Technology-Rich Inquiry Science in Urban Classrooms: What are the barriers to inquiry pedagogy?

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Abstract

What are the barriers to technology-rich inquiry pedagogy in urban science classrooms, and what kinds of programs and support structures allow these barriers to be overcome? Research on the pedagogical practices within urban classrooms suggests that as a result of large numbers of constraints, many urban teachers' practices emphasizes directive, controlling teaching, i.e. the "pedagogy of poverty" (Haberman, 1991) rather than the facilitation of students' ownership and control over their learning as is advocated in inquiry science. On balance, research programs that advocate standards-based or inquiry teaching pedagogies demonstrate strong learning outcomes by urban students. This study tracks classroom research on a technology-rich inquiry weather program with six urban science teachers. The teachers implement this program in coordination with a district-wide middle school science reform. Results indicate that despite many challenges of the first year of this implementation, students in all nineteen classrooms demonstrated significant content and inquiry gains. In addition, case study data comprised of twice-weekly classroom observations and interviews with the six teachers suggest support structures that were both conducive and challenging to inquiry pedagogy. Our work extends previous studies on urban science pedagogy and practices as it begins to articulate what role the technological component plays in either contributing to the challenges we experienced, or helping urban science classrooms to realize inquiry science and other positive learning values. While these data outline results after only the first year of systemic reform, we suggest that they begin to build evidence of the role of technology-rich inquiry programs for combating the "pedagogy of poverty" in urban science classrooms.

Introduction

Between fourth and eighth grade, American students' achievement and understandings of complex science decline relative to their peers internationally (Linn, Lewis, Tsuchida and Songer, 2000). For urban students, these gaps are even more pronounced such as in high poverty urban Detroit where standardized test scores are among the nation's lowest. In one approach to addressing this issue, a technology-rich, inquiry-focused science program called *Kids as Global Scientists: Weather (KGS*) (Songer, et al. 1999*)* was developed, refined, and researched with tens of thousands of students nationwide, then recently customized to the needs of thousands of students and teachers in urban Detroit Public Schools. This paper documents an examination of the patterns that occurred after the first year of this adaptation to a specific set of urban classrooms, including both successes and challenges within student achievement and factors favorable to inquiry pedagogy among nineteen middle school classes taught by six teachers in Detroit Public Schools. Our focus question included: What are the barriers to technology-rich inquiry pedagogy in urban science classrooms?

Urban Science Education

Recent research indicates that when struggling to implement reform science programs, students and teachers in urban settings face many barriers, several of which are distinct from those barriers experienced by their colleagues in suburban and rural settings. Atwater and Wiggins (1995) report that while a majority of urban African American students hold favorable attitudes towards science careers, a small percentage (25%) hold favorable attitudes towards classroom science. Barton (1998) argues that policy documents that advocate "Science for All" do not take into account the multiple realities of many participants, such as students in poverty. Barton argues that because of this discontinuity between the realities of classroom science and the lives of many science students, we should not be surprised that urban students often do not find science to be interesting or relevant to their lives.

Other researchers provide additional explanations for the challenges faced by urban science students. In his paper, *The Pedagogy of Poverty Versus Good Teaching,* Haberman (1991) argues that urban teachers have tremendous constraints on their teaching including large class sizes, inadequate prep time, lower levels of training, inadequate classroom space and outdated materials, and that often these constraints result in a “directive, controlling pedagogy” (p. 291) that he calls the pedagogy of poverty. This pedagogy is characterized by teacher-controlled activities such as: giving information, tests, directions and grades; monitoring seatwork; settling disputes; and reviewing tests and homework. This pedagogy of poverty also includes a set of beliefs, such as “teachers are in charge and responsible” that often runs counter to both the beliefs that support inquiry science, and the beliefs that motivated these individuals to become teachers in the first place. Haberman argues that the pedagogy of poverty teaching practices are so common in urban classrooms that “a teacher in an urban school of the 1990’s who did *not* engage in these basic acts as the primary means of instruction would be regarded as deviant” (p. 291).

Similarly, Teel, Debruin-Parecki and Covington (1998) observed that “one of the most important causes of African American students’ low achievement in school is inappropriate teaching strategies which make it difficult for them to reach their full potential, thus alienating them from school” (p. 480). As a result, Teel and colleagues designed a set of alternative teaching strategies based on motivation and school failure theories. Two cohorts of urban African American middle school students were followed through activities designed to promote increased responsibility, student choice and non-competitive grading, among other changes, and results demonstrated successful improvements in both attitudes and performance. In another recent study, Kahle, Meece and Scantlebury (2000) designed a program of standards-based teaching that resulted in improvements in urban African American students’ attitudes and performance in science.

In summary, a set of recent studies on urban science education indicate that the conditions common in urban science classrooms often result in pedagogical approaches which are unlikely to promote student ownership of knowledge, increased student responsibility for learning, and questioning. The national science standards (National Research Council, 1996) describe these thinking skills as essential components of scientific inquiry; a kind of scientific thinking the standards advocate as a foundational component of scientific literacy. Therefore the profile of urban classroom pedagogy presented by Haberman (1991) and others suggest that it is unlikely that most urban science students are experiencing opportunities for scientific inquiry in their classrooms, and are therefore not being allowed opportunities to develop foundational thinking skills for scientific literacy. On balance a handful of studies in urban science classrooms that implement science pedagogy more in-line with scientific inquiry such as standards-based teaching (Kahle et al, 2000) demonstrate significant gains in student attitudes and performance. The goal of this paper is to continue to explore the barriers to fostering scientific inquiry in urban science classrooms through research on the implementation of a technology-rich, inquiry-focused weather program. We worked to build on both what others know about the pedagogical approaches that foster productive and engaged scientific thinking among urban students, as well as build on our eight years of iterative research on the Kids as Global Scientists: Weather (KGS) program which has been shown to foster inquiry and rich content understandings among tens of thousands of students nationwide (Songer, 1996; Songer 1998).

Why Study Programs in Urban Settings That Embrace New Technologies?

While much recent media attention has been directed towards documenting the "digital divide", little research has been conducted to assess what accounts for the discrepancies noticed or how these patterns can be overcome. The digital divide refers to differences between "the information 'haves' and 'have nots'" –in other words the documented differences that exist in computer access and use by race, particularly in education and among K-12 students (Hoffman and Novak, 1999). While studies so far have merely documented demographic patterns, recent studies suggest that the gaps between race in computer ownership and Internet access are increasing rather than diminishing. These gaps are increasing even within a technological world where nearly 100% of public schools have access to networks and computers and practically all other major institutions, such as business and medicine, are witnessing dramatic transformations catalyzed by technological innovations.

Research on students' use of technology also reveals differences in use by school SES. A national study by Becker (2000) documents that students in low income areas often use computers for repetitive activities, whereas students in high income areas often use technology for higher-order thinking, problem solving, and other intellectually challenging activities. Similarly, teachers in low SES schools are more likely to use technology for repetitive practices, whereas teachers in high SES schools are more likely to use technology to foster creativity or problem solving (Becker and Riel, 2000). Interestingly, while Becker and Reil's (2000) data were collected under completely different circumstances from those discussed by Haberman (1991), the practices observed in the more recent Becker study suggest that the pedagogy of poverty continues to thrive, even in urban classrooms embracing new technologies.

In an address at the National Education Summit, Clinton refers to the digital divides in both access and practices when he states,

"The problem now is that the economy has changed much faster than the schools. People used to say, 'you know, the schools just aren't what they used to be.' The problem may be that too many of our schools are too much like they 'used to be,' but the world the children move out into is not at all as it used to be. …We've got the give the schools the tools they need to do the job " (Clinton, 1999).

The work described in this paper outlines one approach to educational reform that aims to provide students currently classified as digital divide "have nots" with our answer to "the tools they need to do the job"-i.e. a technologically-rich science program that encourages many dimensions of scientific inquiry including: the analysis and synthesis of data, the generation of arguments and explanations to complex science questions, and the communication of science explanations to others.

Why an Inquiry Approach to Challenge the Pedagogy of Poverty?

In our view, inquiry science is an important approach for confronting the pedagogy of poverty for several reasons. First, inquiry approaches foster the development of deep foundational knowledge in a content area (Bransford, Brown and Cocking, 2000), a depth of understanding often not possible through the directive, controlling teaching. Many current policy documents recognize the value of deep knowledge understandings in their declaration of inquiry thinking as a foundational component of scientific literacy (National Research Council, 1996). Second, inquiry thinking allows students to build on and expand their own natural problem solving abilities (Bransford et. al, 2000). This allows urban students to find greater congruence between classroom science and their own lives, an opportunity not common for many (Barton, 1998). Third, programs that foster scientific inquiry often provide more challenge learning opportunities, while also providing supports that allow such challenging learning to be realized (Bransford et al, 2000). Many classrooms experiencing the pedagogy of poverty limit students' learning potential through low expectations and uniform assignments to all students, therefore disallowing individual exploration and challenge. Fourth, inquiry programs recognize the importance of students taking more ownership for the development of their own knowledge building, as well as the value of effective guidance and modeling of the development of foundational understandings in science by teachers. In contrast, the pedagogy of poverty see teachers as "in charge" of all aspects of the learning process, therefore disallowing students to guide and learn how to foster learning within themselves. Children often come to the learning environment enthusiastic to learn, and inquiry programs can more appropriately encourage, guide and support students' learning attempts (Bransford et. al, 2000). For more information on the dimensions of inquiry advocated by the KGS program and their alignment with the national science standards, see Table 1.

Why "Inside-Out" Urban Science Reform?

Many educational researchers such as Robert Slavin (1996) believe in the importance of current reforms when he states, "never in the history of American education has the potential for fundamental reform been as great." Others are more specific about the role of technology in current reforms when they state that technology is already "ubiquitous in our living space and will become more so" and therefore we should embrace technology as the vehicle for societal transformation and a means of changing both the "what" students learn and the "how" it should be accomplished (Pea, 1998).

For the last hundred years, American educational reform has been ardently pursued towards a range of goals. Despite the ranges of: approaches (i.e. top-down mandates or bottom-up approaches), level of focus (i.e. national, state or district-level) and agent of change (i.e. intended curricula or professional development), most accounts conclude that efforts have achieved mixed results (Knapp, 1997) and gradual changes which, according to some experts, have only "added complexity" to a highly complex system (Tyack and Cuban, 1995, p. 83).

Most reform experts document that teachers are a critical link in the success or failure of educational reforms, including recent reform efforts with emerging technologies (PCAST report, 1997; Slavin, Dolan and Madden, 1996; Cuban, 1993). As is well known, many research studies document that teacher beliefs, including their beliefs about best pedagogical approaches, are critical to the success of the reform (i.e. Putnam and Borko, 2000). Taking into account the pedagogy of poverty (Haberman, 1991) with the understanding of the value of the importance of teacher beliefs encourages a focus on professional development focusing on the enacted curriculum as an essential agent of change (Cuban, 1993). Expressing this idea clearly, Tyack and Cuban (1995) argue not for top-down or bottom-up approaches to reform, but for change "from the inside out" where policies such as national standards are provided as goals to strive towards, but the focus of the reform should be on-going dialogue, iterations of enactment and reflection with and by cohorts of classroom teachers. Other current thinking in the systemic reform literature resonates with the "inside-out" approach when researchers state that large scale educational development projects which address many aspects of the school system in concert is the only means of obtaining long-term success (Vinovskis, 1997).

Our professional development with Detroit teachers follows this systemic, adaptation approach to urban educational reform through sustained relationships with urban districts and teachers. As a part of the Center for Learning and Technology in Urban Schools (LeTUS), our program was implemented as one piece of a two district, two university partnership that advocates change through the brokering of complex, technology-rich curricular programs between district insiders and university and district personnel. We chose to research the adaptation and use of the KGS program in one of these urban districts (Detroit) in part because the KGS program had already achieved a level of programmatic coherence as a result of seven previous years of implementation in schools nationwide (Songer, 1998). In addition, the LeTUS Center provided our Detroit teachers with an on-going cohort of urban teachers that were implementing the same or similar technology-rich curricular programs throughout the academic year. In our interpretation of this inside-out approach, effort should be directed towards fostering discussions in and around classrooms as the curricular program is being enacted so that each teacher can re-interpret and rework their own best means of reaching these high standards. While experienced teachers and others provide guidance for reflective enactment discussions, program support structures also provide multiple avenues for customization of curricular activities, sequence, and roles for teachers and others.

Gomez (1997) describes the work through the LeTUS Center as "leading to sustained curricular and structural innovation in challenging urban contexts" in part because of a key insight –that the local context is used to shape the innovation, and that the innovation allows such shaping even while maintaining some level of programmatic coherence. Others discuss a similar necessity of local adaptation of programmatically coherent approaches when they discuss how the school frame of reference should be utilized as an inside lens from which the innovation from the "outside" should be interpreted (Darling-Hammond, 1996). Following this thinking, the research presented in this paper is one piece of a multi-institution partnership that focuses on local adaptations of one programmatically coherent curricular program in several middle school classrooms within one large urban district. Now in its second year, the LeTUS Center has implemented five curricular programs with approximately 6% of the middle school students in this district.

Participants, Programs and Research Methods

KGS Program Participants

The KGS weather program (Songer et al, 1999) was implemented simultaneously in 258 classroom settings with approximately 240 teachers and 10,861 4th-9th grade students from 40 states. The classrooms were diverse along many criteria including setting, ethnic diversity and Internet reliability. Settings consisted of rural (33%) suburban (13%) and urban (45%) locations. Ethnic diversity consisted of 42% of classrooms with 50% or greater minority students, 20% of sites with 20-50% and 38% of sites with 19% or less minority students. By self report, Internet reliability was largely unreliable with 6.6% of sites declaring their reliability to be very reliable, 25% adequate and 37.6% as poor. Therefore unlike many other technology reform programs that target high tech classrooms in more affluent areas, a common profile of a KGS site was an urban school with largely minority students and unreliable Internet technology.

Within this large participant population, we selected six local sixth grade teachers for focused study of the implementation of the program within the urban Detroit public school district. The Detroit Public Schools (DPS) serve a population of 95% minority students of which over 70% of the students are eligible for free or reduced lunch. Students in our focus schools reflected larger district trends.

Table 2 illustrates the characteristics of schools and teachers in this study. While many of the characteristics of focus teachers learning environments were similar, variability existed on teachers' backgrounds, years of experience, and populations of students in their classrooms. Concerning type of school, five teachers taught in public neighborhood middle schools and one teacher (Acevedo) taught in a public math and science magnet middle school. Teacher backgrounds also varied, with only three teachers with university coursework that might support their own understanding of weather concepts. While Sparks holds a Master's degree in biological science, she indicated that she was not familiar with concepts in atmospheric science and had no experience teaching this content area. Also noteworthy is the high degree of teacher mobility, a factor that is often a challenge to urban school reforms. Of our focus teachers, only three have been in this district more than five years, and several teachers were looking for more lucrative teaching positions during this study. After this program year, both Brown and Sparks left their schools.

Variability also existed in the amount of instructional freedom and support structures experienced by our focus teachers. Many recent studies document the increased pressure placed on all schools, but especially urban schools, relative to the standards and testing movements. We have observed that our teachers are experiencing reduced instructional freedom over time, in part, as a result of the increased demands related to high-stakes testing and the need for increasing amounts of test preparation activities that take away from time for inquiry science or other in-depth investigations. Of our focus teachers, we observed that only Acevedo and Varney had a large degree of instructional freedom, including choices of what, how, and when to teach. On a positive note, some of our teachers were fortunate to have positive support structures that inevitably helped them implement a program for the first time. In Brown's school, teachers in language, social studies, math, science, and computer had implemented KGS the previous year and had been working as an interdisciplinary team for the entire school year. Therefore even though this was Brown's first year of at this school and first year teaching KGS, her colleagues' experience provided important insights and guidance. Unfavorable support situations included two schools where a school rule restricted computer use by any non-computer instructors (Jackson and Tam), and one school with very strong pressure from the building administration to implement new pedagogy that appeared to restrict teachers' creativity and risk-taking (Sparks). More discussion on teachers' background, students, and support structures is provided in the results section.

Inside-Out Professional Development in Detroit

The six focus teachers in this study are active members of the multi-year professional development initiative in middle school science implemented through the LeTUS Center. As mentioned previously, KGS is one of several science curricula the LeTUS Center uses to promote technology-rich scientific inquiry throughout 6th, 7th and 8th grade in all 60 Detroit middle schools. LeTUS teachers participate in Saturday and summer workshops throughout the year to explore inquiry pedagogy through the CERA framework for professional development. CERA stands for Collaborative construction of understanding, Enactment of new practices in classrooms, Reflection on practice, and Adaptation of materials and practices (Blumenfeld et al, 2000). CERA provides a consistent and continuous research environment where teachers, administrators, and researchers share and discuss inquiry-focused curricula and technological innovations. As CERA reflects professional development in a learning-focused, on-going sustained manner within school buildings, we believe it is reflective of the "inside out" approach to reform discussed earlier.

Inquiry Science Through the KGS Curricular Program

The *Kids as Global Scientists: Weather* (KGS) curriculum is an eight-week, middle school weather program designed to foster the development of rich explanations and interpretations of complex science phenomena through the development and communication of evidence and investigations of science questions. Student questions are of their own design, and are fostered over multiple activities and extended periods of time (Newman, Griffin and Cole, 1989). Actual student activities include data collection, data comparison and critique, explanation building, communication of ideas, and real-time predictions (< biblio >).

Building from foundational theories on how children learn (Bransford, Brown and Cocking, 2000), the KGS program was created through several years of challenging discussions and iterative research about how to develop programs that exemplify these learning theories as they also utilize emerging technologies in productive ways towards our learning goals. The curriculum maintains programmatic coherence through a series of "core activities" that are suggested as guidelines to follow within each of the 200 nationwide classrooms enacting the program at the same time. In addition, each classroom is encouraged to adapt the program to their own learning goals and audiences through interpretation of the core activities combined with extension activities provided at each time point. Core and extension activities are designed to occur in three sequential phases, each of which builds on the experiences in the previous phases. The KGS program culminates in students' application of their understanding of weather concepts towards the prediction and interpretation of current weather events (Songer, 1996). The software developed for this program consists of a CD-ROM and a web-based threaded discussion board. The KGS CD-ROM houses both a Director-created web browser for the retrieval and presentation of multiple representations of current weather imagery, and the presentation of archival storms for when Internet connections are unavailable or unreliable (Songer 1998). The discussion board is organized and facilitated by the research staff and volunteer scientists, and organizes students into ten different clusters for more focused and productive discussions with peers their own age and on-line scientists. Previous research results on KGS programs demonstrate that students develop rich understandings of weather concepts (Songer, 1996; 1998), greater initiation of conversations and control of their own learning (Lee and Songer, 1998) and greater time-on-task compared to more traditional middle school science units.

For this year's implementation with urban teachers, we recognized that the challenges and difficulties identified in Haberman's pedagogy of poverty (1991) might complicate the enactment of the KGS curriculum in urban settings. Therefore we worked with our urban teachers to specifically recognize the importance of high expectations, the value of students' everyday experiences and ideas, the power of modeling inquiry thinking, and the importance of sharing in the discussions with other learners nationwide through the KGS message board. We utilized the CERA professional development opportunities throughout the year to encourage and re-emphasize these ideas. While we observed many cases where these discussions appeared useful, we also recognized that, most likely, such professional development discussions would need additional time for maximum impact.

Instruments and Data Analysis

The purpose of this study was to examine patterns that were present across classroom learning environments, actual curricular enactment and student learning. This study was not intended to demonstrate the effectiveness of the KGS intervention on student learning in comparison with other interventions or traditional teaching methods. Rather we attempted to describe a larger picture of how teachers and students responded to a new technology-rich inquiry program in urban settings so as to increase our understandings about the complicated nature of curriculum enactment against the norms and practices with urban classrooms. Therefore, the primary data sources for this study were written pre and post content assessments, class observation forms, and teacher post interviews.

We chose to use both frequent classroom observations and post interviews towards understanding classroom dynamics in order to strengthen and validate our findings from either the interview (self-report) or the observations (researcher collected). In other words while we understand that teachers' self-report of practice and observed practice are sometimes inconsistent (i.e. Putnam and Borko, 2000) we believed that data that demonstrated consistency in both areas would be stronger than data from either source alone. The results in Figure 1 represent data that were consistent between data sources.

Pre and Post Content Assessments. All classes of students implementing the program in this district were given written pre and post content assessments. The assessment instrument contained a total of 14 open-ended and multiple choice items chosen because of their match to the foundational science content addressed in the program. The multiple-choice items included a sample of seven released National Assessment of Educational Progress (NAEP) items on temperature, weather measurements, weather chart interpretation, and inquiry-focused questions such as the nature of a hypothesis. The test also included four modified Michigan Education Assessment Program (MEAP) items on fronts, the relationship of pressure to weather patterns and the interpretation of weather maps. Because the focus of this paper is on trends and patterns across all nineteen classes, only analysis of the 11 multiple-choice items will be discussed in this paper. The content pre and post assessment was identical at both time points so that repeated measures anovas could be utilized to illustrate changes in student' science content. Rich case-study analyses of student learning in particular classes, including both open-ended and multiple choice analysis, are on-going and will be discussed in future papers.

Classroom Observation Forms. Following Emmer's (1986) observation forms for coding task structures in classrooms, our research team designed a classroom observation form to track the elapsed time, participants, classroom description and activities performed in classrooms. We designed this instrument in order to systematically record how the same KGS program was adapted and enacted similarly or differently along time and activity dimensions within each teacher's classroom. One or two graduate student researchers were assigned to each of the six teachers for regular observations of classroom practices and supports. Researchers were required to observe each classroom a minimum of two hours a week during at least eight weeks the program run time. The six classrooms were observed from eleven to twenty-seven 50-minute class periods each for a total of 132 observations. At the completion of each observation, a Classroom Observation Form was completed by the researcher(s). A complete copy of the observation form is available upon request from the paper authors.

Teacher Interviews. At the completion of the program detailed teacher interviews were conducted with all six focus teachers. The interviews were semi-structured (Merriam, 1998) and were adapted from previous project interviews developed in concert with current research in teacher reflection and learning (Yorker and Songer, 1999). The interviews focused on teacher motivation and expectations, challenges and successes, evaluation of student learning and motivation, a characteristic lesson, resources utilized, and a description of support systems utilized by the teacher including administrative support, peers, teachers in other locations, and project staff and scientists. On average the interviews lasted 25 minutes, although they ranged from 20-50 minutes in duration. After the program ended all interviews were transcribed in full for detailed analysis.

Data Analysis of Content Assessments. Content assessments were coded to reflect the emphasis on patterns between nineteen classes. Using only students who completed both pre and post tests, eleven content items were analyzed for each student. Repeated measure anovas were used to illustrate changes in students' science content by teacher.

Analysis of Classroom Observation Forms and Teacher Interviews. Once the program was complete, researchers adapted the qualitative analysis protocol of Chi (1997) for the analysis of the two types of qualitative data: teacher interviews and the coding of the 132 observation forms. Beginning with the coding of the observation forms, we followed Chi's (1997) eight functional steps for coding qualitative data including sampling the data, reducing the data and choosing a coding scheme which in our case was the development of categories. Once preliminary categories were determined, we coded each classroom on all school factors, and then checked and re-checked data sources for consistency. As mentioned, we used our multiple data sources to develop measures of validity. Patterns that emerged were checked for consistency with interview data and discrepant cases were discussed among the primary researcher in that classroom and other researchers until consensus was reached. In addition, three other data sources were utilized to strengthen the information and patterns emerging from primary data sources. These sources included: data from the LeTUS staff on the degree of technological readiness, message board data to document students' degree of online correspondence with other students, and records of attendance and involvement of teachers in the Teacher

Workshops. For coding each classroom on each factor, qualitative evaluations in the form of a three-point scale (i.e. low, moderate/average, high) were determined.

Results: Were Classroom Environments Supportive for Inquiry Pedagogy?

We analyzed our data to explore whether in the first year of enactment within focused urban classrooms, classroom environments were supportive or not to inquiry pedagogy. In other words, we wished to determine if our patterns were reflective of the challenges commonly experienced by urban teachers (i.e. Haberman, 1991), or do they more accurately reflect an environment that might foster inquiry learning, such as allowing greater student ownership of learning, questioning, and other dimensions of inquiry pedagogy? Our data reflect information collected by both qualitative and quantitative research methods. We combined methods in order to be able to describe both larger student outcome trends, as well as important characterizations of classroom environment factors conducive or not to inquiry learning. For each case, a team of three researchers discussed the trends observed by analysis of the observation forms, student learning data and teacher interviews resulting in the most coherent profile possible.

Quantitative Data: Student Learning Outcomes

We looked at patterns evident from statistical analysis of nineteen sixth grade classes of our six focus teachers on pre and post content assessments. Table 3 shows student scores on these items by class, and as a group. Note that all classes demonstrate statistically significant differences from pre to post assessment on the measures of both science content and science inquiry, and the group of nineteen classes also demonstrates statistically significant differences from pre to post assessments.

Qualitative Data: Case Studies of Each Classroom

Following are short narratives articulating information collected from teacher interviews and classroom observations on each of the six focus teachers and their classrooms. We present our cases in a rough order from the classrooms we considered most favorable towards inquiry pedagogy, to those most challenged.

Acevedo's Classroom and Students

As reflected in Table 3 and Figure 1, Ms. Acevedo appeared to be teaching under the most optimal teaching conditions of the six teachers we studied. At her magnet school, her students were a selected population of students with demonstrated interest in math and science. Her class size was significantly smaller than the district average. Our data demonstrated several important consistencies in her thinking with what we were observing in her classroom. First, Ms. Acevedo believed that enacting this program would be beneficial to both her own learning and the learning and motivation of her students.

A: "It sounded so exciting that I wanted to do it."
I: "What benefits did you see?"
A: "The first thing that caught my attention was that they were talking about the children being able to write and I know how much the children need to write…also the weather is a part of the 5^{th} grade [district curriculum standards]…and using technology, I thought it would be more interesting for them and for me to teach, actually."

"[the KGS program] caused the kids to have a great enthusiasm for learning…Kids were always excited…another expectation I have…is that they would gain self esteem…I think this made them feel very special and that their self-esteem was raised tremendously because um they had someone else who cared about them and they really felt good about themselves. They would smile in the halls, they was like, KGS today!!…and it helped attendance for many of them, cause they knew the days they were gonna do KGS, and it was like, I'll be there for KGS."

Our observations demonstrated that she was able to enact a majority of the activities in the program, that students were engaged in the learning activities, and that she had good access to computers, even if the reliability of the network was inconsistent. We also observed strong administrative and researchers supports, therefore allowing her to feel her work to enact this program was valued. In her interview, Ms. Acevedo articulated the importance of administrative support in her enactment of programs such as ours when she stated,

"I'm honored when I'm asked to something other than what I normally do [like the KGS program]…because it shows me that the district and those that are my superiors have confidence in me. And when they ask me, especially with a new program… they will allow me to work the program in order to get some data that will be used for the district. Well, I feel really honored that I was asked."

Not surprisingly, the students in Acevedo's classroom demonstrated very strong pre and post scores on our content and inquiry assessments, and they both showed significant gains and the highest average post score gains of any DPS classroom.

Brown's Classroom and Students

Our observations, interview data and student learning results coalesced into our belief that the opportunity to enact inquiry pedagogy was second highest within Brown's classrooms. Brown was a brand new teacher, but she was also placed within a strong interdisciplinary team, all of whose members had participated in KGS in previous years. The support structure allowed her to carry out a majority of the activities, and by both self report and statistical data, her students appeared to learn a great deal about the science concepts.

"I think the kids learned a lot about weather… I think that some of them really got some complex ideas about weather and kind of the idea being that it is this huge system with lots of different factors…I liked the forecasting activity too. I thought it was really neat that the kids could come in and..look at current weather maps and make a prediction and then come in the next day and find out if they were right or not. I think they really enjoyed that and…they learned a lot from having to incorporate..different pieces of information. So I think that was really positive."

Interview and observation data consistently demonstrated, however, that the lack of reliable Internet connections resulted in student and teacher disappointments, as poor connections challenged the frequency that the learning activities that used the sharing of artifacts, ideas and real-time prediction activities could be performed. One of the members on Brown's interdisciplinary team commented on the learning potential of these sharing activities when she stated,

"It's in programs like KGS that offer kids a chance to compose messages, talk to other kids, find out who that other kids are not that different even if you live in murder city or whatever you want to call Detroit…there is an opportunity to see that there is a use for all of this stuff you are learning in school..Last year we used the discussion boards a lot more…and the language arts teachers noted phenomenal improvement in the kids' desire to write properly..it really brings the computer in to the proper use rather than just babysitter or something like that. Kids are actually creating something."

Varney's Classroom and Students

The classroom factors in Varney's classroom reflected both supportive and non-supportive conditions for inquiry pedagogy. Varney is an ESL teacher in a bilingual school and does not have formal education in science. He also experienced two weeks of vacation interruptions and strong pressure to prepare his students for upcoming standardized tests, and these activities limited the time he had available to enact the KGS activities. Nevertheless, he was very excited about participating in our program, both for the potential learning for his students and himself.

"I did experience the unfortunate timeliness of KGS. We had two weeks off. We had a winter break…and a easter/spring break. And that was unfortunate. We had to play a lot of catch up…That was probably the biggest problem I encountered."

"I was very excited as a matter of fact..[I chose to teach KGS] knowing that since I teach ESL students my job becomes a little more complex. It requires a lot of translation and type of work that other teachers may not require. I usually have reservations about some things that I do….but at this point..my attitude is that if it is exciting for students..then I'm willing to give it a try…Personally, I learned a lot."

Table 3 demonstrates that Varney's students also learned a lot, demonstrating strong significant gains from pre to post tests. On balance, our observations demonstrated that Varney's support structures were reasonable but not extensive, and his interview articulated his need to take initiative to educate his administrators about the value of his work with programs like this one.

"Often times I'm not asked how things are going. What I do instead, especially during staff meetings I will just volunteer information to let them know what we are doing…it would behoove them to know that our students are challenged and succeeding."

Jackson's Classroom and Students

Observation and interview data on Jackson's classroom also demonstrated some positive and some challenging factors towards the implementation of inquiry pedagogy. First, Jackson only meets with his science students three days a week, therefore reducing significantly the available time for KGS inquiry. Observations revealed that Jackson's students had restrictions on the amount of time they could spend in the computer lab, therefore also limiting the available time for the learning activities that involved computers, although he had a set of older classroom computers. Network reliability, like others, was not strong in his building.

Some of the positive factors included Jackson's observations that when students did KGS activities, they helped each other more and they took more initiative outside of class time.

"Another [advantage] would be students help one another more while during the KGS program…Students also take more initiative outside of class time. I found this interesting. It involves homework completion, doing extra research via the Internet or.. writing quality is better when they use the message board. It forces them to update their grammar."

Concerning challenges faced, Jackson often found himself as the leader of such reforms in his buildings, and as a result, did not have many colleagues nearby to assist him. He states,

I: "Okay, and other teachers in your building encourage you to try new ideas?
J: No, as a matter of fact, I encourage them."

Tam's Classroom and Students

Tam's observation, interview and test scores demonstrated two classrooms that had challenging management problems, and one classroom with more favorable classroom dynamics for inquiry learning. Nevertheless, all three of Tam's classes demonstrated significant learning gains, as shown in Table 3.

In interviews, Ms. Tam articulated several positive benefits for teaching KGS including a way for students to: guide their own learning, perform better on high stakes tests, and learn technological literacy. In addition, Ms. Tam noticed interesting observations about how a shift to the inquiry learning approach in KGS benefited some of the students who were low achievers in other subjects, while it challenged the high achievers because of the differential learning approach than what they were used to.

"I think that letting them explore on the computer is the only way it can be done. You can't tell them, you know, now go here, and go there, and do this and do that. It has to be allowing them to learn for themselves."

" [My partner teacher] noted that she has had students that have done nothing all year and have done this and done well. She has had some students who ware in the "A" caliber who are used to reading and regurgitating and they found this challenging because they didn't know what was expected of them….So she found that it was a challenge for the bright students…and then she found these hard core few that I tend to ignore actually came on board and have done very well. Some of them for the first time ever perhaps are going to get a C or D…I think the kids like it [the KGS program} and therefore they are going to do more than were we to do it any other way."

Ms. Tam's challenges, however, were not slight. One of Ms. Tam's greatest struggles was that her computer lab was inadequate and seldom available. Tam's classes averaged 34 students, and the computer lab held only 17 chairs. In addition, lab access was restricted to a single key that Tam did not have access to. Her students had no computer experiences at all prior to this program. Ms. Tam discusses these challenges.

"I could handle seventeen computers and 34 kids if they could all sit down. But having seventeen chairs and 34 kids becomes a real challenge, as some of them ended up kneeling…Our kids do not have computers. They do not have computer courses."

By her own account and ours, Ms. Tam persisted despite large challenges. Her perseverance clearly had positive benefits, as it allowed her learning goals of student exploration of ideas and computer fluency to be realized.

I: "With all these challenges, what made you keep going and still want to continue to try out as many activities as you did?

T: "Because I liked, I really liked the curriculum. ..To use the technology to let them explore and find answers for themselves, that was one of my goals and I think that was something they really enjoyed.. I think [KGS] has a lot of rewards for the kids. The part I think they were missing in a regular curriculum where they are not posting their data or looking at someone else's data or seeing what's happened to the high pressure or what is happening to the sky. It brings it more into their world."

"A lot of them had never been on a computer before and I think a lot of them at the end were really good on the computer."

Sparks' Classroom and Students

The teacher that from both her account and our observations that experienced the largest challenges to inquiry pedagogy was Ms. Sparks. Ms. Sparks was the science teacher in this school, and she was partnered with Ms. Marks, the computer teacher, to teach KGS. Our observations and interviews resulted a classroom profile with many areas not favorable to inquiry pedagogy including inadequate computer lab space, inadequate time to enact the inquiry program, little administrative support, and unreliable networks. In interviews, Ms. Sparks and Ms. Marks both describe how they were not asked whether or not they wanted to participate in the program, and they did not find out they were teaching it until a week before the program began.

S: “It was not a decision of mine. I was just informed.”

I: “Did you feel you had a choice whether or not to participate?
M: No it was clear that I did not have a choice at all…it had already been decided that I was going to be in it, but no one let me know.
I: At that time did you see any benefit in participating?
M: No…I had no idea what KGS was.”

Sparks and Marks’ challenges with adequate space and feeling supported in this work continued throughout the enactment.

M: “The major challenges had nothing to do with the KGS program. ..I wrote [the principal] 3-5 different letters requesting to see her because I had concerns about the computer lab. The other side of the room was teaching a different content area than KGS and at times almost every day…I’d have to literally cup my hands and yell instructions to the students because they could not hear me.”

S: “Maybe it seemed like I lost my enthusiasm over the program, it wasn’t because of KGS or from you. It’s just that from things happening inside of the school I just wanted to finish.”
M: “I did not get any support at all. In fact even to hear something negative would’ve been at least an acknowledgement that I was teaching the program. There was nothing said negatively, nothing said positively. It was as though I was invisible. Which is zero support. I’d rather have something negative then to be just nothing.”

Interestingly, both Sparks and Marks adopted, to use their own words “an open mind” with these challenges, and came to recognize many positive benefits of the program for their students.

M: “Overall I’m very positive about the KGS program. My basic philosophy through all of teaching is that I want to make education relevant for our kids, I want to make it real for them. I think studies have shown that even our honor students live somewhat a schizophrenic life. There’s school and there’s the real world. And I’m trying to connect these two together. I saw KGS, Once I started reading about it as an opportunity to have real live data and things that the kids could understand in school related to home.”

M: ”The KGS software was very good. I liked the idea of having a weather specialist that students could talk to. They were very excited about that, about going all over the world. They wanted to get out of the United States and into other countries. The kids really enjoyed, really enjoyed more than I thought, talking back to each other.”

Discussion

This study was designed to explore the barriers to technology-rich inquiry pedagogy in urban science classrooms. While a handful of studies have researched the impact of inquiry-focused pedagogical approaches on African-American or urban science students, few studies have researched initiatives that utilize technological-rich science programs to challenge both the pedagogy of poverty and the digital divide.

We began with a discussion of what we might observe as some of the barriers to inquiry pedagogy in urban science classrooms, as identified by Haberman (1991), Barton (1998) and others. We return to this discussion, adding insights from our study to these discussions.

Were Haberman's Constraints Observed in KGS Classrooms?

Our case studies supported the ideas presented by Haberman (1991) and others that urban teachers experience tremendous constraint that challenge their ability to implement pedagogy of any kind, including inquiry pedagogy. The specific constraints we observed were:

- Inadequate space, equipment and materials (no chairs, no key-Tam; noisy room-Sparks/Marks);
- Inadequate prep time to plan and reflect on a new program (all teachers, but especially Varney, Jackson, Sparks/Marks);
- Low levels of science content or computer knowledge and training (many, particularly on content background helpful to guide the exploration of current weather events);
- Large class sizes (all but Acevedo);
- High amounts of teacher and student mobility (all);
- Limited instructional freedom and/or a lack or administrative support (Varney, Jackson, Sparks); and
- Unreliable Internet connectivity (all).

Haberman (1991) believes that a prevalence of these constraints can result in predictably difficult student behaviors and resulting teacher burnout.

“The classroom atmosphere created by constant teacher direction and student compliance seethes with passive resentment that sometimes bubbles up into overt resistance. Teachers burn out because of the emotional and physical energy that they must expend to maintain their authority every hour of every day. The pedagogy of poverty requires that teachers who begin their careers intending to be helpers, models, guides, stimulators, and caring sources of encouragement transform themselves into directive authoritarians in order to function in urban schools.” (p. 291).

While we did experience two of our six teachers leaving the district after our program, in general we would not document student behaviors or teacher burnout as realizing these high, volatile levels. We hypothesize that part of the reasons why these extremes were not realized might be attributed to several positive dimensions of the KGS experience for our teachers, many of which influenced their beliefs and practices. A characterization of positive values attributed to the KGS program enactment by the teachers is presented in the next section.

What Positive Values Did the KGS Program Provide for Students and Teachers?

Our data outline six positive values to the KGS program as outlined by teachers in our study. These included: relevance, learning benefits for all students, learning benefits for special populations of students, learning benefits for teachers, enthusiasm for learning, and developing fluency with technology.

Relevance

Barton’s (1998) work outlines how many students in poverty do not find classroom science interesting or relevant to their lives. According to our teachers, one of the strongest benefits of the KGS program was the many opportunities for students to find personal meaning and relevance in KGS classroom science. Acevedo, Brown, Marks and Tam all described the enthusiasm students experienced when they utilized Internet technologies to track live storms, share their scientific understandings and personal experiences with other students, use message board conversations to combat stereotypes, and in other ways connect the worlds of their own experience, scientific reasoning and others. We believe the program allowed students to find science relevant as a result of the open-ended nature of inquiry activities, the control students’ experienced in their own learning including asking their own questions about storms, and in providing activities and an enthusiastic audience for students' scientific ideas.

Benefits to Student Content and Inquiry Science

Another strong benefit was teachers' belief that students were learning important science content about weather systems, forecasting, data analysis, and the developing of explanations and writing skills through the on-line message board conversations. Acevedo, Brown, Varney, Jackson, Tam all described the value of these learning opportunities and the positive challenges such activities placed on students allowing many students to strive towards their full potential as compared to more traditional, less-challenging curricula. In addition, Brown, Tam, and Jackson specifically described important dimensions of inquiry learning that they experienced in their classrooms. These included the value of students' creation of their own products (Brown), finding answers for themselves (Tam), and helping each other learn (Jackson).

Learning Benefits for Special Populations of Students, including New Challenges

Varney and Tam described how the inquiry and Internet sharing dimensions of the KGS pedagogical approach provided opportunities for challenge and new learning among special groups of students. Tam described how some of their lowest achievers would earn a C or D "for the first time ever". She also describe a result common in inquiry learning programs, where the high achieving students are challenged in new ways as a result of the thinking tasks they are asked to do, rather than rote memorization or other forms of more routine learning. Varney liked adapting KGS to his bilingual classroom and the resulting learning that occurred, despite the extra demands this placed on him.

Benefits to Teacher Learning

Several teachers described how a program that tracks current science and utilized technology to foster inquiry thinking also provided challenging and important opportunities for their own learning in science and with technology. Marks was pleased that even though she did not volunteer for KGS, she gained important understandings about how to use technology as a result of the experience. Other teachers mentioning this benefit included Acevedo, Brown, Varney, and Tam.

Student Enthusiasm and Strong Self-Esteem

Acevedo described the value of having her students participate in a program that utilized new technologies and had high visibility in her school on her students' enthusiasm for learning and self-esteem. A strong motivation for her participation was her interest in helping her students to feel valued and special, in part to help provide support for the less positive factors common in their lives outside of the classroom. Similarly, Brown described the importance of her students being able to combat negative stereotypes for Detroit, such as "the Murder City" through interactions with students and scientists on-line. Jackson valued students' high interest in the program, as it facilitated extra time on homework and initiative outside class time.

Developing Greater Fluency With Technology

Many teachers discussed the value of helping their students who largely did not have access to computers either at home or in school to become fluent with technology. Because of the lack of technology access, these students could be described as information "have nots" in the digital divide, and many teachers recognized the potentially large disadvantage a lack of computer experience might present for their students in the future. Acevedo and Tam discussed the importance of their students becoming fluent in an increasingly high-tech world. Several teachers valued the role the technology played in KGS, to foster higher order thinking, student questioning, and student sharing of ideas and products, rather than for routine drill and practice activities.

On balance, our study also provides evidence that despite efforts like KGS, the digital divide persist in many urban areas. Every teacher described their frustrations with Internet reliability and the manner in which a lack of reliable access diminished the potential impact of inquiry science on their students' learning. Despite the high degree of Internet connectivity across the nation, urban areas such as Detroit still face tremendous hurdles with local Internet service providers and utility companies in obtaining reliable Internet connections to school buildings. Programs such as KGS can provide resources such as canned storms on our CD-ROMS that allow students and teachers to continue with activities even when their Internet connections are down (Songer 1998). However, we know that while we provided strong support and opportunities for students to experience higher-order thinking, our goal of combating the “meaningful use” dimension of the digital divide was often under-realized because of unreliable networks and poor resources. Technology cannot play an essential role in changing both the “what” and “how” students learn until basic issues of network reliability and support for technology are realized in urban settings.

Summary

Our study provides evidence that a systematic program for fostering inquiry including accompanying professional development activities can overcome many of the norms and practices commonly referred to as the pedagogy of poverty, including norms on how science is taught and learned, and how technology is utilized towards learning. While we realized significant learning results in every classroom, we also discovered several persistent barriers to our work, including several cases each of inadequate space and materials; inadequate time; low content knowledge among teachers; large class sizes, high student and teacher mobility, limited instructional freedom, and unreliable Internet connectivity.

Our work suggests that even the most innovative pedagogy and professional development approaches cannot overcome many of these barriers. In the classrooms where these barriers were large and numerous, our approaches showed gains, but were inevitably not realizing their full potential.

In contrast, systematic support structures such as LeTUS for working with professional development, administrators and technology, and classroom supports provided by KGS staff helped teachers and us to chip away at many of the barriers towards stronger learning outcomes. While we did not run our program in Detroit schools that were not a part of the LeTUS structure, we speculate that without the multiple avenues for support and reflection LeTUS provided, the learning outcomes and positive benefits we observed would be severely reduced.

One of the goals of this study was to try and understand what role technology played in contributing to either the challenges or the learning benefits observed. In reviewing the list of constraints observed above, only the last constraint, unreliable Internet connectivity, was a direct result of the presence of technology in our program. The other six constraints are those common in urban classrooms across the nation, and, as such, would likely be present in any curricular reform program implemented in these classrooms.

On balance, we observed six values that the KGS program added to inquiry pedagogy in these classrooms. These included: relevance, student content and inquiry learning, learning by special populations, teacher learning, enthusiasm, and fluency with technology. We speculate that each and every one of these benefits would not be present without the technology components of our program. For example, we expect that the Internet conversations and real-time weather forecasting allowed students to break down stereotypes about Detroit and provide their own views on tomorrow's weather in a focus city, therefore allowing them to find value and relevance in their studies. Student learning gains in content and inquiry would have been different without live weather maps, conversations with online scientists, and opportunities for students' own questions and forecasts. The sharing of products across the message boards contributed to special populations' motivation to explore science questions of their own design, and to practice online writing for valued audiences, including scientists. Teacher learning was facilitated through the challenge of learning about current weather events, online conversations with scientists about content issues, and teachers' abilities to find support for increasing fluency with technology. Concerning students' increased enthusiasm, we speculate that students' abilities to recognize that their ideas were important and valued, and to track current scientific events as they unfolded encouraged students to be excited about the program. Therefore when we ask what role technology played in contributing towards the learning experience, we can conclude that while technology was not able to overcome many of the classroom barriers that are most persistent such as class size, mobility, inadequate space or reduced instructional freedom, we do believe that technology was an essential component of all of the observed learning benefits discussed. We encourage the continuation of studies such as this one that explore the barriers common in urban classrooms that contribute both to the pedagogy of poverty and the digital divide, as well as the exploration of best mechanisms to challenge those barriers. We present this study as work towards an evolving discussion on the mechanisms to overcome the barriers and realize the opportunities for classroom-based, technology-rich inquiry pedagogy.

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Table 1: The KGS Curriculum and the National Science Education Standards, National Research Council (1996).

NSES Standard and Fundamental Concepts	KGS Learning Activities	Phase
Science as Inquiry **Content Standard A: All students should develop the abilities necessary to do scientific inquiry and understandings about scientific inquiry. (p. 143)**		
· Identify questions that can be answered through scientific investigations	· Exchange information and data with other sites, develop questions and predictions	All Phases
Physical Science **Content Standard B: All students should develop an understanding of transfer of energy. (p. 149)**		
· Energy is associated with many substances, including mechanical motion, and is transferred in many ways.	· Tornado in a Bottle experiment	2
Earth and Space Science **Content Standard D: All students should develop an understanding of the: (a) structure of the earth system and (b) earth in the solar system. (p. 158)**		
· Global patterns of atmospheric movement influence local weather. Oceans have a major effect on climate, because water in the oceans holds a large amount of heat.	· Compare weather data from different geographical sites and explain similarities and differences · Report currently occurring severe weather worldwide	3 Any Phase
Science in Personal and Social Perspectives **Content Standard F: All students should develop understanding about (a) natural hazards (b) risks and benefits, and (c) science and technology in society. (p. 166)**		
· Processes of the earth system cause natural hazards, events that change or destroy human and wildlife habitats, damage property, and harm or kill humans. Natural hazards include floods and storms.	· Report a current severe storm (descriptions of severe weather: floods, blizzards, storms, especially that are experienced locally)	Any Phase
History and the Nature of Science **Content Standard G: All students should develop understanding of (a) science as a human endeavor, and (b) the nature of science. (p. 170)**		
· Women and men of various social and ethnic backgrounds engage in the activities of science. Some scientists work in teams, and some work alone, but all communicate extensively with others.	· Communication with weather specialists and other students. · Students work in small groups.	All Phases

<u>Assessment Standard A</u>: Assessments must be consistent with the decisions they are designed to inform. (p. 78)		
· Assessments have explicitly stated purposes.	· see the "purpose" section of activities	All Phases
<u>Assessment Standard B</u>: Achievement and opportunity to learn science must be assessed. (p. 79)		
· Achievement data collected focus on the science content that is most important for students to learn.	· curriculum questions; weather recording forms	1, 2
<u>Assessment Standard C</u>: The technical quality of the data collected is well matched to the decisions and actions taken on the basis of their interpretation. (p. 83)		
· Students have adequate opportunity to demonstrate their achievement.	· curriculum questions, e-mail, data collection, hands-on activities, group presentations	All Phases
<u>Assessment Standard D</u>: Assessments practices must be fair. (p. 85)		
<u>Teaching Standard A</u>: Teachers of science plan an inquiry-based science program for their students. (p. 30)		
· Work together as colleagues within and across disciplines and grade levels.	· Message Board communication; Teacher listserv	All Phases
<u>Teaching Standard B</u>: Teachers of science guide and facilitate learning.		
· Focus and support inquiries while interacting with students.	· all activities	All Phases
<u>Teaching Standard C</u>: Teachers of science engage in ongoing assessment of their teaching and of student learning. (p. 37)		
· Use multiple methods and gather data about student understanding and ability.	· written messages, hands-on activities, group presentations	All Phases
<u>Teaching Standard D</u>: Teachers of science design and manage learning environments that provide students with the time, space, and resources needed for learning science. (p. 43)		
· Identify and use resources outside the school.	· Weather specialists, students from other sites, World Wide Web.	All Phases

Table 2: Teacher Characteristics, Backgrounds and Instructional Freedom (Self-Report)

	School Characteristics	Teacher Characteristics			
		Majors	Years teaching overall	Years teaching in the district	Instructional freedom
Acevedo	Magnet school	Science	25 years	10 years	High
Brown	Public	Science	1 year	1 year	Moderate, coordinated w/ the interdisciplinary team
Varney	Public	Social Studies	10 years	4 years	High, coordinated with the computer teacher
Jackson	Public	Math	31 years	31 years	Moderate
Tam	Public	Science	26 years	26 years	Low, constrained by the computer teacher
Sparks	Public	Biological science	4 years	4 years	Low, w/ the computer teacher and constrained by administrative pressure

Table 3: Class Pre and Post Assessment Results

	Acevedo	Brown	Jackson	Varney	Tam(1)	Sparks	Tam (2&3)	all
N	19	96	53	54	30	128	43	423
Pre assessment	5.95	4.09	3.34	3.96	4.67	4.52	3.37	4.17
St. deviation	2.37	1.73	1.89	1.74	1.49	1.57	1.43	1.83
Post assessment	8.05*	5.59**	5.06**	5.22**	6.40**	5.06*	3.79*	5.23**
St. deviation	1.55	1.82	2.41	2.09	2.14	1.82	1.58	2.09

***= p<.01**
****= p<.001**

Table 4: Classroom and School Factors Coding Rubric

Note: All classifications are listed as N/A when corresponding evidence was not available

Category	Sub-Category	Data Source	Criteria
Curriculum and Enactment Time Estimates	Total enactment time	Observation	+ more than 8 weeks 0 8 weeks – less than 8 weeks
	Implementation of Foundational KGS activities (total=11 activities)	Observation	+ 9-11 0 7-8 – <6
	Implementation of Foundational KGS correspondence (i.e. gross evaluation of the frequency of messages posted on the message board per class)	Message board data base	+ high- average 4 or more class sets per program 0 medium-2-3 class sets per program – 1 or fewer class sets per program
Technology	District Evaluation of Technological Readiness	LeTUS Center evaluations, 1/99	+ high degree of readiness 0 mid-level of readiness – low degree of readiness
At School Setting	Computer Access	Observation	+ < 50% observed reliability 0 ~ 50% observed reliability – > 50% observed reliability
	Technology reliability for curriculum enactment	Observation/ Interview	+ no restrictions 0 minor restrictions – major restrictions
Support	Admin. Support	Observation/ Interview	+ helpful/satisfactory support 0 not a factor – limited teacher's curriculum enactment
	Colleague Support	Observation/ Interview	+ helpful/satisfactory support 0 not a factor – limited teacher's curriculum enactment
	Researcher Support	Interview/ Classroom supporter's account	+ helpful/satisfactory support 0 not a factor – limited teacher's enactment
	Online Support (email with researcher or manager, fax, teacher listserv, teacher message board)	Records of teachers' use of communication tools	+ use more than one resource during program 0 use at least one resource – use none
	Workshop Experience (summer + 3 Saturday workshops)	Records of workshop attendance	+ participated in all 4 occasions 0 missed one – missed two or more
Student Population	Nature of student population	Observation/Interview	+ selective for academic talents 0 non-selective, mixed abilities – unusually challenging population

Figure 1: Enactment and School Factor Schematics By Teacher

Teacher	Enactment			Technology			Support						Factor Totals		
	Time	KGS Activities	Message Board Use	District Evaluation	Computer Access	Reliability	Administrative	Colleague	Researcher	On-line	Workshops	Student Population	+	0	−
Acevedo	+	+	0	+	+	−	+	0	+	0	0	+	7	4	1
Brown	0	+	+	+	0	−	+	+	+	+	−	0	7	3	2
Varney	−	−	+	+	+	0	+	0	+	0	0	0	5	5	2
Jackson	−	−	0	0	+	0	+	0	−	+	+	0	4	5	3
Tam	0	+	0	−	−	0	−	0	+	+	+	0	4	5	3
Sparks	0	0	+	−	+	0	−	−	+	0	0	0	3	6	3