990	80071	12051	17.72
2000	95694	15623	19.51

Note. (City of Hudson, 2002, February 24).

During the 1962-63 school year, the Hudson Public Schools included 8 elementary schools (serving grades 1-6), two junior high schools (serving grades 7-9), and one high school (serving grades 10-12). The total school district average daily student attendance was estimated to be approximately 6,000 students. Two new elementary schools were opened for the 1963-64 school year. Another elementary school was opened for the 1968-1969 school year. To cope with a large population increase in the early 1970s, a reconfiguration of the school district occurred for the 1973-74 school year in addition to the opening of the twelfth elementary school. The average daily attendance for the 1973-1974 school year was approximately 9,500 students. All elementary schools were reconfigured to serve students in grades K-5. The two junior high schools (grades 7-9) and one high school (10-12) were reconfigured to three middle schools serving students in grades 6-8, two mid high schools serving students in grades 9-10, and one high school serving students in grades 11-12. In 1974-1975, one elementary school was closed, and the number of elementary schools maintained at eleven until 1985-1986 when a new elementary school was started. Two additional elementary schools were formed in 1990-1991, while another elementary school was founded in 1993-1994.

The 1997-1998 academic year marked the second school district reconfiguration. The two mid high schools were reconfigured to accommodate a second high school and a fourth middle school. To date, the HPS is comprised of 15 elementary schools (grades K-5), four middle schools (grades 6-8) and two high schools (grades 9-12) with an estimated average daily attendance of approximately 12,500 students. According to the Oklahoma Office of Accountability (2000)*, Profiles 2000 District Report*, the HPS employed 1,006 teachers and administrators and 540 support personnel at the time of this study.

Data Collection and Analysis

Data for this study were collected primarily through artifacts and supported and augmented with interviews. Artifacts comprised technical and non-technical documents that were associated with the reform effort of this school district. Technical documents consisted of journal articles, theses and dissertations, district administrative documents, and grant proposals (funded and non-funded) associated directly or indirectly with the science curriculum reform. Non-technical documents included newspaper clippings, press releases, and personal correspondence also related to the reform. The Science Education Center and the Western History Collections, both at the University of Oklahoma, housed many of these historical artifacts.

The principal criterion in selection of interviewees was their involvements either in the development, implementation, and continuation of this inquiry based curricula and teaching approach at the classroom level and/or in the curricular decisions for adoption at the administrative level. In other words, the researcher utilized purposeful sampling (Patton, 1990), which included a combination of network sampling and theoretical sampling (see Merriam, 1998). Additionally, purposeful sampling “maximizes the researcher’s ability to identify emerging themes that take adequate account of contextual conditions and cultural norms” (Erlandson, Harris, Skipper, & Allen, 1993, p. 82). (See Appendix A for the informed consent form.)

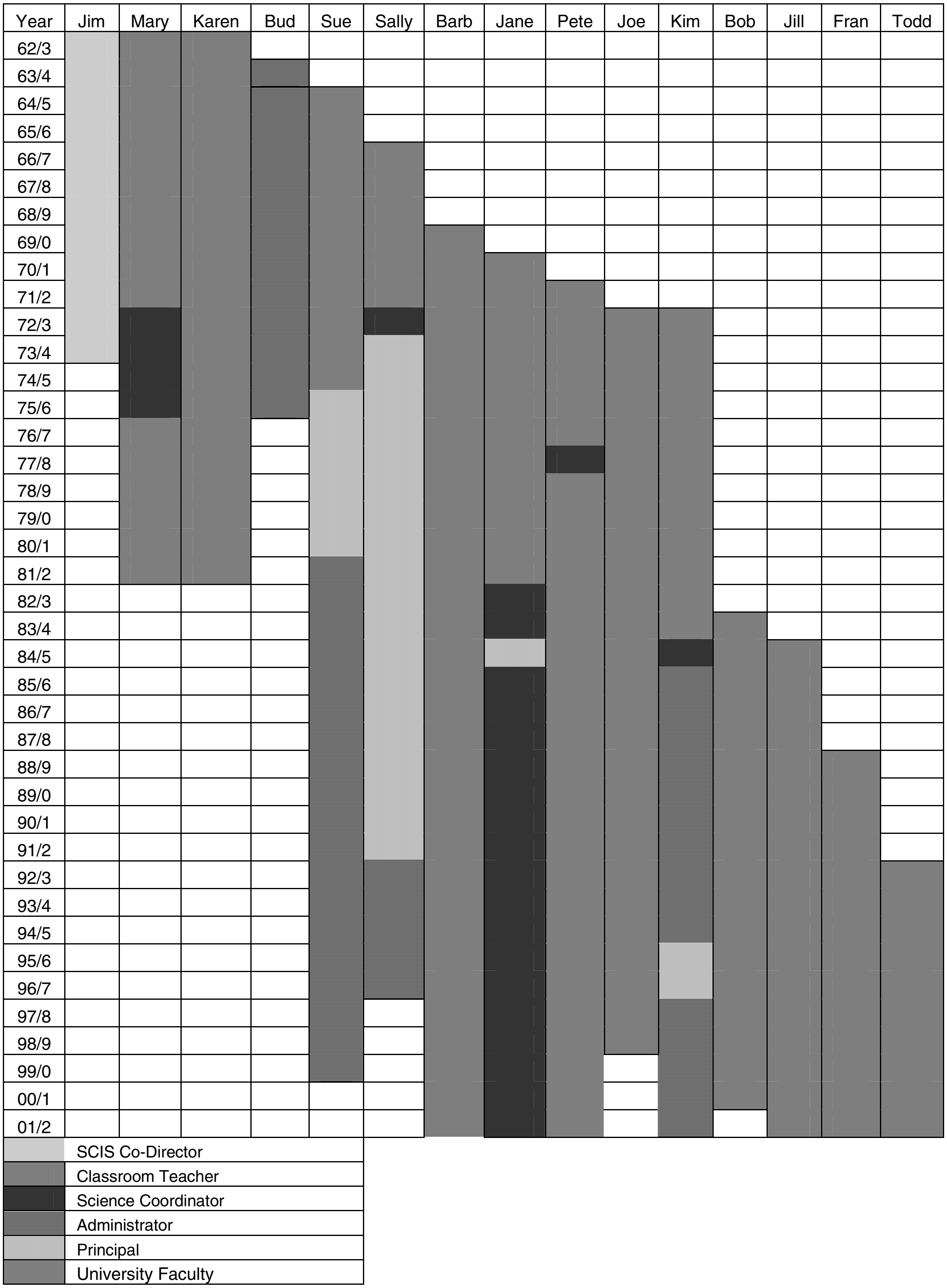
Fifteen people comprised the interview consortium with professional responsibilities including (a) administrative roles, such as superintendents, assistant superintendents, principals, and curriculum consultants/coordinators; (b) classroom roles, such as elementary and secondary school teachers who taught science; (c) partnership roles, such as university faculty who collaborated with those in administrative and classroom positions within the district; and (d) the co-director of SCIS who worked with the SCIS trial center director. See Table 2 for a graphic representation of the various interviewee roles and lengths of involvement during the evolution of this reform. For a biographical sketch of each participant see Appendix C. Open-ended or informal interviewing techniques, which are a "mixture of conversations and embedded questions" (Erlandson et al., 1993) were implemented throughout each interview. Each interview was audio taped by the researcher and later transcribed verbatim. (See Appendix B for possible interview questions.)

Each technical and non-technical document and transcribed interview was coded and analyzed following the constant comparative method of data analysis (Glaser & Strauss, 1967). The constant comparative method is a systematic technique for developing grounded theory where categories, properties, and tentative hypotheses emerge from the data and lead to informative or grounded theory (Glaser & Strauss, 1967; Strauss & Corbin, 1998). Strauss and Corbin (1998) succinctly described grounded theory as when,

> . . . the researcher begins with an area of study and allows the theory to emerge from the data. Theory derived from data is more likely to resemble the "reality" than is theory derived by putting together a series of concepts based on experience or solely through speculation (p. 12).

Table 2

Years and roles of involvement of the interview consortium (names are pseudonyms)



The first step toward generating a theory for this research study is communicating the descriptive details of the bounded system or case of study: "It is important to understand that description is the basis for more abstract interpretations of data and theory development" (Strauss & Corbin, 1998, p. 18). The descriptive details of the events attributable to the sustained curriculum reform are chronologically provided in chapter 4.

The transcribed data were then *micro analyzed*, which is the combination of open coding and axial coding that leads to selective coding (Strauss & Corbin, 1998). Open coding is referred to as *line-by-line* analysis where data are (a) conceptualized, in other words, broken down into discrete parts; (b) closely examined; (c) compared for similarities and differences; (d) grouped under more abstract concepts termed categories; and then (e)reassembled through statements about the relationships among categories, which are termed hypotheses (Strauss & Corbin, 1998). Strauss and Corbin described axial coding as "the process of reassembling data that were fractured during open coding" (p. 124). Finally, selective coding is the process of integrating and refining theory from the categories and subcategories that developed from open and axial coding procedures.

This aspect of theory development is the precursor to theorizing (Strauss & Corbin, 1998). Theorizing is explained by Strauss and Corbin as a "work that entails not only conceiving or intuiting ideas (concepts) but also formulating them into a logical, systematic, and explanatory scheme" (p. 21). This idea of grounded theory in terms of description, conceptual ordering, and theorizing, is the basis of this historical case study research design and is communicated in chapter 5.

Merriam (1988) stated, ". . . .because humans are the primary instrument for data collection and analysis in qualitative research, interpretations of reality are accessed directly through their observations and interviews" (p. 203). As a result of this close relationship between self and data, internal validity is a "definite strength of qualitative research" (p. 203). Internal validity was enhanced in this qualitative study by ancillary data, triangulation, member checks, peer examination, participatory or collaborative modes of research, and researcher biases (Merriam, 1998).

Merriam (1998) claimed that reliability is difficult to obtain in case studies and other types of qualitative research methods, because human behavior is never static. Because humans and their behavior are apt to change, Lincoln and Guba (1985) suggested viewing reliability in terms of qualitative research as the dependability and consistency of the research results. In other words, rather than try to replicate a study, the results of a qualitative research study should be consistent with the data that were collected. The reliability of this research was obtained through triangulation and audit trail (Merriam, 1998). Audit trail is a detailed description of how data were collected, how categories were developed, and how decisions were made throughout the inquiry (Merriam, 1998).

External validity in single case studies, such as this, can prove to be problematic. Some researchers resist making generalizations based on a sample of one. This was remedied by random sampling subunits of the case study and then treating the data quantitatively (as suggested by Merriam, 1998). Following the recommendation by Cronbach (1975), I replaced the generalizability associated with qualitative research with working hypotheses. Working hypotheses take into account local conditions and offer the researcher guidance in making choices (Cronbach, 1975). To ensure external validity in this study, a rich, thick description of the research situation is provided in chapter 4. A rich, thick description is defined by Merriam (1998) as, "providing enough description so that readers will be able to determine how closely their situations match the research situation, and hence, whether findings can be transferred" (p. 211).

In light of the employed research methodology for uncovering grounded theory, I reiterate an argument made by Fullan (1999) in that, generating a theory to describe the complexity of reform is difficult for manifold reasons. Fullan stated that, "The link between cause and effect is difficult to trace, that change unfolds in non-linear ways, that paradoxes and contradictions abound, and that creative solutions arise out of interaction under conditions of uncertainty" (p. 4). Moreover, Fullan continued,

> There will never be a definitive theory of change. It is a theoretical and empirical impossibility to generate a theory that applies to all situations. Definitive theories of change are unknowable because they do not and cannot exist. Theories of change can guide thinking and action . . . but the reality of complexity tells us that each situation will have degrees of uniqueness in its history and makeup, which will cause unpredictable differences to emerge (p. 21).

Although I am seeking a grounded theory related to the continuance of a science curriculum reform, I agree with Sizer (in Goldberg, 1996) in that, "There is no template or model for American schools—just guiding principles and a deep respect for the culture of an individual school [district]" (p. 2).

A Historical Account of the Systemic Curricular Reform

> "Change is a journey, not a blueprint. . . There can be no blueprints for change, because rational planning models for complex social change (such as education reform) do not work. Rather, what is needed is a guided journey" (Fullan & Miles, 1992, p. 749).

There is much to be learned from the curriculum reform under investigation, from understanding the conditions that brought it into existence to the factors that allowed it to persist for more than forty years and to its influence on district- and state-level reform initiatives. This chapter chronicles the history of the Hudson Public Schools (HPS) science program by providing some of the important events, key players, research, and the nature of the reform from 1962 to 2002. Presently, the HPS science program (preK-12) is vertically and horizontally aligned with inquiry-based curricula that are established upon the central purpose of education (Educational Policies Commission, 1961), the structure of science, the intellectual development of the learner (Piaget, 1963), and national (NRC, 1996) and state (OSDE, 2002) curriculum standards. These separate components comprise a theory base that guides curriculum decisions throughout the district. To say that the science curriculum began with this theory base would be unreasonable. The following pages provides a guided journey of the evolution of an elementary school science curriculum reform effort as it pervaded the HPS science program and school district en masse, and influenced statewide curriculum reform initiatives. See Appendix D for a timeline of the curriculum reform under investigation.

Preview of the District Science Program

Prior to the early 1960s, the science program of the HPS was considered traditional in its approach and use of resources (Atkinson, 2001; personal communication, April 19, 2002). Bud, a former superintendent (1964-1976), described the science program at the beginning of his tenure as, ". . . a well equipped science program that was a very traditional kind of program, textbook oriented and things like that. It was not very inquiry oriented" (personal communication, April 19, 2002). Wilson (1967) identified the HPS elementary school science program in the early 1960s as one "that was basically that which was taken from the science textbook" (p. 13). Until the early 1970s, the methodology used in most HPS junior high science classes consisted of the traditional recitation-demonstration format (Friot, 1970). Similarly, the predominant science teaching methodology at the high school level consisted of exposition (Lawson, 1973). During the 1962-1963 academic year, a teaching approach and curriculum development model was introduced in the district that would eventually change the way science would be taught at every grade level.

Elementary School Science

As addressed in chapter 2, the end of World War II and the launching of Sputnik provided impetus for an increase involvement in the development of "new" curriculum programs in science and mathematics. Accompanying the national sense of urgency for improving science and mathematics courses, many college and universities were developing science curriculum programs that were activity-based (inquiry) curriculum programs. One such program was the Science Curriculum Improvement Study (SCIS). The SCIS was established in 1962 by Robert Karplus, a professor of physics at the University of California at Berkeley. Karplus directed his efforts toward developing an elementary school science program that had as its objectives the intellectual development of and the scientific literacy for all students (Karplus & Thier, 1967). The educational activities and related materials in the SCIS program were based primarily on the contemporary work of Jean Piaget and his theory of cognitive or intellectual development (Piaget, 1963). The associated teaching approach inherent in the SCIS consisted of the following sequence: preliminary exploration, invention, and discovery (Karplus & Thier, 1967). This teaching approach was given a label known as the learning cycle.

Sometime during the 1962-1963 school year, John W. “Jack” Renner, Ph.D. (1924-1991), Professor of Science Education at the University of Oklahoma (OU) and director of the Science Education Center at OU, initiated the beginning stages of science curriculum reform through a graduate level science education course at OU. In this graduate course, Renner acquainted teachers with the new science curriculum developments of that time and how they are taught (Renner to discuss, 1965, p. 3). In addition to introducing the SCIS, Renner also introduced the Elementary Science Study (Elementary Science Study [ESS], 1965) and Science-A Process Approach [SAPA] (AAAS, 1963). At that time, the SCIS only served students in grades 1-3. The ESS program was designed for students in grades 4-6; the ESS presented a model for those teachers who wished to build their own science curriculum from the 56 units that were offered. Additionally, “the ESS program provided learning experiences using materials children could work with, problems they could investigate, and questions they could ask and find answers for themselves” (Oklahoma State Department of Education [OSDE], 1971, p. 11). The SAPA program, designed for students in grades K-5, was developed to promote an understanding of the processes and procedures of science. A commonality between these elementary school science curriculum programs was the emphasis on developing scientific literacy using inquiry-teaching procedures.

As these new curriculum programs were being examined in science education courses at OU, Mary, a graduate student in the science education program at OU, who also was a HPS elementary school teacher, volunteered to try out unpublished lessons from the SCIS and from the ESS in her third grade classroom in the spring of 1963. Mary became the first teacher in the southwest to use both the SCIS and the ESS materials on a trial basis (Grant Proposal No. SPE-8320690). By her willingness to try “some of that stuff” in her third grade classroom, Mary indirectly offered Jack Renner, and essentially the Science Education Center at OU, an informal right of entry into the HPS. Thus, HPS science curriculum reform began its embryonic development in the spring of 1963.

During the next school year (1963-1964), the curriculum reform of the HPS was an isolated effort in Mary’s science classroom. Mary struggled implementing these innovative curriculum programs in her upper elementary classes. Personnel from OU procured workbooks for Mary that supplemented the SCIS and ESS programs; they observed her teaching these inquiry programs; and they assisted Mary in the acquisition of materials necessary to implement these programs.

Concurrently, Renner introduced the SCIS, the ESS, and the SAPA programs to seven elementary school teachers at the University of Oklahoma Laboratory School. Renner used this opportunity, in combination with science education courses in which he taught at OU, to develop further his understanding of the theoretical framework undergirding these inquiry-based programs, specifically the SCIS. Renner also continued communicating this understanding with Mary, and began corresponding with those teachers at the OU Lab School. It was here where Renner and colleagues, using their observational data taken in Mary’s HPS classroom, began devising the necessary laboratory materials from sketchy information in the SCIS and ESS teacher's guides. An excerpt taken from the December 1964 issue of the OSTA Bulletin of the Oklahoma Science Teacher's Association clearly reveals Renner's intentions:

> Elementary school science programs, therefore, must be [more] concerned with developing HOW the child thinks [rather] than concentrating on WHAT he thinks. The laboratory school at the University of Oklahoma feels it has a responsibility to assist in the development and testing of programs, which can ultimately benefit all schools in Oklahoma (Renner & Lanier, 1964, p. 3).

Renner began selecting materials and ideas from several of the research projects in elementary school science (SCIS, ESS, and SAPA) and combined these with his own ideas of how science should be taught at the elementary school level to begin developing his theory base of science education. It was during this time when Renner began formalizing his theory base and sharing it with Mary, the HPS elementary school teacher and Bud, the HPS superintendent. The framework of Renner's incipient theory base consisted of the following elements: (a) assisting students in developing an understanding of the processes of science; (b) achieving the central purpose of education; and (c) becoming acquainted with the "new" inquiry-based elementary school science programs, which would accomplish elements "a" and "b" (Renner & Lanier, 1964).

According to Renner, the first element of his theory base—the processes of science, "cannot be listed in a step by step order but they focus around questioning, hypothesizing, observing, comparing, evaluating, interpreting, synthesizing, and generalizing" (Renner & Lanier, 1964, p. 3). In other words, "the scientific processes must form the structure of curriculum. The children involvedn   this program must be engaged in searching for information, that is *inquiry*" (Renner, 1967a, p. 10).

The second element of his theory base—the central purpose of education—comes from the Educational Policies Commission, EPC (1961). The EPC declared that the central purpose of education is to develop students' ability to think. Thinking ability was defined by the Commission in terms of the rational powers of the mind, which include recalling, comparing, inferring, generalizing, deducing, classifying, analyzing, imagining, synthesizing, and evaluating. Renner compared these rational powers with the basic processes of science and concluded that the study of the processes of science contributes to the development of a child's ability to think (Renner & Lanier, 1964).

The teaching approach inherent in the SCIS encompassed the third element of Renner's preliminary theory base of education. The SCIS teaching approach comprised three phases. The first phase, *exploration*, provides activities that allow students to experience the concept under investigation. These activities prepare students for the introduction of the concept, the second phase, *invention.* The third phase allows students opportunities for *discovery*. In other words, students can apply the newly constructed concept to other situations. Hence, the teaching approach of the SCIS consisted of three distinct phases—exploration, invention, and discovery.

In the summer of 1964, Renner directed OU's first documented inservice/seminar for inquiry science. The SCIS was the primary science curriculum that was examined during this inservice, while the ESS and SAPA curriculum programs were also investigated. Mary, the "volunteer" HPS elementary school teacher, was one of nine teachers in the metropolitan area who attended this workshop. In the fall of 1964, Mary continued to implement the SCIS and the ESS on a trial basis in her HPS elementary school classroom.

The SCIS program continued to be the focus of many science education courses at OU. These courses were designed (a) to acquaint preservice teachers with the new developments in science and how they are taught and (b) to provide preservice teachers the opportunity to make extensive observations in those classrooms that were implementing SCIS and other new developments in science teaching (Renner to discuss, 1965). Because of Renner's influence on preservice teacher education in science and inservice teacher education in the HPS, the University of Oklahoma was officially invited to participate as an official trial center for the SCIS group. This influence was noted in a letter dated April 8, 1965 from the Assistant Director of the SCIS to Renner:

> As you know, part of our [SCIS] new policy is to enter relationships like this with outstanding laboratory schools throughout the country. I want you to know that this decision to use these schools as a way of influencing preservice teacher education was based, in large part, on the trial of this plan at the University of Oklahoma. Of course, the fact that you did this on your own is a most promising indication for future success, if we can find interested people like yourself at these various laboratory schools.

At that time (1965), OU was the only college or university in the Midwest or Southwest that was participating in the SCIS program:

> We were chosen for three reasons—our attitude, facilities, and cooperation. We were already using some the SCIS materials before we were invited as a participant. We were experiment minded. Another factor involved in our selection is that we had a laboratory school. We also had cooperation of schools and teachers in Hudson [and other communities] (Renner in OU teaching tips, 1966).

The successes that were evident in those HPS classrooms that were implementing the SCIS and other new science programs resulted in the design of another workshop. In the summer of 1965, a six-week workshop was conducted specificallyfor HPS teachers who were interested or eager in learning to teach science using an inquiry approach. Ten HPS elementary school classroom teachers volunteered to participate in this workshop that was directed by Renner at OU. These ten teachers represented nine of the ten elementary schools at that time in the district. It was reported that the HPS was one of the few school systems in the nation taking part in the SCIS program (Group studies new science approach, 1965). Renner described the workshop in this newspaper clipping:

> The whole philosophy behind the [workshop] is that science is a natural vehicle used to develop a child's ability to think objectively. All these studies are pointed toward the same purpose—to develop a child's ability to think, using his ten rational powers. These powers are recalling and imagining, classifying and generalizing, comparing and evaluating, analyzing and synthesizing, and deducing and inferring (Group studies new science approach, ¶ 6).

This workshop addressed the theoretical underpinnings of the SCIS and its inherent teaching approach—exploration, invention, and discovery. The ESS and SAPA programs were also examined during this workshop.

Implementation of the SCIS at the elementary school level permeated throughout many HPS classrooms. HPS elementary school teachers continued working closely with Renner and other personnel at the Science Education Center of OU in furthering their understandings of the theoretical basis and teaching approach associated with the SCIS. Renner was quoted as saying,

> The work of science education at the University of Oklahoma Center revolves around the science teaching in the laboratory school and the [Hudson] public schools. SCIS units and locally developed units are implemented in the laboratory school, revised, and later implemented in the "selected" public schools(Renner, 1967b, p. 6).

In the summer of 1966, a similar workshop to the one conducted in the summer of 1965 was provided for local elementary school teachers (OU teaching tips, 1966; Science teaching methods developed, 1966; Teaching techniques tested, 1966). Twenty teachers from the HPS attended this workshop. Beginning in the fall of 1966, 29 teachers representing most of the elementary schools in the HPS had received formal preparation and were using the SCIS for grades 1-3 and ESS for grades 4-6. In response to the increased implementation of the SCIS throughout the elementary schools in the district, a newly built elementary school was selected as a SCIS national pilot school by the Science Education Center at OU in 1966. Several research studies investigating the effectiveness of SCIS were undertaken specifically at this national pilot school. In the October 1967 issue of *Science Education News*, Renner described the science teaching center at OU and its partnership with HPS:

> The work of science education at the University of Oklahoma Center revolves around the science teaching in the laboratory school and the [Hudson] public schools. With the assistance of a SCIS and a NSF grant, the Center has provided consultive service to the public schools. Consultants have observed the classroom teaching, performed demonstration teaching, held conferences with groups and individual teachers and assisted with the acquisition of teaching materials. The undergraduate curriculum in science education is closely tied to the work going on in the laboratory school and the public schools. Undergraduates, in conjunction with their university work, make extensive observations of the teaching in elementary and secondary classrooms. The [Hudson] public schools have encouraged the Center personnel to use entire classes of children for demonstration teaching; that teaching takes place in the regular classroom (Renner, 1967b, pp. 5-6).

The SCIS was becoming the principal elementary school science curriculum throughout the district. Many HPS elementary school teachers either supplemented the district's science program with the SCIS materials or they made complete use of the SCIS program for elementary school science (Wilson, 1967). To supplement existing inquiry science curriculum, several HPS teachers with the assistance of Renner developed original, inquiry science lessons and implemented these lessons in their elementary school classroom (Durbin, 1966; 1967). Inquiry science was being intensely implemented in many HPS elementary school classrooms. Consequently, these elementary classrooms soon became a "living laboratory" for Renner and others at the Science Education Center of OU. As a cohort of HPS classroom teachers began implementing the SCIS, Renner and colleagues went into these elementary school classrooms and began conducting research on the effectiveness of the SCIS (Renner, Stafford, Lawson, McKinnon, Friot, & Kellogg, 1976). Many of these early studies resulted in dissertations, published journal articles, or components of science methods texts.

During the summer following the 1966-1967 school year, the NSF-funded Cooperative College-School Science (CCSS) Program was established. The entities comprising this program were primarily science education faculty from OU and teachers from HPS. The primary objectives of this workshop were to acquaint teachers with the philosophy, procedures, and materials of "new" or inquiry-centered science teaching, and to make it possible for teachers to assimilate and internalize the philosophical and operational changes necessary to begin this kind of teaching in the fall of 1967 (Schmidt, 1969). HPS elementary school teachers were required to perform experiments, gather data, test hypotheses, and make predictive inferences; to make a presentation to the entire class of teachers one unit of study for the particular grade level that teacher taught; to design a sequence of study for one grade level for one year; and to engage in observations of microteaching. As a result of this program, personnel from HPS and OU developed a scope and sequence of science experiences for grades 1-6 (Renner, 1967b). The sequence of study for each grade level was later combined into the scope and sequence subsequently incorporated by the HPS.

The succeeding 1967-1968 academic year marked a significant era of the HPS elementary school science program. It was reported that 70 HPS elementary teachers from all 11 elementary schools had received formal education in the SCIS inquiry teaching approach (Wallen, 1970). Many HPS elementary school teachers were implementing the SCIS and ESS programs. Frequent inservices and workshops that focused on inquiry science teaching were provided for HPS elementary teachers by personnel at OU during the next several years.

During the 1972-1973 academic year, the district formed a science curriculum consultant position to assist with the district-wide dissemination of the SCIS program and materials at the elementary school level. This position was shared for one year by two elementary school teachers, Mary, who helped initiate science reform at the elementary school level and Sally, who had taught four years at the elementary school level. At that time, the HPS system consisted of eleven elementary schools serving students in grades 1-6. Due to growth of the Hudson population, the schools in the district were reconfigured and a twelfth elementary school was opened in the fall of 1973. Sally became principal of the new elementary school, while Mary retained her curriculum consultant position for three additional years. Beginning in the 1973-1974 academic year, all twelve elementary schools were serving students in grades K-5 and implementing the SCIS and supplemental inquiry materials in its classrooms.

The configuration of the district, science curriculum consultant position led to the continuation of the partnership between the OU Science Education Center and the HPS. Renner and staff at OU, while working with the HPS elementary school teachers and science curriculum consultants, observed classroom teaching, demonstrated classroom teaching, held conferences with groups and individual teachers, and assisted with the acquisition of teaching materials. As the curriculum consultant for the district, Mary co-directed workshops and in-services for HPS elementary school teachers and teachers across the state.

One of the deficiencies of the SCIS at that time for those elementary school teachers who were dependent upon a written text was the lack of a true textbook (personal communication, May 30, 2002). To accommodate textbook-dependent teachers, Renner along with a former graduate student of OU and Mary, who at the time was the district science consultant, began developing in 1973 a science textbook series named the Learning Science Program [LSP] (Renner, Stafford, & Coulter, 1977). The LSP incorporated the same theory base and teaching procedure that was inherent in the SCIS. Furthermore, the LSP represented a synthesis of the original SCIS, SAPA, and ESS projects. The most important element from these inquiry-based projects included in the LSP was the common, underlying philosophy that children learn scientific concepts through interacting with materials. The LSP provided two new dimensions to inquiry-based elementary school science. It placed the directions and suggestions for investigations in a teacher friendly book, and it incorporated reading in an inquiry-centered program. These textbooks were implemented in the HPS elementary science program in 1975 and were published as a six-book set in 1977 (Renner, Stafford, & Coulter, 1977).

In the fall of 1975, the HPS formally adopted the SCIS as the district-wide curriculum for elementary school science. Associated with the science curriculum of the SCIS was the utilization of live organisms. To meet the demands of ordering and managing these organisms, Renner and the Science Education Center at OU and Mary, the HPS science curriculum consultant, formed a cooperative science education program in the spring of 1976 (OU-city schools join in program, 1976). This program enabled prospective teachers at OU to learn how to grow living organisms, while providing the material to HPS elementary school teachers quickly and at low cost. Later that spring, the science curriculum consultant position was terminated with the hire of a new HPS superintendent (1976-1985), and Mary returned to the classroom teaching 5th grade science.

During the late 1970s, five personnel from HPS (four classroom teachers and one principal) with over 350 participants nation-wide served as reviewers for all (or portions of) the first commercial edition of the SCIS and provided the authors and editors with critical comments and recommendations. These recommendations contributed immeasurably to the development of the revised and updated SCIIS program, which was adopted for HPS elementary school classrooms for the 1982-1983 school year. This school year marked the time when the HPS district began supporting elementary sites with inquiry, science equipment purchases. The district provided its eleven elementary school sites with new SCIIS kits and teacher's guides and professional development opportunities for teachers that facilitated the implementation of these inquiry materials. A workshop was also held for elementary school principals to develop their understanding of the theory-based science program (Atkinson, 2001).

During the summer of 1984, a NSF-funded workshop (Grant No. SPE-8320690) was facilitated by Renner, Mary of HPS, and Pete (former HPS secondary school science teacher and district science coordinator) who was then an assistant professor at the Science Education Center at OU. Eighteen HPS elementary school teachers participated in utilizing the learning cycle in elementary school science. In this workshop, teachers (a) participated in theory-based science education (i.e., the nature of science, the developmental and mental functioning models); (b) conducted science investigations

(SCIS, ESS, and LSP); and (c) developed elementary school science curriculum. The following summer, four other HPS elementary school teachers participated in a similar NSF-funded workshop (Grant No. TEI-8550107).

In 1988, the HPS established a five-year program (1988-1992) titled Science Teaching: An Elementary Project (STEP). A committee of Kindergarten through fifth grade teachers participated in a day of intensive professional development once a month during this five year period. Throughout these meetings, topics pertinent to contemporary science education were discussed. These topics included, but were not limited to, the developmental needs of the elementary science student, effective teaching strategies, articulation and coordination of science content, and curriculum development (Atkinson, 2001). The committee members piloted the suggested materials for an entire school year before the inquiry science curriculum was implemented in all the elementary schools during the 1993-1994 school year. As a result of this five year program, decisions were made to retain the SCIS science program. The district adopted and purchased the latest version of SCIS, SCIS3, for all 15 elementary school sites. New teacher's guides and updated equipment were provided for all schools (Atkinson, 2001).

During the 1999-2000 school year, the HPS adopted new resources for science. At the elementary school level, the district provided each elementary school with the latest revision of the SCIS program, SCIS3+. Each teacher in the district was provided the updated teacher's guide and materials associated with the SCIS3+ program. Currently (2002), HPS elementary school teachers supplement the SCIS3+ curriculum (grades K-5) with Harcourt Science (grades K-3), FOSS modules (grades 2-5) and Science Court CD-ROM (grades 4-5).

The wealth of experiences gained during forty years in the HPS elementary school classrooms have been used to establish further the theoretical framework and the teaching procedure inherent in the SCIS. The inquiry foundation that the elementary school science program has established has been instrumental in the support of and influence in curriculum and philosophical decisions throughout the HPS district and the state of Oklahoma.

Systemic Influence at the District Level

The combination of successful implementation of the SCIS and other inquiry related programs in a few HPS elementary school classrooms and the professional relationship between Renner of OU and Bud (superintendent) of HPS led to a system-wide, inquiry philosophy of education beginning in the fall of 1965 (Renner & Coulter, 1976). Many HPS elementary school teachers began implementing science curricula (SCIS, ESS, and/or SAPA) that were congruent with this philosophy.

The positive results associated with the implementation of SCIS at the elementary school level over the next seven years had a tremendous impact on the development and adoption of an inquiry based district-wide philosophy that encompassed all content areas (Hudson Public Schools, 1975). The philosophy statement was developed by members of the teaching faculty and administration of the HPS and Renner. The final draft was approved October 2, 1972. The district philosophy stated in part, “To provide an environment in which content is the vehicle, inquiry is the process and self-actualization is the goal” (Hudson Public Schools, 1975, p. 2). Inquiry was described in this document as,

> . . . the process used to develop the elements of rational thought. Inquiry includes discovery activities as well as important learning activities in which facts and information are presented from prepared materials or from group interaction. The guiding principle of inquiry is to enable the student to become actively involved in the learning process. The inquiry process should be used in every part of the curriculum (p. 2).

Attending to the district-wide inquiry philosophy and reconfiguration, committees of HPS teachers developed a *Statement of Purpose* for each school in the district (elementary, middle, midhigh, and senior high) during the fall semester of 1972 (HPS, 1975). The district-wide philosophy was embedded in each document as seen in the following excerpt, “The purpose [of each school] is conceived within the framework of this philosophy” (pp. 2-5). Similarly to its impact on the district-wide philosophy, the HPS elementary school science program also influenced the development of several components embedded in each school level’s Statement of Purpose. These components are the characteristics of the cognitive development of the students at each school level, basic [process] skills development, and developmentally appropriate educational experiences that provide a full range of exploratory experiences (HPS, 1975).

Systemic Influence at the State Level

The developments regarding elementary school science teaching that were being made by Mary in the HPS and Renner at OU in the early 1960s were recognized by the Oklahoma State Department of Education (OSDE). Mary and Renner were asked to participate on the State Committee on the Improvement of Science Instruction in Oklahoma in March of 1965. The Committee agreed that the elementary school science program was in dire need of revision to meet the current trends in science education. Curriculum reform efforts were not only being directed toward the products of science but also toward the processes of science, or *how* science should be taught.

In subsequent meetings between members of the State Science Committee (including Mary and Renner), the basic philosophy of elementary school science teaching to be recommended was thoroughly discussed. The group unanimously agreed that the inquiry approach of instruction was irrefutably the philosophical approach that was recommended to elementary teachers of science (OSDE, 1968). The state-wide emphasis directed toward inquiry science teaching at the elementary school level proved to be ground-breaking, "Oklahoma [was] one of the first states in the nation to attempt to initiate 'inquiry' teaching of science on a statewide basis" (Stafford & Renner, 1968, p. 44). The HPS elementary schools were acknowledged by the State of Oklahomaas being the first in the state to implement the SCIS in their science program.

In 1971, *The Improvement of Science Instruction in Oklahoma Grades K-6* (OSDE, 1971) was revised and disseminated to schools and colleges throughout the state of Oklahoma. Renner and Mary again contributed to this curriculum reform document. The theory base components (the structure of science, the central purpose of schools, and the nature of the learner) that were evolving in the HPS elementary school science program were made manifest in this reform document. These components comprised the section titled "The Basic Philosophy for an Elementary School Science Program." The curriculum model that Renner and HPS locally developed was published in this particular elementary school reform initiative.

In the mid 1970s, the OSDE mandated that all schools develop educational goals as part of the state-mandated Educational Accountability Program for Oklahoma schools. It was this reform initiative that influenced the HPS to develop *Educational Goals of the Hudson Public Schools* (Hudson Public Schools, 1975). The district-wide goals served to meet the accountability requirements set forth by the state. In doing so, this document significantly contributed to greater articulation of the school system's curriculum.

The next state-level science curriculum reform initiative was the *Oklahoma Curriculum Committee. Recommendation: Learner outcomes: State Competencies Grades 1-5* (OSDE, 1990a). Jane, the HPS district science coordinator at that time, participated as a drafting committee member for this reform document. Taking the suggestions and recommendations of HPS elementary school teachers with her to the drafting committee meetings, Jane and the HPS contributed to the development of this reform document. Components of the HPS theory base were embedded in this document, such as, developing the ability to think (as outlined by the Educational Polices Commission [EPC] in 1961) and understanding the nature of science. Developing the ability to think was referenced as the overarching goal of science instruction and understanding the nature of science was listed as a secondary goal of student achievement. Inquiry in the science classroom was suggested as the vehicle to achieve these goals. By using inquiry in laboratory classrooms, it was concluded that students would develop the *basic process skills* (observing and measuring, classifying, experimenting, interpreting, communicating, and modeling). Through the use of these skills, the student would also develop what was labeled as *integrated skills*. The integrated skills identified in this document reflect the rational powers of the mind (EPC, 1961), which defines the central purpose of education.

The *Learner Outcomes* prompted the next wave of curriculum reform in the state, the *Priority Academic Student Skills* (OSDE, 1993). State law mandated in 1991 that the State Board of Education should adopt curricular standards for instruction to be implemented no later than 1993-1994. State law also required a three-year cycle of this reform initiative. Jane, as well as other HPS administrators and teacher committees, have participated at every developmental phase of this state-wide curriculum reform initiative. HPS personnel have dogmatically advocated theory base science education at the state level, and portions of the theory base are evident in this reform document.

Secondary School Science

At the end of the 1960s, inquiry science teaching was evident throughout HPS elementary school classrooms. Inquiry methodologies were now making their way into HPS secondary school classrooms through state-adopted, secondary school science textbooks. The following secondary school inquiry science programs were being used to some extent throughout HPS in the late 1960s and early 1970s: versions of the Biological Sciences Curriculum Study (Biological Sciences Curriculum Study [BSCS], 1969) in biology; the Chemical Bond Approach [CBA] (Chemical Bond Approach Project, 1964) and the Chemical Education Material Study [CHEM-study] (Merrill, 1963) in chemistry; and the Physical Science Study Committee [PSSC] (Haber-Schaim, 1967) and the Harvard Physics Project [HPP] (Holton, 1967) in physics.

One basic problem that many of the early, secondary school, inquiry science programs failed to address was the intellectual level of the student (Brown, Weber, &

Renner, 1971). Renner and colleagues of OU (Renner et al., 1976) during the 1970-1971 school year examined the Piagetian levels of intellectual development (specifically concrete operational and formal operational) of 588 students in grades 7-12 from 25 schools across the state of Oklahoma. Their results indicated that 83% of the seventh grade students, 77% of the eighth grade students, 82% of the ninth grade students, 73% of the tenth grade students, 71% of the eleventh grade students, and 66% of the twelfth grade students were considered concrete operational. Although these data were not exclusively collected from students in the HPS, the implications of these data caused HPS teachers and administrators to consider the appropriateness of the inquiry curricula that were being provided to HPS secondary school students.

Another inherent problem with these programs pertained to the implementation of the inquiry materials. Although inquiry was advocated as a method of learning, no attention was directed toward the philosophy of teaching required to implement these materials. As a result, the predominant science teaching philosophy of exposition remained unchanged at the HPS high school level (Brown, Weber, & Renner, 1971; Lawson, 1973). Consequently, an incongruity existed between the method students used to learn science and the approach teachers employed to teach science.

In response to these embedded problems with the then current, secondary school science inquiry programs, Pete, a first year HPS high school biology teacher who taught the *BSCS Yellow Version* (Moore, Meyer, & Dryden, 1963) during the 1971-1972 school year, was asked by Renner to attend a workshop at the Mid-Continent Regional Educational Laboratories in Kansas City, Missouri, during the summer of 1972. [Pete received his undergraduate degree from OU and was working at that time on a graduate degree in science education from OU.] The purpose of attending this workshop was to learn the framework of the Inquiry Role Approach [IRA] (Bingman, 1968) and to facilitate a summer inservice workshop for HPS classroom teachers. The IRA program was designed to develop social skills and attitudinal qualities by having students work in small groups and assigning each student a specific role within the group. Inquiry skills were also used and learned by students following the inquiry guides associated with the IRA program (Marek & Renner, 1975). Upon receiving the IRA workshop education, Pete became the IRA program director for HPS. Implementation of the IRA in theHPS high school biology program began in the 1972-1973 school year.

Accompanying the 1973-1974 district-wide reconfiguration of its schools, the high school, which had served students in grades 10-12, was now configured to serve students in grades 11-12. Tenth grade students from the high school joined ninth grade students from the two junior high schools to constitute two mid high schools. The Statement of Purpose for the mid high school and the high school was reflected in the stated philosophy "to provide an environment in which content is the vehicle, inquiry is the process, and self-actualization is the goal" (Hudson Public Schools, 1975, p.5-6). To this end, the IRA program, which was experienced by tenth grade students at the high school, became the mid high school biology curriculum, while the Earth Science Curriculum Project (ESCP, 1973) became the mid high school earth science program. The BSCS continued to be part of the biology program at the high school while the previously implemented inquiry programs in chemistry and physics also remained at the high school.

During this time (1973-1974), no secondary school science programs existed that incorporated the same theory base and learning cycle (inquiry) teaching approach that was inherent in the elementary school SCIS program. There were “new” science curricula at the secondary school level, but the teaching procedures that accompanied these innovative curricula were not unlike the expositional approach that was in use prior to these programs.

Chemistry and Physics Curriculum Development.

Similar to the genesis of the HPS elementary school science curriculum reform that began in a graduate level science education course at OU, the HPS secondary school science curriculum reform had a similar beginning. The theoretical framework that was introduced and investigated in elementary school science education courses at OU and that underpinned the HPS elementary school science reform also comprised secondary school science education courses at OU. The SCIS was used in these courses as a model for inquiry teaching that reflected the theoretical framework that was developing at OU and HPS (Renner & Nickel, 1979).

After taking a secondary school science education course at OU, Joe, a HPS high school chemistry teacher, learned “a logical way of going about teaching science based on the theory of how people learn” (personal communication, May 8, 2002). Joe began applying this knowledge in developing and implementing a learning cycle chemistry unit on acids and bases during the 1973-1974 academic year. The successes that accompanied this new way of teaching chemistry at the high school level were shared with other HPS high school science faculty and Renner and colleagues at OU.

During the summer of 1974, Joe, along with another chemistry teacher from HPS who also was a former student of Renner at OU, began intensive lesson development for a theory base chemistry curriculum. These two teachers committed an entire summer to writing and revising learning cycle lessons in the field of chemistryBy the end of that summer, Joe and his colleague developed five chemistry learning cycle units. Concurrently, the initial drafts of many of the learning cycle lessons in the HPS physics program were being developed by a HPS physics teacher and former student of Renner and revised by other HPS high school science faculty who were also graduates of OU.

Rudimentary curriculum development in chemistry and physics began by selecting one or two concepts and designing laboratory experiences that followed the theoretical approach that would lead students to understand those concepts. From this point in time, curriculum development based upon a theoretical foundation was the principal objective forRenner of OU and high school chemistry and physics teachers of HPS.

During this time period, Renner and HPS secondary school science teachers considered Piaget's theory of mental structures a basis for developing science curriculum. Prior research (Renner et al., 1976) in theHPS indicated the generalized developmental level of the learner for students in grades K-12 (e.g., preoperational, concrete operational, and formal operational). It was understood that Piaget's theory of mental structures was the fundamental process in promoting intellectual development (Lawson & Renner, 1974).

At that time, Piaget's model of mental structures included assimilation, disequilibrium, and accommodation. Mental structures were referred to as "mental blueprints” that serve to organize the environment so that the learner can function successfully within it (Lawson & Renner, 1975) and as “systems of transformations" that are used to receive and transform data from the environment” (Renner & Nickel, 1979). The formation of mental structures begins with the process of assimilation. Assimilation was described as the process that guides the learner’s behavior (Lawson & Renner, 1975). Assimilation was understood as the cognitive process of what learners do when they interact with the environment. If the data that are received from the environment do not fit into existing mental structures, then the learner is in a state of mental disequilibrium. Consequently, the learner makes mental adjustments by either altering or replacing the existing mental structures so that these data do correspond to existing mental structures. This process was referred to as accommodation. The learner then is given additional opportunities that allow further assimilation and accommodation of the same conceptualizations. (It was later when the term organization was added to the Piagetian model.) These combined elements comprised the theory base that was evolving in the elementary and secondary classrooms of the HPS. See Table 3 for a graphic representation of the HPS evolving theory base of science education, specifically Piaget’s model of mental structures.

Table 3

A graphic representation of the evolving HPS theory base of science education

Piaget's Model of Mental Structures/Function		**Learning Cycle Phases**	
1962-1979	1979-	1962-1979	1979-
Assimilation (Disequilibrium)	Assimilation (Disequilibrium)	Exploration	Exploration
Accommodation (Equilibrium)	Accommodation (Equilibrium)	Invention	Conceptual Invention or Term Introduction
Further Assimilation and Accommodation	Organization	Discovery	Expansion of the Idea or Concept Application

The evolving HPS theory base adhered to Piaget's model of mental structures, i.e., assimilation (disequilibrium), accommodation, and organization. It was not until the early 1980s that the concept of mental function supplemented Piaget's model of mental structures (Birnie, Renner, & Abraham, 1983). The idea that the learner's mental structures are altered as a result of experiences was viewed as a "variant" process. However, the sequence of cognitive structure development (assimilation, accommodation, and organization) was believed to be "invariant", in other words, the process of mental functioning "... continues to operate in that fashion building mental structures as long as we interact with our environment" (Birnie, Renner, & Abraham, 1983, p. 30). The concept of mental function depicts the learning process (Marek & Cavallo, 1997).

What students do during assimilation was termed *exploration* in the learning cycle curriculum development model and teaching approach and what happens mentally during accommodation was labeled *invention*. Renner and science education faculty at OU later added the term *conceptual* to invention, which implies what the student experiences during this aspect of learning science content. Renner and HPS personnel included another aspect of Piaget's model of mental structures. After students accommodated the data from their environment, in other words invented/constructed the concept, they then were given opportunities to expand the new idea just gained to include in its domain as much of the environment as possible (Renner & Nickel, 1979). Furthermore, "The newly invented idea has really been expanded to include much more than the originally invented concept but everything that is included is a function of and dependent upon understanding the original concept" (Renner & Fix, 1979, p. 738). Thus, the third phase of the learning cycle, which was initially named discovery, was labeled *expansion* of the idea and/or concept *application*.

Now that Piagetian influences were becoming elements of science education within the HPS and OU, the HPS and OU were in need of discovering "a procedure that could be used to predict the level of intellectual development of a student by analyzing written language" (Renner, Prickett, & Renner, 1977, preface). In January of 1976, one hundred HPS mid high school students in addition to students (grades 10-12) in other school districts across the state participated in a NSF-sponsored research project titled Cognitive Analysis Project (Grant No. EPP-7519586). HPS classroom teachers and OU science education faculty worked collaboratively in finding "a procedure that could be used to predict the level of development of a student by analyzing his written language." Research results indicated that almost 78% of students in high school were concrete operational thinkers or transitioning between concrete and formal operational thought.

Therefore, HPS and OU used this finding as a single criterion with which to examine curricula for the elementary and secondary schools (Renner, Grant, & Sutherland, 1978).

Thereafter, HPS high school science teachers commenced development of the HPS chemistry and physics programs by structuring the learning experiences according to the model of mental function and its parallel teaching procedure—the learning cycle. The process for designing these courses with intellectual development as a premise began with (a) the identification of scientific concepts that represent the content to be taught; (b) the selection of laboratory experiences that were designed to lead students to collect information that the teacher and student could use to construct scientific concepts; and (c) the utilization of the concept that explained other phenomena and/or apparatus (Renner, 1976).

At the beginning of the 1977-1978 school year, the HPS Curriculum Department was established serving the four content areas (language arts, mathematics, science, and social studies). The science coordinator position, at that time, was a half-time appointment and was filled by Pete for one year (Pete was a HPS high school science teacher and graduate of science education at OU). After Pete completed his doctoral program at OU he accepted an assistant professor position at an out-of-state university the following year. The science coordinator position was vacant from 1978-1982.

The beginning of wide-scale curriculum development led Renner and the HPS chemistry and physics teachers to design the Chemistry and Physics Teachers' Project (CAPT-P). The primary purpose of the CAPT-P was to develop additional chemistry and physics learning cycles following the HPS curriculum development "plan" (Renner & Fix, 1979). The "general plan" that reflected how learning was believed to take place was the evolving HPS/OU theory base. Eager to share their evolving theory base of education as a curriculum development model and teaching approach, Renner, with high school science teachers at HPS, conducted numerous summer workshops for other high school chemistry and physics teachers from around the state and surrounding states (Andres, 1979).

Because of the CAPT-P, the work done by secondary school science teachers at HPS and Renner and faculty at OU became a nationally recognized model for curriculum development and instructional practices (Hudson teachers honored, 1980). At the conclusion of the CAPT-P, HPS classroom teachers had developed a complete set of learning cycle science lessons for chemistry and physics. It was also during this four-year period that the mental functioning model of Piaget became operationalized and articulated as an essential component to the theory base that was evolving for those at HPS and OU.

With the development of a chemistry and physics program undergirded by a theory base of education, Renner, another faculty member from OU, and three HPS high school science teachers set out to find empirical evidence of the connections between their curriculum model and aspects of their theory base. In January1981, NSF funded a three-year study titled the Chemistry and Physics Teaching Study (CAPT-S) (Abraham & Renner, 1983; Renner, Abraham, & Birnie, 1983). Renner and the other OU faculty member literally moved their offices to the HPS high school during this comprehensive and intensive study (Copeland, 1981, May 3). The purposes of this study were (a) to test the correlation between the theory base and their curriculum model, (b) to test each phase’s importance to the learning cycle, and (c) to determine each phase’s proper place and form. Research results from this study indicated that the learning cycle was an effective means of instruction, and the learning cycle followed closely to the developmental and learning models of Piaget (Abraham & Renner, 1986; Renner, Abraham, & Birnie, 1985; 1986).

Biology Curriculum Development.

The findings from the CAPT-S influenced the development of the HPS biology curriculum program, which took place during the summer of 1981. With the chemistry and physics programs established, the HPS biology teachers agreed that the developmental and learning models of Piaget and the learning cycle teaching approach could also be applied to the development of the high school biology curriculum. HPS had been using the Biological Science Curriculum Study Green Version (BSCS, 1969) and the Outdoor Biological Instructional Strategies [OBIS] (Lavine, 1985) biology programs. Four HPS biology teachers (three teachers from the two mid high schools and one teacher from the high school), under the direction of Renner, adapted lessons from the existing biology programs and developed ten learning cycle lessons according to the theory base curriculum model (Copeland, 1981, July 31). All of the teachers had done graduate work in OU's science education program and had demonstrated their understandings of theory base science education. Curriculum writing was funded by a private organization. This funding also allowed for the implementation of the newly developed biology program in the fall of 1981.

During this era of intensive curriculum development at the secondary level, the district science coordinator position was reestablished. The position was filled at the beginning of the 1982-1983 school year by Jane, a former science teacher in the district who participated as teacher/researcher in the CAPT-S (Jane served as the science coordinator until she retired at the end of the 2001-2002 school year).

Over the next two years, the biology program was endangered by lack of funding. Two private organizations provided adequate support for the reeducating of teachers and the rewriting of the biology curriculum in the summer of 1983. Renner and Pete (former HPS science teacher and science coordinator), who was then Assistant Professor of Science Education, directed a six-week workshop, which allowed HPS classroom teachers to revise the student and teacher's guides used in the biology program. Revisions were also made to the chemistry and physics learning cycle programs.

At the end of summer in 1983, HPS had in place biology, chemistry, and physics programs that adhered to the developmental and learning models of Piaget and to the learning cycle. The 1983-1984 school year served as an intensive trial period of the newly, revised science programs. The positive data collected during the year of implementation led to the continued development of the high school science curriculum. In the summer of 1984, four HPS science teachers and two consultants (Renner and Pete of OU) devoted a month revising and compiling a complete set of the following materials: student investigations, student readings, teacher's guides, and assessments.

The following summer in 1985, Renner and Pete directed an honors workshop at Hudson High School for teachers across the state who taught secondary school biology, chemistry, and physics. HPS teachers served as staff members where participants (a) investigated the nature of science and learning theory, (b) participated in HPS science investigations, and (c) developed science curricula using the learning cycle approach.

With a high school science program in place, the teachers of HPS along with Jane, the district science coordinator, articulated and coordinated the biology (Renner, Cate, Grzybowski, Surber, Atkinson, & Marek, 1985), chemistry (Renner, Fix, Atkinson, Renner, & Abraham, 1985), and physics (Renner, Nickel, Westbrook, & Renner, 1985) curricula during the 1985-1986 school year. In addition, several HPS science teachers continued to participate as staff members in annual NSF summer workshops (1987-1989) that were directed by Pete, who was then Associate Professor of Science Education at OU.

Since the 1986-1987 school year, the biology, chemistry and physics learning cycle programs have undergone multiple revisions based upon student feedback, teacher recommendations, technology advancements, and national- and state-level reform initiatives. In 1996, the biology and chemistry programs were revised and republished. Frequently, classroom teachers develop original learning cycle lessons to supplement the existing program. The Science Education Center at OU and the HPS make available the biology, chemistry, and physics programs to those science teachers, schools, or districts who are interested in theory- and inquiry-based science curricula.

Junior High/Middle School Science.

The inquiry philosophy of science teaching that was becoming widespread at the elementary school level in the middle 1960s pervaded the HPS junior high school science program in the late 1960s. During the month of June in 1967, a four-week workshop was conducted by OU for HPS junior high science teachers (grades 7-9) who were interested in examining current inquiry based science programs for life, earth, and introductory physical sciences (Science teachers summer workshop, 1967). The science programs examined were Introductory Physical Science [IPS] (IPS Group, 1967); Time, Space, and Matter [TSM] (Secondary School Science Project, 1966); and Investigating the Earth—the Earth Science Curriculum Project (Earth Science Curriculum Project [ESCP], 1973).

As can be seen in Table 1 in chapter 3, the population of Hudson experienced tremendous growth in the early 1970s. To accommodate an increase in attendance, the HPS district personnel during the 1972-1973 school year planned for a district-wide reconfiguration of its schools. At that time, the HPS system consisted of two junior high schools serving students in grades 7-9. The district's two junior high schools were replaced with three new, middle schools serving students in grades 6-8 and two mid high schools serving students in grades 9-10.

Before the 1973-1974 district reconfiguration, the elementary school science program consisted of SCIS and ESS units; the junior high school science program consisted of IPS, ESCP, Physical Science: Ideas and Investigations in Science [IIS] (Wong & Dolmatz, 1971b), Biology: Ideas and Investigations in Science [IIS] (Wong & Dolmatz, 1971a), and the Intermediate Science Curriculum Study [ISCS] (Burkman, 1970). In the fall of 1973, several sixth grade teachers from the elementary schools were relocated to the new, middle school sites. Many of these teachers chose to teach sixth grade middle school science in which they taught the sixth-year SCIS units and materials from the ESS. For the next couple of years, inquiry science programs continued to be implemented throughout the HPS. In 1975, the ISCS became the adopted middle school science program.

The success that was evident with the implementation of the SCIS at the elementary school level when combined with the successes resulting from the chemistry, physics, and biology programs provided support for the district's decision to develop a middle school science curriculum that was also based upon the developmental and learning theories and the learning cycle. In March of 1985, a collaborative effort between the Science Education Center at OU and the HPS provided the forum for a one-week workshop to plan the HPS Middle School Science Program (MSSP). Renner, Jane (HPS science coordinator), and Kim (former HPS science teacher, curriculum coordinator, principal, and then current HPS director of curriculum and instruction) directed the workshop. Pete, who at that time was an Assistant Professor in Science Education at OU, also presented portions of the workshop. In these sessions, all eighteen middle school teachers were introduced to the HPS scientific and educational theory base by addressing the following topics: the structure of science, the central purpose of education, the development of the learner, the mental functioning model, and the learning cycle teaching approach. These teachers also formed a list of developmentally appropriate scientific concepts for learning cycle development that would take place during the upcoming summer.

During the summer of 1985, fifteen middle school teachers met all day, five days per week, for three weeks to write the MSSP. During that time, middle school teachers reviewed existing curriculum and essentially developed original learning cycles from "scratch" (Murphy, 1985). Private foundations, the HPS, and the Science Education Center at OU funded this three-week workshop. By working in sixth, seventh, and eighth grade teams, the HPS middle school science teachers prepared teacher guides and student guides for each concept for each grade level.

During the 1985-1986 school year, 17 middle school teachers implemented the MSSP learning cycle curriculum in 80 HPS middle school science classes. Data were collected by Renner, Jane, and Kim on the effectiveness and problems associated with the learning cycles. These data were shared with the grade-level teams in supplying information, ideas, and constructive suggestions for the revisions to be made during the following summer. Each grade level team revised the learning cycle lessons during the summer of 1986, in accordance with the received feedback. The second implementation was based upon data from classroom experiences with the materials of the MSSP and took place during the 1986-1987 school year. Throughout the second year implementation, researchers and teachers concentrated on the clarity and effectiveness of the teacher guide materials for each learning cycle. Data were also collected upon tests and evaluation techniques. Enough data were gathered to include a series of questions to be used by the teacher during class discussion for each investigation. Detailed suggestions for student materials and teacher guide for each grade were provided during this implementation. At the end of July 1987, the MSSP was completed. A final printed copy of each set of student materials and teacher guides for each grade level was published. Since the publication of the MSSP, teachers make yearly revisions based upon the effectiveness of the lessons and materials in their classroom.

Physical Science Curriculum Development.

The final secondary school science program to be developed by the HPS was the physical science curriculum. Development of the physical science curriculum took place during the summer of 1986. Nine HPS mid high school science teachers, under the direction of Renner and Pete of OU, and Jane and Kim of HPS, followed the same procedures of theory base curriculum development that middle school science, biology, chemistry, and physics teachers followed. Implementation of the physical science program took place during the 1986-1987 school year. For the next six years, broad-scale revisions were made to the physical science curriculum. From the time of the physical science learning cycle program publication, teachers make yearly revisions based upon the effectiveness of the lessons and materials in their classrooms.

Systemic Influence at the District Level.

In May 1985, the Hudson Board of Education approved *Decisions for Excellence*, a long-range plan for school improvement. A synopsis of this reform document is stated in part, "It is a district plan which provides a superstructure through which all staff members have an opportunity to participate in decision-making that effects learning and over-all school improvement" (Hudson Public Schools, 1999, p. 4). The evolving theory base that had been in place in the science program throughout the district for twenty years (1965-1985) served as a model for this newly developed district-wide reform document. Embedded in this document were three overarching elements: (a) processes for effecting change, (b) program for effective teaching and learning, and (c)procedures for participatory decision-making. Positive research results associated with the HPS science program contributed to the establishment of element (b), while the model for continued improvement of classroom teachers (elementary and secondary school science teachers) contributed to the structure of element (c).

In 1999, the HPS received the U.S. Department of Education's National Award for Model Professional Development. The HPS was one of four school districts in the nation to receive this award. The HPS also received the National Showcase of Excellence

Award given by the National Council of States on Inservice Education. To date, the HPS school improvement plan is in its sixth revision. The theory-based science program of HPS continues to serve as the prototype for instructional improvement throughout the district.

Systemic Influence at the State Level.

Due to the "explosion of discoveries in new areas of scientific knowledge and the rapidity of progress in recent materials and innovative teaching methods employing diversified techniques" (OSDE, 1970, p. ii), the State Science Committee, in 1970, acknowledged an urgent need to publish a secondary school version of a science curriculum reform initiative titled, *The Improvement of Science Instruction in Oklahoma Grades 7-12* (OSDE, 1970). This particular science curriculum reform was the earliest attempt in the state of Oklahoma at coordinating a K-12 inquiry science program. Because of the pioneering efforts by HPS classroom teachers in the teaching of science, four additional HPS secondary school science teachers were asked to contribute to the publication of this secondary schools, science reform document. Others that contributed to this document and those documents that followed were Renner and many of his former graduate students who conducted their doctoral research in the HPS. It should also be emphasized that Bud, theHPS superintendent who allowed Renner and inquiry science teaching in the district, also served on the Oklahoma State Board of Education for several years.

The influence of the evolving HPS theory base components is apparent in this secondary school science curriculum reform document. The central theme to the guide was science should be taught as inquiry and ". . . in this guide there is *no compromise* to this approach" (OSDE, 1970, p. vi). Two of the fundamental principal ideas expressed in this reform document were (a) inquiry and (b) developmental levels of the learner. It was written that inquiry science teaching should lead students to understand the structure of the discipline, to develop scientific literacy, and to achieve the central purpose of school (developing the ability to think as outlined by the Educational Polices Commission [EPC] in 1961). The developmental level of the learner was recognized as the basis for the selection of scientific materials and concepts; "It is better to present materials to students based on their [developmental] levels of ability rather than based on the levels of the materials" (p. vi).

The next state-level, secondary school science curriculum reform initiative was the *Oklahoma Curriculum Committee. Recommendation: Learner outcomes: State Competencies Grades 6, 7-8, & 9-12* (OSDE, 1990b). Jane, the HPS district science coordinator, sat on the drafting committee and contributed to the development of this reform document. Several components of the HPS theory base were embedded in this document: (a) developing the ability to think was referenced as the overarching goal of science instruction and (b) understanding the nature of science was listed as a secondary goal of student achievement. Inquiry in the science classroom was suggested as the vehicle to achieve these goals. By using inquiry in laboratory classrooms, it was concluded that students would develop the *basic process skills* (observing and measuring, classifying, experimenting, interpreting, communicating, and modeling). Using these skills, the student would also develop what was labeled as *integrated skills*. The integrated skills identified in this document reflected the rational powers of the mind (EPC, 1961), which define the central purpose of education.

The *Learner Outcomes* prompted the next wave of curriculum reform in the state, the *Priority Academic Student Skills* (OSDE, 1993). State law mandated in 1991 that the State Board of Education should adopt curricular standards for instruction to be implemented no later than 1993-1994. State law also required a three-year cycle of this reform initiative. Jane, as well as other HPS administrators and teacher committees, have participated at every developmental phase of this state-wide curriculum reform initiative. HPS personnel have dogmatically advocated theory base science education at the state level and portions of the theory base are evident in this reform document.

Overview of the District Science Program

To date, the Hudson Public Schools have developed an articulated and coordinated, theory-based pre K-12 science curriculum program that is in alignment with national and state science curriculum standards. The learning cycle is the teaching approach and curriculum development model that adheres to this theory-based science education (Marek & Cavallo, 1997). The principal elementary school science curriculum is the SCIS3+. Teachers often supplement the SCIS3+ with other inquiry-based science curricula and at times develop original science lessons based on the learning cycle. The middle school science program consists of teacher-developed learning cycles for students in grades 6-8. The high school science program encompasses teacher-developed learning cycles in physical science, biology, chemistry, and physics. Theory-based education influences other areas of science where teachers incorporate learning cycles in their classrooms. Throughout the district, teachers in other disciplines outside of science also incorporate theory-based elements in their classroom teaching.

Factors for Sustaining and Continuing Reform

> “It is one thing to see an innovation ‘up and running’; it is entirely another matter to figure out the pathways of how to get there in your own organization”
> (Fullan, 1999, p. 14).

The purposes of this study were to provide a better understanding of *how a particular school district has been able to sustain and continue a theory-based program of inquiry science for more than forty years* and *how this science program has been able to influence district- and state-wide curriculum reform initiatives*. In order to understand more clearly the sustaining and continuing factors of reform, the researcher believes the pathways to achieving this level of reform must be addressed.

The curriculum reform under investigation evolved through five levels throughout its duration. Thus, the research findings in this chapter are divided into five parts, grouped according to major themes or categories that emerged from the artifacts and were augmented by the interviews (see Table 4) These themes are Initiation, Education, Implementation, Confirmation, and Continuation. The initiation level is when the goals of reform are envisioned. The envisioned goals are then communicated to a group of people during the level referred to as education. Once the group has been educated of the envisioned goals, they then operationalize the reform in the implementation level. After the reform has been implemented, evidence in terms of research or other types of substantiation further support the reform; this level represents confirmation. The ultimate level of reform is continuation. This is when the reform has been institutionalized and becomes part of the system.

Table 4

Main themes or categories that emerged from the data

Initiation	**Education**	**Implementation**	**Confirmation**	**Continuation**

The sequence of the district-wide curriculum reform is as follows: the adoption of an inquiry-based elementary school science program (SCIS) that adhered to the evolving HPS theory base; the development of inquiry-oriented chemistry, physics, biology, middle school science (grades 6-8), and physical science curriculum programs that also adhered to the evolvingHPS theory base. Within each level and throughout all levels of reform, there were significant factors that supported the curriculum reform progression. Although the levels of reform are delineated in this chapter, a realization that many of these factors reappeared throughout each level of reform is warranted.

The five themes or categories that emerged from the data lead to several working hypotheses that supported the HPS in sustaining and continuing a K-12 science curriculum reform effort for an extended period (see Table 5). These components are a committed visionary; a theory base of education; forums promoting the education of the theory base components; shared-decision making; a university-school partnership; a core group of committed educators and teachers; evidences of success; national and state reform initiatives; a core group of administrators; longevity of the science program; district support (philosophical, financial, and emotional); and community support all contributed to the initiation, education, implementation, confirmation, and the continuation of the systemic, curricular reform. Palestini (2000) suggested that when attempting to implement successful change that each step must be taken concurrently. Following these steps linearly or in isolation will not lead to successful educational reform.

Table 5

Hypotheses that supported the systemic curricular reform

Initiation	Education	Implementation	Confirmation	Continuation
Committed Visionary	**Coursework**	**University-School Partnership**	**Evidences of Success**	**Longevity of the Science Program**
Theory Base of Education	**Workshops and In-Services**	**Core Group of Committed Teachers**	**National and State Science Reform**	**Core Group of Committed Administrators**
	Shared-Decision Making			**Support**

Initiation

Committed Visionary

Vision and personal purpose are the “starting agenda” for any reform (Fullan 1999, p. 13). The findings from this investigation indicate that vision and personal purpose servd also as the “sustaining agenda” for reform. Jack Renner had a vision of transforming the entire educational system. His initial passion was to change secondary school science from being a product-driven discipline (where the goal was the accumulation of scientific facts) to being more of a process-driven discipline (where the objective was to develop the skills necessary to accumulate and understand the facts of science) (Carleton & Renner, 1960).

It was not until his preliminary interactions with Robert Karplus (director of the SCIS) that Renner focused his efforts toward elementary school science education. As seen in the science curriculum reform examined in this research, Renner (Renner & Wiggins, 1971) believed that the successful induction of massive change at the elementary school level should begin with the science curriculum by shifting from the existing convergent, deductive, and closed system to a divergent, inductive, open system. In other words, Renner called for an inquiry-centered elementary school science program that would maintain the integrity of the discipline of science, take into account the characteristics of the students, and allow children to achieve the purpose of education (which is to develop the ability to think) (Renner, 1967a). These components of Renner's inquiry-centered science program served to carry out his vision.

Renner (1971) described his educational purpose as the development of the intellect of the student. Curriculum reform, therefore, should be guided by a purpose, which Renner (1982) described as an "umbrella" that included all conditions, which identify why a particular research activity is undertaken, a particular course is taught, or schools exist. He further described his purpose as having a two-fold function: (a) "to improve the existing procedures for teaching science", and (b) "to establish new and verified procedures for teaching science" (p. 709). Renner's purpose of science education, therefore, was "to be concerned with the education in science of the students who populate the schools" (p. 709).

Renner committed his educational life to the fulfillment of his vision and educational purpose. The commitment that Renner demonstrated is evident in personal correspondences written by HPS district personnel on Renner's behalf:

> . . . Jack Renner served without pay as a science consultant. Largely through his efforts, our school system has benefited from many grants to provide inservice training, materials, and supplies. Dr. Renner has donated literally thousands of hours of his time in conducting workshops for teachers, supervisors and administrators, and in working with science teachers on a variety of special projects (Bud, personal communication, November 11, 1976).
>
> . . . The Hudson, Oklahoma Public Schools have enjoyed a long and profitable association with Professor Renner. He has been the prime mover in the development and implementation of science programs at the high school level in chemistry, physics, and biology that are based on the learning theory of Piaget. . . Professor Renner has [also] served our district as a consultant in the implementation of the SCIS program at the elementary level. He has conducted workshops for our teachers and assisted in the development of appropriate materials for the age groups being served (personal communication, July 1, 1985).

Mary, when asked about Renner's involvement in building the HPS science program, expressed, "Jack Renner was always very involved. If you would ask him to do anything, he would do it. If he had to cancel something that he really liked, he would do whatever the Hudson schools or classroom teacher wanted" (personal communication, May 30, 2002).

Bob, a middle school science teacher, commented on Renner's commitment, "It is extremely rare to find somebody like Jack who will spend the time working with the public school when there is no encouragement and little reward for doing it. . . . it is a long term commitment; it's not a quick payoff" (personal communication, May 23, 2002).

Renner also had a systemic influence at the elementary school level in the HPS:

> Jack Renner had a tremendous impact on Hudson Public Schools, not just in science, but in general. For one thing, [the reform] has been such an important part of the elementary school. Of course, those teachers are self-contained, so they don't quit doing [inquiry] when they go into other content areas. So, his influence is just immeasurable (Mary, personal communication, May 30, 2002).

Renner's systemic influence also pervaded the secondary school level. A former director of curriculum and instruction indicated:

> His influence went beyond science as a result of promoting his theory base and inquiry and why it was important with kids. Those of us who were in the curriculum area in the school district recognized that it was important in all the other curriculum areas also (Sue, personal communication, July 9, 2002).

Theory Base of Education

Renner (1979b) stated it is "my firm conviction that education will probably change no more in the next 33 years than it has in the last 33 years if sound theory is not used to guide it" (p. 10). The theory base of education that guided Renner's educational endeavors evolved concurrently with the curriculum reform in the HPS. As previously indicated, the primary elements of this theory base of education included the structure of science, the central purpose of education, the development of the learner, and the mental functioning model. The learning cycle was advocated as the teaching procedure that allowed for the inclusion of each theory base component. The learning cycle also served as the curriculum development model, which was incorporated throughout the district science program, specifically at the secondary school level.

Education

Coursework

Renner's initial mechanism for sharing his vision and purpose (theory base) was through science education courses at OU. It was in these courses that science curriculum reform began to emerge. Many HPS teachers were graduates of science education at OU or were students enrolled in science education courses pursuing their teaching credential. Several teachers who were interviewed recalled their first introduction to this theory base of education in classes taken under Renner at OU:

> He [Renner] was talking about some of this stuff [inquiry], and I thought this was the craziest stuff. . . I cannot imagine going into a classroom and doing this kind of nonsense. But, the more I thought about it, the more it started to make sense. . . I told Jack that if he could get me some of that stuff I wouldn't mind giving it a try (Mary, personal communication, May 30, 2002).
>
> I went to OU to get my teaching certificate. I didn't have a teaching philosophy at that time. After I met Jack Renner, my philosophy was shaped (Sally, personal communication, June 11, 2002).
>
> I went to OU to get my elementary school certificate, because the more I talked to [HPS] elementary teachers, the more I realized that they had much more of an

> understanding of how children learn. . . That one part of how children learn—that one part was missing (Barb, personal communication, August 16, 2002).
>
> My decision to go and study in graduate school had everything to do with wanting to continue to take courses with Jack Renner and learn from him. It had little to do with wanting a degree. It was time for an education. . . Actually taking a [Piaget] class with him is what prompted me to want to continue my education (Pete, personal communication, May 14, 2002).
>
> I wanted to get to a place [HPS] where I could implement what Jack Renner was talking about (Joe, personal communication, May 8, 2002).

In a sense, the incipient stage of curriculum reform started for many teachers as they participated in science education courses at OU. From the onset of the reform, Renner of OU and personnel of HPS began forming a theory base of education, which helped many teachers and administration operationalize the components associated with theory base.

Workshops and In-services

For those teachers who were already teaching in the district who had not received an introduction to the theory base of education in science education courses at OU, they were provided summer workshops and in-services by the district to become familiarized and educated in the theory base. Renner and science education personnel at OU facilitated many of the initial workshops and in-services. Karen, who participated in the district's first inquiry workshop recalled, "The reason why I volunteered to teach SCIS is because I saw something new in it; I wanted to learn more" (personal communication, April 29, 2002).

As the science curriculum reform progressed to the secondary level, many of the district's science teachers, who displayed a working knowledge and understanding of the theory base, assisted Renner and science education faculty in district- and state-wide workshops. Jane (district science curriculum coordinator) and Kim (former science curriculum coordinator and district administrator) directed subsequent district-wide in-services (K-12) where knowledgeable classroom teachers would lead portions of the in-service activities.

Jane provided a description of the current in-services provided at theelementary and secondary school levels:

> Currently, the district provides several different workshops, especially at the elementary school level. The teachers actually do the inservice and the principals support us pulling those teachers out of class for a day, because it is so important for them to have that hands-on information about how to teach science. It's a half-day in-service and a classroom teacher does it by grade level in their classrooms, so that teachers can see how to arrange the room, how to do the equipment. We have that first and second semester. At the secondary level, we do a district-wide new teacher in-service. It's also a release time. We go over the learning cycle and then we also have grade level teachers actually talk about their curriculum. . . I think grade level teachers are the best help, because they're the ones doing it (personal communication, May 22, 2002).

These district-sponsored staff development activities are/were much different than traditional in-services observed in other reform efforts (O'Day, Goertz, & Floden, 1995). Traditional activities were generally too short and lacked the follow-up necessary to develop the pedagogical knowledge necessary to carry out the reform. The professional development opportunities provided by the HPS continue to have a moral purpose—a theory base of education (Renner, 1982). Jane (science curriculum coordinator) succinctly summarized the influence of the theory base on the HPS science program and the professional development opportunities: "We have had really two basic premises, a theory base of how children learn and the learning cycle as a way to provide those experiences for student learning. Everything we have done is based upon those two things" (personal communication, May 22, 2002).

Shared-Decision Making

The educational atmosphere surrounding the science education courses and professional development opportunities was conducive for learning due to the structure of these opportunities where participants (classroom teachers, principals, and administrators) were treated as colleagues of Renner (and later Pete of OU and Jane of HPS) not as subordinates; and, participants were encouraged to contribute in the decision making process. This dual participation led to teacher autonomy in all science curriculum decisions (development and/or implementation). Jill, who participated in the middle school science project (MSSP) talked about her working relationship with Renner,

> The thing I remember the most about that week was how awesome Dr. Renner was and that I, as a first year teacher, was still important to him. It was just so awesome. That was just a really neat week and the start of what is still in place here after all these years (personal communication, July 15, 2002).

This collegial atmosphere proved to be the catalyst for many classroom teachers to assimilate the theory base components and to prepare them for the implementation process soon to follow. Group members were not forced to “buy-in” to the theory base but rather encouraged to experience the theory base components and take “ownership” of their understanding and their ability to implement the reform in their own classrooms. Several teachers who participated in different levels of the reform indicated:

> We were involved in it. Jack didn’t tell us about it; he allowed us to do it. . . we all became thinkers and we understood what education was; we were all missionaries of it. . . if they hadn’t modeled it, and we hadn’t lived it, then it wouldn’t be here (Sally, personal communication, June 11, 2002).
>
> They would get people together and have retreats and we would brainstorm. . . it was just great. . .I was right in my element. . . They allowed us a lot of time to talk about it (Barb, personal communication, August 16, 2002).

Bob, who participated in the MSSP indicated,

> All the middle school teachers from all three buildings were all involved in this. . . What we’re talking about here is an integrated, theory base middle school science program. . . That was at least twelve years ahead of anything that was commercially available. It was a lot of excitement, a lot of ownership, a lot of pride in the curriculum . . . it was one of the most rewarding professional activities I have ever been involved in (personal communication, May 23, 2002).

The shared-decision making component in science influenced other decisions throughout the district, such as the development of the 1972 district-wide philosophy statement and goals. Sally remembered,

> We worked on it. . .we met several times. . . and we hammered this out. . .The philosophy went to the entire Hudson faculty, and we had a series of days where

> people met in their department. . . and hammered out the purposes . . . and field goals at each level. This [philosophy statement] is the product, but it was the process. And I think that this is one of the reasons that it stayed (personal communication, June 11, 2002).

Jane commented on the importance of obtaining ownership by her teachers,

> This has been a goal of mine from the very beginning. . . we make decisions together. I bring forward the information and we work through it as a group and make our decisions. . . The teachers have to believe in what they're doing, and my role is to make sure that happens (personal communication, May 22, 2002).

When asked to describe the capacity of the district to sustain the science program, Jane responded whole heartedly,

> I think it's the group feeling that they [teachers] are important to the decisions that are being made and the ownership they have in the program. Everybody's valued. . . It's a very cooperative process. It's that ownership. They're all involved, and it's all focused on improving learning for students (personal communication, May 22, 2002).

The establishment of the HPS Elementary and Secondary Science Advisory Boards in 1982 was an innovative and effective undertaking regarding the shared-decision making process throughout the district. The science advisory boards address the district level responsibility for continuity of science curriculum, meeting the needs of science teachers, and the sites' responsibility of meeting the individual needs of students. Advisory board representatives (classroom teachers) serve as liaisons from their building site to the district advisory board, as advocates for their teacher colleagues, and as communicators of advisory board decisions to their building site. (Atkinson, 2001).

Implementation

University-School Partnership

When Mary volunteered to try out some of the inquiry materials in her classroom in the early 1960s, she informally gave Renner and the Science Education Center at OU an informal right of entry into the HPS. The HPS soon became Renner's "living laboratory" as inquiry science was being implemented throughout the district, eventually being implemented at each level, K-12. Science Education Center personnel regularly assisted HPS classroom teachers in the implementation of and the acquisition of materials for the SCIS and ESS elementary school science programs.

It was this rudimentary partnership between HPS and OU that allowed the Science Education Center at OU to become an official part of the SCIS in 1965 (personal communication, April 8, 1965). The work done by OU in the HPS was recognized by the SCIS,

> Extensive involvement with the local public schools [HPS] and a very significant effect on the teacher education program in science are outstanding aspects of the center headquartered at the University of Oklahoma. The major support of this center comes from the participating local school systems [HPS]. The work of the Oklahoma Center is integrated with an overall plan of the College of Education, which has as its purpose the familiarizing of the schools in the area with major curriculum development programs (Karplus, Searcy, Moyer, & Bolton, 1966, p. 32-33).

> Two Cooperative College-School Science projects and leadership training activities have spread the use of SCIS throughout Hudson and several other communities in Oklahoma (Karplus & White, 1969).

When the curriculum reform shifted to the secondary school level, Science Education Center personnel also assisted in the development, implementation, and confirmation of these science programs. By agreeing to be a living laboratory for those at the Science Education Center at OU, the HPS contributed to the understanding and evolution of a theory base of education across all grade levels. Although the manner of involvement has changed between these two entities, this partnership has sustained for over forty years.

Sue recalled her relationship with Renner and OU,

> Eventually a number of teachers knew he [Renner] was doing research from the University of Oklahoma and really viewed Jack as a colleague. That's how he acted. He had no airs of "I'm here as the great savior of education because I'm from the University of Oklahoma." He came in with wanting to have a real live laboratory. I heard him say on a number of occasions of how he appreciated having a real live laboratory for this work. He became a partner and I think teachers, if you can still find some of those really old teachers who worked with him, came to view him that way—that he was trying to find out what we could do in the schools to make a difference with the kind of learning kids do, and in this case in particular, in science. And so, in the truest sense of the word he was a collaborator. We weren't just cooperating with Jack where he said, "Now this is what I want you to do and I want you to cooperate with me." We collaborated as

> he said, "This is what we need to find out, now let's try to find this out together" (Sue personal communication, July 9, 2002).

Joe, the chemistry teacher who became the initiator of the inquiry chemistry program remembered this about the OU-HPS partnership,

> So, I gave him that [chemistry learning cycles] to read, and he was thrilled. He said we really need to get going on this. This is what we've been looking for. . . that's when Jack started really haunting the halls of Hudson High. From that time on, the relationship kept getting more and more full orbed, you know, in terms of developing curriculum. He got behind us with this(personal communication, May 8, 2002).

The OU-HPS partnership received national attention. The following excerpt in a letter from Bud (former superintendent) about Renner, "The results of this cooperative relationship have been gratifying. Hudson's science program has developed into a nationally recognized model" (personal communication, November 11, 1976).

Bob, a MSSP participant confirmed,

> What you had here was a unique combination of circumstances that I don't know if it is happening at any place else in the country. You had a university person and a school system who were working closely together. I've been in other university communities; I've lived in them; I've taught in them. And, usually they're seen as separate entities. Very seldom did they work together—very seldom is there this kind of collaboration than there was between OU science education and the local school system (personal communication, May 23, 2002).

From the middle 1980s to the early 1990s, the HPS and Science Education Center at OU collaborated on many summer workshops and institutes. This partnership was evident in an excerpt of a letter written to Pete (associate professor of science education) by the superintendent during that time,

> Hudson schools will be pleased to enter into a joint venture with the Science Education Center at the University of Oklahoma to conduct workshops for secondary school biology, chemistry, and physics teachers. We feel the joint effort will be mutually beneficial to both entities. . . (personal communication, July 2, 1985).

To date, the partnership between the HPS and the Science Education Center at OU provides opportunities for elementary and secondary education majors to fulfill various levels of field experiences. Elementary and secondary pre-service teachers are provided many opportunities for developing and implementing learning cycle science lessons in classrooms throughout the district. These experiences are beneficial for both the pre-service teachers at OU and the in-service teachers in the HPS (Marek, Laubach & Pedersen, 2003).

Science education faculty at OU also arrange placements for secondary school student teachers in HPS science classrooms. Student teachers are placed with HPS cooperating teachers whose teaching philosophy and practices coincide with the theory base of science education at OU. Frequently these teachers are graduates of the OU science education program or are currently graduate students in science education.

Core Group of Committed Teachers

Schlechty (1997) substantiated the importance of a core group in sustaining reform, “For change to be sustained, it is essential that a group be established that can be depended on to sustain and support a course of action intended to produce change, even in the absence of the leader who initiated the change” (p. 55). The creation of this group is one of the most important tasks of sustaining reform efforts.

At each stage of the curriculum reform there was a core group of teachers who were committed to the theory base and inquiry science teaching. Bud reflected on his understanding of the nucleus of teachers who were committed to change, “In general, particularly with his relationship with the [elementary] teachers there was really a core of committed people not only to Jack but also to his ideas” (personal communication, April 19, 2002).

Mary elaborated on the relationship that existed between the core group of teachers,

> Why did we keep working at it? . . . We would sit and talk about science and some of those programs . . . There was a nucleus of us who were interested in the science program . . . The fact that we were friends, and I don’t know, I think we had an affect on it, who knows (personal communication, May 30, 2002).

Regarding the research endeavor, Chemistry and Physics (CAPT-S), Jane commented, “There was a lot of collaboration before and after school, just a lot of ‘what did you do today’ and ‘how did that go’ and ‘that worked well’. Everyone was on board” (personal communication, May 15, 2002).

Jill commented on the core group of teachers at the middle school level,

> The main thing is that we have a few teachers still in the district from the very beginning that really believe in it and say, “this is the way to do it, period” and continue to work on it. I mean there is a core of teachers, and I think it really takes a commitment from those who have been here for the long haul, likeJane and Kim. But, it also takes new people who have gone through the OU program coming in and saying, “yes, this is what we need to do” and reminding us older people that that’s still how we need to do it (personal communication, July 15, 2002).

Curriculum reform at the secondary school level involved more of a grass roots effort when compared to the reform at the elementary school level. Teachers who were committed to the theory base and learning cycle science participated in curriculum development projects, such as the CAPT-P and CAPT-S in chemistry and physics, the biology program, the Middle School Science Project (MSSP), and the physical science program. Teachers contributed countless hours to the development, implementation, and revisions of these programs. Jill, a MSSP participant, recalled her willingness to work during the summers in making revisions to the middle school science programs,

> I think it’s important even if I didn’t get paid to do it. . . I want to be in on the decision making . . . I want to be able to help decide what we do with our kids, and even if my opinion isn’t the way it goes at least I’ve been able to voice my opinion (personal communication, July 15, 2002).

When asked to list some factors from her perception that allowed for the continuation of theory base education at the middle school level, Jill responded,

> The main thing is that we have a few teachers still in the district from the very beginning that really believe in it and say ‘this is the way to do it, period’ and continue to work on it. I mean there is a core of teachers, and I think it really takes a commitment from those who have been here for the long haul (personal communication, July 15, 2002).

To the core group of teachers in the district, this way of teaching and learning “just made sense” and they were able to operationalize the theory base and apply it in their own classrooms. To others, who did not understand the theory base, this way of teaching and learning appeared to be just another difficult tasks required of a public school teacher.

Confirmation

“Evidence is the driving force behind almost every successful change”
(Slavin, 2001, p. 26).

Evidences of Success

Teacher behavior.

Early research conducted in the HPS elementary school classrooms indicated that teacher behavior was positively influenced as a result of involvement with the SCIS when compared to not having any involvement with the SCIS. SCIS educated teachers provided a higher number of essential science experiences (Wilson, 1967) and asked significantly greater number of higher level questions in science (Schmidt, 1969; Wilson, 1967; Wilson & Renner, 1969), in social studies (Schmidt, 1969), and in reading (Porterfield, 1969). SCIS educated teachers also demonstrated more positive attitudes toward science teaching (Wallen, 1970). These initial, positive results validated the implementation, continuation, and support of the SCIS at the elementary school level.

As the chemistry and physics programs were being implemented, teachers expressed their satisfaction with the "new" way of teaching science:

> "In many ways teaching our course is more enjoyable than methods we previously used. The focus of the attention is on the student, not the teacher, which frees the teacher to spend more time interacting with students, asking questions, suggesting alternative methods of solving experimental problems, finding out what the students are like, particularly at what level they think, and stimulating their thinking" (in Renner & Fix, 1979, p. 739).

In a newspaper clipping titled "Students, teachers and parents praise new science" (Murphy, 1985), the middle school teachers expressed similar sentiments when they implemented their new science curriculum:

> "It's great. . .There a few bugs in the program and we're working harder than ever, but the kids love it and they are learning. . . It is exciting and fun to be part of a group of teachers involved in the creative end of curriculum development. . . I'm working harder than ever, but it's by far the best way to teach science. . ."

Joe discussed his emotional connectedness to the chemistry and physics program, "You could be happy being a teacher, because you're really working at something. You're working hard at it, and you're seeing the results of your work. It sells itself" (personal communication, May 8, 2002).

More recentstudies of teacher behavior (Cavallo & Laubach, 2001; Marek & Cavallo, 1995; Marek, Eubanks, & Gallaher, 1990; Marek, Haack, & McWhirter, 1990; Marek & Methven, 1991; Reap, 2000) indicate that HPS elementary and secondary classroom teachers have varying degrees of theory-base understandings, thus resulting in a wide range of learning cycle implementation throughout the district. In spite of the varying levels of implementation, many teachers experience enjoyment and satisfaction when teaching science using an inquiry approach that is steeped in a theory base of education.

Student achievement.

At the elementary school level, early research indicated that student achievement was also positively effected by the SCIS. SCIS experiences improved conservation skills (Stafford, 1969; Stafford & Renner, 1971); reading readiness (Kellogg, 1972; in Renner, Stafford, Weber, Coffia, & Kellogg, 1972); process skills development (Brown, 1973; in Brown, Weber, & Renner, 1971; Weber, 1971; in Weber & Renner, 1972); achievement in reading, mathematics, and social studies (Coffia, 1971); and creative thinking ability (Brown, 1973; in Brown, Weber, & Renner, 1975).

Modeling similar research that was conducted at the secondary school level, Renner and a cohort of HPS elementary school teachers examined the intellectual development (preoperational to concrete operational) of 252 HPS elementary school students" (Renner, Brock, Heath, Laughlin, & Stevens, 1971). Classroom teachers found that all children do not become concrete operational thinkers on all tasks at the same time. The findings of this research prompted the classroom teachers to reevaluate the concepts and tasks inherent across all subject areas that require the facility of conservation reasoning. The teachers' sentiments are best reflected by a quote taken from this article, "Studying when children conserve can influence one's expectations in the classroom; it influenced ours" (p. 26).

As noted in chapter 2, inquiry science programs were increasingly being implemented across all grade levels in many classrooms throughout the nation during the 1970s. In 1973, the National Assessment of Educational Progress (NAEP) evaluated the science knowledge of pre-college students. The 1973 NAEP results were inferior when compared to the results obtained in 1970 (in Renner & Coulter, 1976). However, in the fall of 1974, the grade level means attained on the California Tests of Basic Skills (CTBS) by HPS students in grades 3-9 were found to be above the expected chronological means of all students for all subjects (science, reading, mathematics, language, social studies, and reference skills). Achievement in science was among those subjects on which the students scored the highest or was the highest score they obtained (Renner & Coulter, 1976). Inquiry science teaching also increased cognitive development, content achievement, inquiry skills achievement, and intelligence quotient (Marek and Renner, 1979). It was reported in January of 1978 that students in grades two, four, six, eight, and ten outscored national norms in every category of the widely used CTBS (Hudson students score high on tests, 1978). Farthest ahead of national norms was the eighth grade score for science, 10.8 up from 10.3. These findings further substantiated the implementation of inquiry science programs in the HPS.

The middle to late 1970s marked a period of education when the attitudes of high school students across the nation were declining. However, enrollments in HPS chemistry and physics courses significantly increased, mean scores on the science subtest of the American College Training Program (ACT) drastically improved, and student attitudes toward scientific inquiry greatly improved (Renner & Fix, 1979; Renner & Nickel, 1979).

The evidence became clear that theory base science programs were an effective approach in the HPS.

Beginning in 1995, the state of Oklahoma began testing fifth, eighth, and eleventh grade students using curriculum Criterion-Referenced Tests (CRT) designed to measure student academic skills in Oklahoma's core curriculum, Priority Academic Student Skills (PASS). The eleventh grade CRT was removed from the state testing program in 1999. In six years of testing, HPS students have steadily improved. On average, 90% of fifth grades students scored satisfactorily on the CRT; 85% of all eighth grade students scored satisfactorily; and 77% of all eleventh grade students scored satisfactorily between 1995-1999 (Atkinson, 2001). Achievement on the Academic College Test (ACT) has also been favorable over the past few years. From 1995-2000, means on the science subtest have increased while HPS students score above the state and national averages (Atkinson, 2001). In 2002, HPS students had the second highest ACT scores in the state of Oklahoma (Griffin, 2002).

National and State Science Reform

Curriculum reform in HPS preceded many of the current national and state science education reform initiatives that were calling for an inquiry approach of teaching science. This fact further substantiated the theory base that was being operationalized throughout the district. Kim recalls the national mandates in the middle 1990s and the negative, national sentiment preceding these reform initiatives,

> We kind of heard about it [national call for science curriculum reform], but I didn't worry too much about it, because I knew good things were going on here. That was at the national level. . . We were seeing good things happen. I just thought that they just don't know what the whole story is. . . We've already changed (personal communication, August 1, 2002).

Jane corroborated,

> So, really they've [national and state reform documents] been very influential in what we're trying to do. When we did get the actual documents from the national standards, we looked at our articulation where we were meeting them or where we weren't and made adjustments. . . Actually it's been very supportive for the standards to come out. It said at a national level we are doing what we need to be doing (personal communication, May 15, 2002).

When asked about the HPS influence at the state level, Kim responded,

> The other thing that's important is that we've worked at the state level. If we had let the state go the way they wanted to, as they have in some of the other content areas, we'd be teaching pure content, and we couldn't have kept what we had. So, our teachers, our science people, being involved in state organizations has really helped (personal communication, August 1, 2002).

Continuation

Longevity of the Science Program

Throughout the forty year period under examination, the HPS has developed a "culture of inquiry" that has encompassed its K-12 science program and influenced other disciplines as well. As previously communicated, the science program became the leader of change throughout the district. It served as a prototype for professional and curriculum development for the district. The various successes that accompanied the implementation of the elementary and secondary school, theory-based science programs provided impetus for its continuation. Pete confirmed,

> It seems that there is so much momentum behind this. It is established. . . When you say teaching traditionally— here that means different species of inquiry for a long time . . . What are you going to replace it with? If there is something better, we would be the first ones to replace it. But, what will we be replacing it with? (personal communication, May 14, 2002).

Core Group of Committed Administrators

Over the years, there has been a core group of committed teachers at the elementary and secondary school levels that have believed in theory-based science education, as well as a core group of committed administrators who also have believed and continually provide their support of the HPS science program. Several of these committed teachers are now serving administrative roles in the district where they have taken on the role of "cheerleader" in support of the inquiry-based science program. Each of these individuals participated at various levels of the curriculum reform at various grade levels.

Bud (former HPS superintendent who advocated a district-wide inquiry philosophy) stated, ". . . I gradually became a real convert . . . I became pretty committed to it" (personal communication, April 19, 2002).

Mary (first inquiry science teacher in the district and elementary science consultant) stated with conviction,

> The people involved felt so strongly that this was what they should be doing. This was more effective than anything else we've ever done in science. I think the very fact, that those of us who did feel so strongly about, that is what sustained it" (personal communication, May 30, 2002).

Sue (former classroom teacher, assistant superintendent and superintendent) indicated that she was committed to theory-based education,

> I was the head cheerleader as the assistant superintendent for curriculum and instruction. . . I wanted all of the other curriculum directors to work like Jane worked with the science teachers . . . I was in a position to have those expectations of all those curriculum directors at that time, and they were very much open to that and they could see the progress that we were making in science (personal communication, July 9, 2002).

> Sue was repeatedly referred to as "the biggest advocate all the way through" the history of the HPS science program.

Sally (former elementary school teacher, elementary school science consultant, principal, and director of curriculum and instruction) recalled her time as principal,

> The inquiry philosophy was so engrained in all of our teaching that I cannot remember who [specifically] taught science. There was some discussion about cutting back the amount of time spent teaching science because of other demands. That was something I would never allow, because I knew it [inquiry] was good for the kids (personal communication, June 11, 2002).

Kim (former middle school teacher, curriculum coordinator, principal, and director of curriculum and instruction) remembered her role as director of curriculum and instruction in the continuation of the science program,

> I was over all of the curriculum areas and over all of the directors . . . but I probably stayed more involved with science than any other discipline. . . I made sure that science had their budget. . . I made sure that people understood that science needed to stay at the level of funding it had been to be successful (personal communication, August 1, 2002).

The primary person responsible for the continuation of the inquiry science program in HPS is Jane, the district science curriculum coordinator. Jane contributed 19 years of service in the role of curriculum coordinator. Of those teachers and administrators who were interviewed and who were working in the district since 1982, each interviewee indicated that Jane made a significant contribution and impact on the HPS science program. Early in Jane's coordinator career, she felt strongly about collecting input from the science teachers throughout the district:

> This has been a goal of mine from the very beginning. That's my leadership style—to build that 'buy-in' . . . We make decisions together. I could put out from this office a lot of things, but if they [teachers] don't have buy-in, it wouldn't happen. . . The teachers have to believe in what they're doing, and my role is to make sure that happens (personal communication, May 15, 2002).

When asked to describe the capacity of the district to sustain the science program, Jane replied,

> We have an overall commitment to continued learning, continued improvement, continued staff development across the district not just in science. That helps support science. Then within science . . . I think it's the group feeling that they are important to the decisions that are being made and the ownership they have in the program. Everybody's valued . . . It's a very cooperative process (personal communication, May 22, 2002).

Barb (former middle school teacher and current elementary school teacher) credits Jane for the continuation of inquiry science at the elementary school level,

> Jane was the one who kept it [inquiry science] steady . . . she kept it alive . . . she kept it here. We had the research and the experiences to show that it was the right thing to be doing. Jane spent time organizing materials, getting materials out to us, making sure we had the training we needed, organizing curriculum documents, and going to the state (personal communication, August 16, 2002).

Jane commented on the residing factors, which she believed have supported the longevity of the science program,

> This role [district science curriculum coordinator] has been very instrumental [in the continuation of the science program]. There's no doubt about it. But, I think if I hadn't involved the teacher I wouldn't have been able to do it. I mean the teachers are what makes it work (personal communication, May 22, 2002).

Support

Anson and Fox (1995), senior research analysts to the U.S. Department of Education, stressed that, “Reforms will take hold and be sustained only if innovators explicitly build the support necessary to ensure that the reforms will work in their particular settings” (p. 18). Sustaining the aforementioned science curriculum reform requires unyielding philosophical, financial, and emotional support from all stakeholders. Stakeholders are defined as those involved with the reform either directly, such as administrators, board of education members, classroom teachers, and students; and indirectly, such as parents and other members of the community. Although each stakeholder will not be able to provide equivalent support in all three areas, the combined support, or in other words, the “ownership” is necessary for the continuation of any successful reform effort.

Building level.

Many teachers and principals in the district expressed that this way of teaching and learning “just made sense” and they were able to operationalize the theory base and apply it in their own classrooms or schools, respectively. When these teachers and principals were asked why they continued to teach science, or why they continued to support science teaching according to a theory base, they simply responded that, “it works.” For those teachers and principals who did not acquire ownership of the theory base, teaching in this manner seemed to be another difficult task placed on the teacher.

In the early years at the elementary school level, no mechanisms were in place to educate the principals in the theory base that was inherent in the science program. Nonetheless, many principals were receptive and supportive of the innovative science program. Mary recalled her principal's reaction to this innovative way of teaching science,

> He [principal] had no idea of what I was trying to do, but he let me do it. . . He would come in and see all this interesting stuff, but he didn't know what I was trying to do. He had no notion about the goals or what we were working toward; but, he didn't try to stop me (personal communication, May 30, 2002).

Sally (served 19 years as elementary principal in the district) reminisced those initial meetings (mid 1970s) where principals would met to discuss elementary-wide curricular programs,

> It was a moot question in regard to science in my mind, because we were always going to use the SCIS. That was not up for debate. . . In our school, I knew I needed to support those teachers or otherwise they would get out of it (personal communication, June 11, 2002).

Before the re-establishment of a district-wide science coordinator in 1982, most, if not all, elementary and secondary school principals were in favor of inquiry science education. Interview participants indicated that they received overwhelming support (philosophical and financial) from their principals at each level of curriculum reform:

> I don't remember anybody [principals] saying that we should not be doing this [inquiry] because this is not good education (Sally, personal communication, June 11, 2002).

> The principals could not have been more supportive, could not have been better models, and could not have been better professionals. Supportive is not an accurate enough term (Pete, personal communication, May 14, 2002).

> My principal from the very beginning essentially gave me carte blanche to do whatever I wanted to do [inquiry] (Joe, personal communication, May 8, 2002).
>
> My principal encourages other teachers to look what science is doing and see if they can do that in other areas (Jill, personal communication, July 15, 2002).

When Jane became the district science coordinator one of her primary objectives was educating the principals of the theory base that was influencing science instruction and learning at all levels. In-service opportunities continue to be provided where principals experience the theory base by participating in learning cycle lessons. It has been learned over the years that principals who are educated in the theory base better understand the need for their philosophical, financial, and emotional support of their teachers who teach inquiry science.

District level.

Philosophical.

A visionary and a core group of teachers to carry out the vision are essential components to the initiation of any successful reform. However, securing thesupportof the superintendent and other district administrators is vital from the initiation level of the reform through the continuation level. The HPS was fortunate to have in place during the incipient stage of reform a superintendent who was willing to support a theory base of education. Bud commented on his initial struggles at the onset of the reform, “Jack and I spent a lot of hours arguing the pros and cons of it, until he finally got through to me. It just made sense to begin with. . . . I gradually became a real convert. I became committed to it.” Bud continued,

> I became committed to it [theory base] that it needed to be a system-wide approach. From that point on, you identify personnel within your system or people which you might employ to fill vacancies as they occur who themselves will be amenable to workshops and educational experiences to implement the program system-wide (personal communication, April 19, 2002).

Mary recalled the support she received from Bud throughout the early years of the elementary science program,

> Bud gave me support. Bud understood. Bud gave us all kinds of support and like I say, we would never have been able to do it if it wasn't for Bud. Without Bud, this would never have happened. Often the inquiry program ended when a particular teacher who believed in this left the classroom. As long as we had Bud—he tried very hard to hire teachers who would continue what we were doing (personal communication, May 30, 2002).

Bud spoke of how the reform transitioned from the elementary school level to the secondary level,

> It was a natural progression. There was an acceptance of it. It was just a natural thing. If this philosophy of teaching is working, then why can't it keep working well throughout [the district]? One of the things I kept trying to implement in Hudson is that we are called a system. So, there should be elements that are systematic. We can't go off in different ways (personal communication, May 30, 2002).

Two influential events have verified the district's philosophical support of inquiry science throughout the forty year process of reform. These events were the development of the district-wide statement of [inquiry] philospphy and the establishment of the district science curriculum coordinator position. An excerpt of the 1972 philosophy statement indicated that the district shall provide "an environment in which content is the vehicle, inquiry is the process, and self-actulization is the goal" (Hudson Public Schools, 1975). Although the rhetoric may have changed since its thirty year inception, the role of inquiry in the classroom has not. The district continues to support an educational environment in which a theory base of education is operationalized and institutionalized in its elementary and secondary school science classrooms.

The other event that has had a significant impact on the K-12 science program was the establishment of the district science curriculum coordinator position. This position has evolved from the beginning of its formation in 1972. The first position was established for the implementation of the elementary school science program and was terminated after the 1975-1976 school year. A district-wide science coordinator position was formed for the 1977-1978 school year and ended the following year when the coordinator took a position out of state. In 1982, the position was re-established and has maintained one director throughout a 20 year period with the exception of one year.

Financial.

The earliest evidence of district-level financial support for inquiry science occurred when the HPS school board in 1965 paid for half the tuition for its elementary teachers to attend an inquiry-workshop provided by OU. As the SCIS and other inquiry science programs were initially implemented at the elementary school level, the district committed itself to in-service education and purchase of all needed materials (Renner & Coulter, 1976).

Each elementary school's site-budget was responsible for procuring science equipment and supplies prior to the 1983-1984 school year. Many of the materials and equipment were purchased with monies attached to particular grants directed by Renner at OU. During the early years at the elementary school level, the SCIS and the ESS provided the materials to implement their programs on a trial basis. During the 1983-1984 school year, the district began supporting elementary school sites with equipment purchases.

The first evidence of district support at the secondary school level occurred when the middle school implemented the MSSP in 1985. District support at the high school began during the 1989-1990 school year. The current district budgetsupports science teacher salaries, equipment and supplies, student copies of curriculum materials, textbooks and related resources, and substitutes and stipends for staff development. The site-level budgets are established by the school administrator and staff and are used for general supplies, textbooks, curriculum resources, and support materials (Atkinson, 2001).

Sue (former superintendent who was an advocate of the HPS science program) stressed the importance of district financial support,

> From my experience in the school district . . . what happens when you no longer have Central Office support both philosophically and financially it [science program] eventually would have enough attrition that you would lose what you had. It took all these years—almost 40 years—and yet just by decisions to take

> science off the bond issues . . . we're back to teaching biology out of a textbook. It' so hard to get something good in place and it can be dismantled in a short time . . . Every time there was pressure to do away with the curriculum directors in a budget shortfall I would get in a board meeting and I would say, "Yes we could have a school without this curriculum work;people are having it all over the country, but you're not going to get out of it what people expect in Hudson." This has to be someone's job; it does not happen in a vacuum (personal communication, July 9, 2002).

Several former and current teachers communicated the importance of district support in sustaining the science program:

> If the district hadn't continued to order the materials, and make it easy to use those things, it wouldn't happen. I think that is one of the big things (Sally, personal communication, June 11, 2002).
>
> You had a central administration that was willing to fund this. As far as financial support, it would be hard to ask for better financial support for materials and equipment than we've had in Hudson for science. I can't think of any major problems or roadblocks (Bob, personal communication, May 23, 2002).
>
> Equipping the lab is a priority and the district continues to fund and support lab/inquiry based science. The district needed an inventory of what it would take to stock two new science lab/classrooms [in 1997]. Some rooms required at least $40,000 to stock. . . It's a commitment and I don't see that changing (Todd, personal communication, May 14, 2002).

Emotional.

One of the most neglected dimensions of educational change is the emotional one. The more unpredictable passionate aspects of learning, teaching, and leading, however, are usually left out of the change picture . . . Emotions are at the heart of teaching (Hargreaves, 1998, p. 558). Mary tearfully recalled her involvement as the elementary science consultant in the development of the district-wide philosophy statement, “I could almost cry over that. You don’t have any idea how many hours we spent working on that” (personal communication, May 30, 2002).

Even being interviewed after forty years from the embryonic stage of implementation, Mary recalled,

> Well, the people involved felt so strongly that this was what they should be doing. That this was more effective than anything else we’ve ever done in science. I think the very fact, that those of us who did feel so strongly about it, that is what sustained it. That’s about all I could say for it, because I still get kind of goose bumpy when I think about some of the teachers who were exposed to this kind of science, and just thought it was so wonderful. It was something that they were never going to give up, and to know they had that feeling, and to know that we helped trigger that, like I say I can still get kind of goose bumpy over it (personal communication, May 30, 2002).

Similar emotions are shared by many current teachers and administrators regarding the continuation of the HPS science program. There is a direct relationship involving the shared-decision making processes and the level of ownership of the HPS science curriculum. Seeing the fruits (successes) of their labor (curriculum development, implementation, and/or revision) sustains the passion for many HPS science teachers and administrators.

Community level.

Bud commented on the advantage of a school district being located in a supportive community,

> When I came to Hudson this was the only system in Oklahoma that I would have been interested in moving in as superintendent of schools. It is primarily because of the university environment here. That is the primary reason there's enough people, not just particularly connected with the university, but here because of the university that truly offsets many of the problems that you would have in some school systems in implementing those kinds of changes (personal communication, April 19, 2002).

In the beginning at each level of curriculum reform, community members (primarily parents) questioned the theory-based teaching approach implemented in science—the learning cycle. Many parents questioned the role of the textbook in the science curriculum. The textbook is used a secondary resource while the laboratory investigation is the primary resource (Concept popular, 1977; Marek, 1988). Classroom teachers encouraged and continue to encourage parents to attend class investigations so parents can experience the significance of learning science through inquiry (Todd, personal communication, May 14, 2002). Once parents are educated of the reasons why their children experience science in a manner that is in accordance with a theory base, most parents support the district's decision of implementing this science teaching approach. For example,

> I know that [one of our middle schools] has had some parent nights where they've had parents come in and go through some of the activities with their children, and the parents have gone away believers. Once they understand what this is about, parents realize that students are not just "playing with stuff," but that the program is rigorous science (Bob, personal communication, May 23, 2002).

Bob recalled many parent/teacher conferences when parents would say,

> 'Oh, my kid comes home talking about science all the time. They just enjoy what you've been doing so much. What are you going to be doing the next nine weeks?' I could sit all day and listen to that (personal communication, May 23, 2002).

Another testament of community espousal is the continual passage of school bond issues that support the financing of science equipment and materials. Public records (as of 2001-02) indicate that the city of Hudson has never failed a school bond issue. Bond funds have provided equipment and technology needs for all elementary and secondary school science classrooms.

Conclusions

The primary question of this research was how has a school district been able to sustain and continue a curriculum reform effort (a theory-based program of inquiry science) for more than forty years. As previously addressed, many innovations in schools and classrooms frequently encounter problems after adoption and often terminate within the first two years without achieving full implementation (Gold, 1999). The research findings in this studyare significant due to the duration (forty years) of the science curriculum reform effort. The findings suggest that the systemic curricular reform process of initiation, education, implementation, confirmation, and continuation is extremely complex but can be achieved.

Even though I attempted to delineate the reform process, it should be understood that many of the aforementioned factors or hypotheses were not solely accomplished in isolation but rather recurred throughout the reform process. By addressing the primary research question of this study, I discovered that many similar factors associated with the primary research question also influenced the secondary research question, which was how has the science curriculum reform effort been able to affect district- and state-wide curriculum reform initiatives.

What began as one teacher who agreed to teach a SCIS unit in her elementary school classroom in the spring of 1963 has led to a district-wide, inquiry-based science program steeped in theory-based education. Throughout the duration of the curriculum reform, the HPS and Science Education Center at OU developed an action theory and an educational theory beginning at the initiation level and persevering to the continuation level. The educational theory (or “theory base”) has guided the action theory at the district and school levels. The participants of the reform under investigation, specifically teachers of science (elementary, middle, and high school) and science curriculum coordinators, institutionalized the theory base and built it into the normal structures and practices of schooling. Evidence of this is seen in the district's capacity to develop and implement science curriculum.

The history of participation of the HPS teachers and administrators in curriculum development and implementation is wide and deep. The school system's participation in science education research is just as wide and deep. The underlying component, or grounded theory generated by the study, that ties these experiences together is the "theory base" that evolved in the HPS classrooms and science education classrooms at OU. I attribute the district's success in sustaining systemic curriculum reform to the development and continued implementation of its theory-based science program.

Unlike many organizations that label a change initiative as a reform, the curriculum change process (or theory base) in the HPS was somewhat different from other reform initiatives. Participants confirmed:

> I didn't feel like it was a reform. It was just another way of doing something. As far as I was concerned, a more effective way of doing something (Mary, personal communication, May 30, 2002).
>
> I did not seem like a reform to me. When this [theory base] started happening it was my first year of teaching. So, to me it was just my career, or just the way it was. I didn't go from teaching just rote learning. I knew our district was inquiry-based, so I didn't have to make a change. . . I think that's what it is all about. I

> don’t think it’s just about teaching science. I think it’s a tenant of living that’s very strong (Kim, personal communication, June 11, 2002).

> I had a nice understanding of how science worked, and I had the background knowledge, but I didn’t have the basic understanding of how children learn . . . Based upon my experience at that time, I was seeing things like this was true . . . I think this is right and I think this is the way we need[ed] to go. . .There was a culture of change already in the group . . .They gave us time to really talk about it (Barb, personal communication, August 16, 2002).

> I was really sold on it. Working with Jack gave me the “why” it worked . . . I think I was headed in that direction, but the learning cycle and the theory base and the research defined it for me . . . We had an activity- based program at the middle school when we wrote the learning cycles, but it wasn’t a learning cycle program, and it wasn’t developmentally appropriate. The same thing occurred in biology. So, even though we had a laboratory program approach, it wasn’t what we knew we needed (Jane, personal communication, May 15, 2002).

> I knew that students needed to be involved and engaged, but I didn’t really have a set process for how that needed to happen . . . We knew what it was, but we didn’t know what it was called or why it was called that. Jack gave us the “why” and the “how” to really put it into place . . . I really didn’t view this as a reform. I just thought it was about doing what was right for kids (Kim, personal communication, August 1, 2002).

> The HPS stated philosophy just put the words to the ideas of what I thought schooling should be about. So, that was a good fit for me (Pete, personal communication, May 14, 2002).

Whether initiating or continuing a reform effort, administrators should guide their thinking systemically (Anderson, 1995). If reform is to be addressed systemically, then "...actions based on knowledge of the change process must be systemic, too" (Fullan & Miles, 1992, p. 749). As seen in the science curriculum reform under investigation, a coordination of efforts between classroom teachers, students, parents, principals, curriculum coordinators, other district administrators, and university faculty led to the sustaining efforts of this reform.

Another issue when contemplating the initiation or the continuation of a reform is the supporting structure. Fullan (1999) cautioned a hierarchical approach to initiating, implementing, and continuing reform, "Neither top-down nor bottom-up strategies by themselves can achieve coherence—the top is too distant and the bottom is overwhelmed" (p. 27). Furthermore, "Top down strategies cause grief but no relief. Bottom-up approaches produce the odd spurt but eventually drown in a sea of inertia" (p. 29). What occurred in the HPS was a mutual collaboration toward reform made by members from the bottom up and those from the top down. Integral to the success of the systemic reform was the emphasis on shared-decision making from all parties involved in the reform. Shared decision-making is at the heart of the success of the HPS. Professional development opportunities, where the theory base was experienced and discussed, were continuous throughout the reform process and was embedded in teaching practices. This shared-decision making process yielded an ownership unparalleled to any other systemic, curriculum reform initiatives. Regarding ownership within a reform, Fullan (1992) stated, “Ownership is stronger in the middle of a successful change process than at the beginning and stronger still at the end” (p. 749). This strength of ownership contributes to the sustaining power of the HPS theory base science curriculum programs.

Science curriculum reform in the HPS began at the elementary school level where teachers and administrators operationalized the philosophical underpinnings inherent in the SCIS and took ownership of the theory base that was driving the reform. A more grass roots effort of curriculum reform occurred at the secondary school level where classroom teachers, while collaborating with faculty from the Science Education Center at OU, institutionalized the theory base by developing learning cycle science programs in their respective sub-disciplines of science. The findings of this research indicate that the HPS science program has had two basic guiding principles: (a) a theory base of how children learn and (b) a teaching and curriculum development approach that closely adheres to the theory base. “Everything that we have done is based on those two things” (Jane, personal communication, May 15, 2002). “The limiting factor for guided, inquiry science has gone from being the curriculum to being the teacher. We have curriculum in the middle school . . . in the high school . . . we have guides or lesson plans. It works or doesn’t work depending on the [people] that’s in there doing it—depending on how much they understand the theory base” (Pete, personal communication, May 14, 2002).

Goodlad, quoted by Goldberg (2000) stated, “Reform just doesn’t work. No model of reform recommended by serious reformers has ever made it to the showroom floor” (p. 83). I disagree. The curriculum reform that has evolved for over forty years in the HPS is evidence that when a sound theory base influences curricular decision-making processes then reform can occur and be sustained. I concur with Renner (1979b), in that, ". . . education [reform] will probably change no more in the next 33 years than it has in the last 33 years if sound theory is not used to drive it" (p. 10).

"We know a great deal about individual school success; we know far less about school systems success—how large numbers of schools in the same system can improve" (Fullan, 2000, p. 583). Sarason (1995) claimed that reform has been demonstrated as isolated efforts in classrooms and even in schools but never in a school system. I believe that the research findings indicate that curriculum reform can be achieved and sustained at a system-wide level. I caution those interested in implementing these change factors in your own schools or classrooms if these factors are addressed linearly or in isolation. This approach will not lead to a successful and sustaining educational reform. Each factor must be undertaken concomitantly. Although evidence of a successful systemic curricular reform has been provided in the preceding dissertation, I would like to provide a caveat by Anderson (1996) in that, "The process by which change occurs varies greatly from one setting to another and from one time to another. Although certain generalizations apply to successful change endeavors, there is no particular set of processes (plural) to apply to ensure success" (Anderson, 1996, p. 10).

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APPENDIX

Appendix A: Informed Consent Form

Appendix B: Historical Case Study—Possible Interview Questions

Appendix C: Biographical Information of Interview Consortium

Appendix D: Timeline of the HPS Science Curriculum Reform (1962-2002)

Appendix A

Informed Consent Form

(for research being conducted under the auspices of the University of Oklahoma-Norman Campus)

I, Tim Laubach, am proposing to conduct a research study titled "A Case Study of Systemic Curricular Reform: A Forty Year History." This study is approved by the Science Education faculty in the College of Education at the University of Oklahoma. I am writing for the consent of your participation in this research study.

While working on graduate degrees in science education at the University of Oklahoma, I have had the opportunity to learn about a specific inquiry based teaching approach called the learning cycle. Although this teaching approach was a novel idea to me, I soon realized that the learning cycle had its beginnings in the late 1950s and early 1960s in an elementary school science curriculum reform effort known as the Science Curriculum Improvement Study (SCIS). A couple of years ago it came to my attention that the [redacted] Public School District adopted this program and its associated teaching approach in the early 1960s. Components of SCIS continue to be implemented in many elementary school classrooms, and the learning cycle teaching approach remains an integral component of many middle and high school science teachers' instruction. The research question driving my research is *how* was the [redacted] Public School District able to sustain this curriculum reform effort and its associated teaching approach for over 40 years.

If you are a former administrator, faculty member, or classroom teacher who participated in the adoption and initial implementation of this science program and its related teaching approach or are one who historically continued the implementation, I would appreciate the opportunity of conducting a brief interview with you. If you are a current administrator, faculty member, or classroom teacher who is involved with curricular decisions, I also would like to interview you. It is important in this kind of research that I am unobtrusive and non-interfering with what you normally do. I assure you that I will not make excessive demands. I will attempt to be sensitive to your time requirements as I plan to coordinate times for interviews around your schedule. All interviews will be audio taped, and the duration of your participation in the interview should not exceed 60 minutes. Of course, you have the right to refuse to allow any such taping without penalty or prejudice. Confidentiality of all records identifying you as a participant will be maintained during and after the completion of this study. A pseudonym will be used to help protect your identity and the identity of the school district.

I am not aware of any reasonable foreseeable risks or discomforts to you as a result of your participation in this study that are beyond those present in normal everyday life. The benefits expected from this study may be the potentiality of sharing information that could serve as a model for systemic, curricular reform.

Your participation in this study is voluntary and refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled. You may discontinue participation at any time without penalty or loss of benefits to which you are otherwise entitled. To participate, you must be 18 years of age or older.

Questions about this research can be directed to Tim Laubach at (405) 517-5744. Inquiries about rights as a research participant can be made to the Office of Human Research Participant Protection at (405) 325-8110.

I hereby agree to participate in the above-described research. I understand my participation is voluntary and that I may withdraw at any time without penalty or loss of benefits.

______________________________	______________
Signature of Participation	Date Signed

Please place a check by the appropriate statement of consent:

I consent to the audio taping of interviews ____
I do not consent to the audio taping of interviews ____

Appendix B

Historical Case Study: Possible Interview Questions

1. What years were you associated with the [redacted] Public Schools ([redacted]PS)? In what capacity(ies) did you serve?

2. Describe the [redacted]PS science program (elementary, middle school, or high school) during your tenure.

3. Did the district have a stated philosophy of science teaching? If so, please describe the philosophy.

4. Did the philosophy change while you were working in the district?

5. How were you introduced to inquiry science in the district?

6. What mechanisms were in place to assist you in the implementation of the science program?

7. Were you involved in curricular decisions? If so, in what capacity?

8. Describe any change(s) that may have occurred in the district (or specific schools) relative to the science curriculum program?

9. Were there any objections associated with the curriculum and/or its approach?

10. Did you see the [redacted]PS science curriculum development as curriculum reform?

11. Explore factors that emerged during implementation:
    a. time
    b. content vs. methodology (process)
    c. leadership
    d. motivation
    e. parental involvement
    f. district/external support

12. What was the capacity of the district, schools and teachers to carry out this reform?

13. What were the sources of support and professional development?

14. What was the district role in providing support?

15. Issues not covered? Comments? Questions?

Appendix C

Biographical Information of Interview Consortium

Participant	Years Involved	Contribution to the Curriculum Reform
Jim	1962-1974	Co-directed the Science Curriculum Improvement Study (SCIS) from 1962-1974
Mary	1962-1982	Volunteered to try the SCIS and ESS programs; became the first teacher in the southwest to use the SCIS and the ESS; taught elementary school in Hudson for 20+ years; assisted in the development of the district-wide inquiry philosophy statement; served 1 year as the first elementary school science co-consultant; served as elementary school science consultant for 3 additional years; co-authored the Learning Science Program (LSP); assisted in numerous workshops in elementary science for the Science Education Center at OU; taught the undergraduate science education course at OU for a number of years; served as a consultant to the SCIS in California and as a special leadership consultant for the Intermediate Science Curriculum Study (ISCS) in Michigan
Karen	1962-1982	Participated in the first district-supported elementary science inquiry workshop; taught elementary school in Hudson for 20+ years
Bud	1963-1976	Served as superintendent of Hudson schoolsfor 13 years; assisted in the development of the district-wide inquiry philosophy statement; strongly supported a district-wide inquiry philosophy and K-12 science program; formed a partnership with Renner and the Science Education Center at OU
Sue	1961-2000	Taught high school social studies for several years; assisted in the development of the district-wide inquiry philosophy statement; served as assistant principal for 5 years; served as district social studies consultant for 2 years; served as assistant superintendent working with curriculum and instruction for 13 years (co-developed the current district-wide long range plan for school improvement); served as superintendent for 3 years
Sally	1966-1997	Taught elementary school for 6 years; assisted in the development of the district-wide inquiry philosophy statement; served 1 year as the first elementary school science co-consultant; worked 19 years as elementary school principal; served as director of curriculum and instruction for 5 years
Barb	1969-	Taught junior high/middle school science for several years; assisted in the development of the district-wide inquiry philosophy statement; has been teaching elementary school in

		Hudson for 20+ years; participated in the Science Teaching: An Elementary Project (STEP); served on district-supported science advisory board
Jane	1970-2002	Taught secondary school science for 12 years; assisted in the development of the district-wide inquiry philosophy statement; participated in CAPT-S and other curriculum development and research projects; served as district science consultant for 19 years; founded the elementary and secondary school science advisory boards; directed the STEP; co-directed the biology, chemistry, middle school, and physical science programs; directed the coordination and articulation of the HPS K-12 science curriculum; primarily responsible for the continuation of the HPS K-12 science program
Pete	1971-	Taught secondary school science for 6 years; served as program director of the Inquiry Role Approach (IRA); served as the first district secondary school science curriculum coordinator for 1 year; concurrently served as adjunct professor at OU; assistant professor for 4 years at an out-of-state university; returned to Science Education Center at OU and worked as assistant and associate professor for 7 years; has been working as full professor for 12 years; participated in biology program development; consulted the publication of the biology, chemistry, and physics programs; directed the publication of the middle school science program; co-directed the physical science program development; co-directed numerous NSF-funded inquiry science workshops for elementary and secondary school science teachers; strong advocate for HPS inquiry science program; maintained partnership with Hudson Public Schools
Kim	1972-2002	Contributed 30 years of service to the district; taught secondary school science for 10 years; co-directed the biology program development for 2 years; served as elementary science consultant for 1.5 years; co-directed the middle school and physical science programs; served as director for several district-wide programs for 9.5 years; worked as elementary principal for 1.5 years; served as director of curriculum and instruction for 5.5 years; strong advocate for HPS inquiry science education
Joe	1972-1999	Taught high school science in Hudson for 27 years; initiated the chemistry learning cycle program; developed majority of learning cycles in the chemistry program; participated in the CAPT-P and CAPT-S research projects; co-authored the chemistry program; received national recognition for contributions to chemistry program; assisted in numerous NSF-funded inquiry science workshops

Bob	1983-2001	Served as assistant professor for five years, prior to Hudson experiences; taught middle school science in Hudson for 18 years; participated in the middle school science project; served as consultant to the Biological Sciences Curriculum Study (BSCS) in Colorado and consultant to the Full Option Science System (FOSS) at the Lawrence Hall of Science in California for two years
Jill	1984-	Has been teaching middle school science for 18 years; participated in the middle school science project; teaches the middle school learning cycle program
Fran	1988-	Has been teaching elementary school in Hudson for 14 years; teaches the SCIS and the FOSS science programs
Todd	1992-	Has been teaching secondary school sciences in Hudson for 10 years; participated in the revision and publication of the physical science program

*Names provided serve as pseudonyms.

Appendix D

Timeline of the HPS Science Curriculum Reform (1962-2002)

ELEMENTARY SCHOOL SCIENCE	
1962-1963	Inquiry science teaching began in one elementary school classroom
1962-2002	Partnership with the Science Education Center at OU
1965-Summer	Teachers participated in initial theory-based inquiry science workshop
1965-Fall	District implemented materials based upon inquiry principles in grades 1-6
1966-Summer	Teachers participated in subsequent theory-based inquiry science workshop
1966-Fall	District implemented inquiry science in all ten elementary schools
1966-Fall	A newly built elementary school became a SCIS National Pilot School
1967-Summer	Teachers participated in theory-based inquiry science workshop and developed scope and sequence for grades 1-6 science program
1973	All 12 elementary schools were using SCIS and other inquiry teaching approaches
1976	District adopted SCIS as the elementary school science curriculum program
1982-83	District adopted SCIIS and purchased materials for all elementary school sites
1982-	Elementary school teachers participated in NSF- and district-sponsored theory-based inquiry science workshops
1988-1992	District established an intensive staff development endeavor—Science Teaching: An Elementary Project (STEP)
1992-1993	Teachers implemented (field-tested) STEP curricula: SCIS
1993-1994	District adopted SCIS3 and purchased materials for all elementary school sites
1999-2000	District adopted SCIS3+ and purchased materials for all elementary school sites

Appendix D, continued

SECONDARY SCHOOL SCIENCE	
	Junior High/Middle School
1967- Summer	Teachers participated in initial inquiry science workshop
1967-Fall	Teachers implemented inquiry science curriculum in both junior high schools
1973-1974	District adopted ISCS and purchased materials for all middle school science classrooms
1985-Spring	Teachers participated in theory-based inquiry science workshop and planned learning cycle curriculum development
1985-Summer	Teachers participated in theory-based inquiry science workshop and developed middle school science learning cycle program
1985-	District continues to purchase materials for middle school science learning cycle program
1985-1986	Teachers implemented middle school science learning cycle program
1986-Summer	Teachers revised middle school science learning cycle program
1986-1987	District field tested revised middle school science learning cycle science program
1987-Summer	Teachers revised and district published middle school science learning cycle program
1987-	Teachers continue to revise middle school science learning cycle program

Appendix D, continued

	Chemistry and Physics
Late 1960s	Teachers implemented commercial inquiry science programs
1972-1973	Teachers developed theory-based inquiry chemistry and physics learning cycle curriculum
1973-1974	Teachers implemented chemistry and physics learning cycle curriculum
1976-1980	Teachers participated in Chemistry and Physics Teaching-Project (CAPT-P)
1978-1989	Teachers participated in NSF funded theory-based inquiry science workshops
1980-1982	Teachers participated in Chemistry and Physics Teaching-Study (CAPT-S)
1983-Summer	Teachers revised chemistry and physics learning cycle programs
1983-1984	District field tested new chemistry and physics learning cycle programs
1984-Summer	Teachers revised chemistry and physics learning cycle programs
1985	District published chemistry and physics learning cycle programs
1985-1996	Teachers continued to revise and district published chemistry and physics programs
1989-	District commits to purchase materials for chemistry and physics learning cycle programs
1996-	Teachers continue to revise chemistry and physics programs

Appendix D, continued

	Biology
Late 1960s	Teachers implemented commercial inquiry science programs
1972-1973	Teachers implemented commercial inquiry science program (IRA)
1981-Summer	Teachers participated in theory-based inquiry science workshop and developed biology learning cycle program
1981-Fall	Teachers implemented biology learning cycle program
1983-Summer	Teachers revised biology learning cycle program
1983-1984	District field tested revised biology learning cycle program
1984-Summer	Teachers revised biology learning cycle program
1985	District published biology learning cycle program
1985-1996	Teachers continued to revise biology learning cycle program
1989-	District commits to purchase materials for biology learning cycle program
1996	District published revised biology learning cycle program
1996-	Teachers continue to revise biology learning cycle program
	Physical Science
1986-Summer	Teachers participated in inquiry science workshop and developed physical science learning cycle curriculum
1986-1987	Teachers implemented physical science learning cycle curriculum
1987-1993	Teachers revised physical science learning cycle program
1989-	District commits to purchase materials for physical science learning cycle program
1993	District published physical science learning cycle program
1993-	Teachers continue to revise physical science learning cycle program

Appendix D, continued

DISTRICT	
1972-Fall	Developed district-wide inquiry philosophy
1983-	Supported elementary sites with equipment purchases
1985	Articulated high school science program
1985-	Supported middle school sites with equipment purchases
1989-	Supported high school sites with equipment purchases
1994-1996	Revised vertical articulation of secondary school science program to adhere to state mandates
1994-1996	Revised secondary school science curricula to adhere to state mandates
1997-2000	Aligned K-12 science curricula to adhere to state and national standards