Curriculum-Focused Professional Development: Addressing the Barriers to Inquiry Pedagogy in Urban Classrooms

Paper presented at the Leadership for Meaningful Technology (Project TIME)
Symposium, Augusta, MI.

Draft of April 3, 2003

Nancy Butler Songer
School of Education
The University of Michigan
Songer@umich.edu

Introduction

Teachers across the nation, particularly self-starters we call "mavericks", (Songer, Lee and McDonald, in press) continue to provide pockets of success of classroom-based meaningful learning with technology. In our work, teachers guide sixth graders' use of weather imaging software towards forecasting live storms and other meaningful uses of technology that, combined with an inquiry-focused learning environment, result in significant improvements in basic weather concepts (Lee and Songer, in press). Interestingly, these teachers not only help students understand basic weather concepts, their careful guidance of knowledge development with learning technologies also provides motivational learning opportunities in science (Mistler-Jackson and Songer, 2000). Research results associated with technology-rich learning environments like these suggest that learning technologies that are used carefully can be important tools in guiding today's students in complex reasoning in science and other content areas.

While these successes with learning technologies exist, they are not commonplace and they often cluster in resource-rich schools, serving students that are, largely speaking, not at-risk for school failure (Songer, Lee and Kam, 2002). The focus of this paper is to discuss strategies that contribute to the promotion of meaningful learning with technology, with a focus on meaningful uses where the technology is integral to the curricular program. The illustrations discussed in this paper draw from implementation in resource-poor urban classrooms that, by and large, support students at-risk for school failure. Through a discussion of what works in resource-poor urban environments, this paper also invites a discussion of better means of moving beyond pockets of success clustered in resource-rich schools towards more widespread implementation of meaningful uses of technology across a range of classrooms, teachers, and audiences.

This article begins with a description of the constraints observed towards meaningful learning technology (MLT) in the middle school classrooms of one large, high-poverty urban district, followed by a description of one professional development partnership that has been developed to address these constraints. The partnership description includes an overview of the driving ideas behind the design of the teacher workshops, curricular programs, and key players. Following the discussion of the partnership, the paper outlines several lessons learned from research and work within this partnership over the past three years.

What constraints challenge MLT in urban classrooms?

While many teachers across the nation struggle to incorporate technology into their classroom activities in meaningful ways, teachers in low income, resource-poor urban classrooms often face particularly daunting challenges. Over the past three years, our research project has focused on the promotion of meaningful learning with technology within one large, resource-poor urban school district (Songer, Lee and Kam, 2002; Songer, Lee and McDonald, in press). While we have achieved a great deal of success, one of our important findings was the identification of several constraints to meaningful learning with technology that inhibit an ability to realize successful MLT outcomes. These constraints included both technology-focused issues common in any school utilizing new technologies, as well as issues commonly experienced in any resource-poor urban classroom. Regardless of their origin, these constraints needed to be addressed prior to realizing meaningful learning with technology in our classroom settings.

The first category of constraints observed were those focusing on technological resources and experiences. In our urban classrooms, we observed very poor Internet reliability in many classrooms and buildings, as well as a high degree of teachers with little experience with technology outside of the classroom (Songer, Lee and Kam, 2002). To directly challenge these constraints, we designed our web-based learning tools to be available both on the Internet and on stand-alone CD-ROMs so that the learning activities could continue even when reliable Internet connections were not available. In addition, we provided a series of on-going summer, weekend, and after school professional development opportunities to help teachers become more comfortable with the tools in their classrooms.

A second category of constraints observed were those not related to the technology directly, but often associated with resource- poor schools in general. These constraints include inadequate space, materials and equipment; large class sizes of 35 or more students; teachers with little autonomy; teachers that felt unsupported by administrators; and a high percentage of teachers that lack a strong background in the content knowledge they teach, such as science (Songer et al, 2002). While some of these constraints were beyond our control, our research team worked hard to address issues of space, materials and equipment through loans and equipment-sharing whenever possible. We also invited school administrators to our professional development workshops to encourage greater understanding and support within teacher's own buildings. To address weak science backgrounds, we focused portions of our professional development workshops on the specific science content addressed in the curricular units so that, once again, teachers could experience learning about weather forecasts or biodiversity themselves, encouraging their ability to become more comfortable with the learning in their classroom.

While we were concerned with resources and building support in facilitating MLT in urban classrooms, current research indicates that it is easy to view resources such as materials, space and money as the limiting factors to MLT when a focus on resources provides only limited understandings of how to improve MLT on a larger scale (e.g. Songer et al, 2002; Cohen and Ball, 2001). Our work and that of others suggests that we need research and guidelines that go beyond the presence or absence of particular resources towards insights into *how* resources should be used towards meaningful learning with technology and strong learning outcomes.

Focusing on how technology is used is the third area of constraints observed in our work. Adopting a curricular and learning goal focus as a lens for examining MLT in urban classrooms, our research team consistently realizes evidence of strong student learning outcomes associated with instructional programs that integrate technology as a central learning resource (e.g. Songer et al, 2002; Songer et al, in press). An emphasis on curricula and learning goals shifts our research questions towards, What kinds of guided inquiry instruction help students in urban schools to realize strong learning goals? How much "guidance" is needed, and what roles do teachers and technology play in this guidance?

Our shift to the role of curricula in promoting meaningful uses is also supported by current research on MLT. Becker (2000) found that while computers are nearly ubiquitous in America's classrooms, how learning technologies are used varies considerably between students in low and high-income schools. While students in high-income schools often use technology for problem solving and higher-order thinking activities, students in low-income schools often use technology for more mundane, repetitive tasks. Our shift to focus our professional development around curricula is also supported by current literature. In a study of schools in California, Cuban (2001) found that while computers were present and used by many at home, less than five percent of the teachers studied used programs with technology integrated into the regular curricular activities. Collectively these results suggest that despite the presence of computers in schools, most teachers are largely not experiencing meaningful learning with technology as a part of regular classroom activities. Adopting a focus on professional development and research around curricular programs might provide important insights into meaningful uses of technology that lead to strong learning outcomes.

Why curriculum-focused professional development?

One of the early decisions made in our shift to curriculum-focused professional development as a means to achieve MLT was to select a focus population for study. The research discussed here represents our work within one urban district, one age group (middle school) and one content area (science). Even within this focus, we were faced with the implementation of meaningful learning among 33,000 students and teachers within fifty different schools.

The urban population was chosen as a focus for several reasons. First, we recognize current statistical research documenting the growing number of children enrolled in America's urban districts where larger class sizes, greater social and disciplinary problems, and smaller involvement from parents challenge teachers' abilities to foster meaningful learning through technology (Agron, 1998). Second, we recognized that urban students represent a high proportion of minority students nationwide (67%) and a high percentage of students eligible for free and reduced-price lunch (52%; U.S. Department of Education, 2000), both populations often overlooked in studies focusing on meaningful learning with technology. For our work, we focused on middle school students within the eighth largest school district in the country, the Detroit Public Schools (DPS). While we run curricular programs that are coordinated among hundreds of schools nationwide, our focus on DPS has shifted our population of participants to include a majority of diverse schools from 1999 on (see Table 1).

Table 1. Number of Diverse Schools as Participants, 1996-2000

School Population	1996	1997	1998	1999	2000
Number of schools with < 20% underrepresented minorities	17	No Data	44	38	101
Number of schools with > 20% underrepresented minorities	14	No Data	31	96	103

Over the past several years, we have come to realize that the benefits of our urban district-university partnership include 1) a focus on the science curricula as the vehicle for meaningful use of the technology as opposed to the development of content-neutral technology skills; 2) classroom activities driven by research on how children learn; and 2) ongoing, sustained relationships. Each of these is discussed below.

Science curricula as the vehicle for MLT

With DPS middle school teachers, we adopted a model of professional development that focused on curriculum as the agent of change (e.g. Songer et al, 2002; Blumenfeld et. al, 2000; Ball and Cohen, 1996). Our approach is supported by a National Science Foundation-funded partnership that includes both the Detroit Public Schools and The University of Michigan. Our partnership, titled Learning Technologies for Urban Schools (LeTUS), holds promise for impact because of the many benefits of a multi-year, district-university partnership.

In our approach, the university and district partners meet regularly to discuss, design and implement standards-based, technology-rich curricula focusing on science topics essential to that grade level and outlined by district curriculum guides. We recognized that while we held a strong interest in using technology in meaningful ways, we viewed the **learning goals, both science content and science inquiry,** as the driving force behind all professional development work in the partnership.

How did we use learning goals and standards-based curricula to foster rich professional development experiences with technology for teachers? We developed a model for professional development called CERA: Collaborative construction of understanding, Enactment of new practices in classrooms, Reflection on practice, and Adaptation of materials and practices (Blumenfeld, Fishman, Krajcik, Marx and Soloway, 2000). In this model, the central work of the professional development workshops and study groups are the collaborative construction of understandings around particular science units, including units focusing on ecology and biodiversity, weather, simple machines, water quality, or communicable diseases. All partners participate in our workshops, including teachers, researchers and school administrators. After detailed discussion and work with these curricular units, teachers and university personnel work together to implement modified or new practices in classrooms, including making sure the teachers are well supported in the implementation of the new technologies towards learning goals. After classroom practices have occurred and student outcomes are realized, teacher study groups and workshops focus on guided reflection on their practices so that improvements of both the curricular resources and the practices can occur in future iterations. In all of these activities, all partners are equal participants and all voices are equally valid. In these ways, the LeTUS model of professional development provides an environment in which teachers, administrators, and researchers dialogue and develop collaborative understandings of inquiry-focused curricula and the appropriate use of technological innovations towards learning goals.

<u>Middle school science curricula and how children learn</u>

Our work with LeTUS focuses specifically on technology-rich middle school science curricular programs. Why do we focus only on professional development within one discipline, science? This decision is grounded in the extensive research on how children learn, including how children learn best with technological tools (Bransford, Brown and Cocking, 2000). Foundational research on learning states that enduring understandings occur when learners obtain a deep foundational knowledge of concepts and facts placed within a meaningful context and organized in such a way that they can apply it to new questions in the future (Bransford et al, 2000, p. 16). In our work, this idea means that in order to provide opportunities for deep, conceptual understandings of science through and with technology, students need to spend enough time with the concepts so that they can engage with scientific questions in some depth, work with scientific data towards patterns, and build explanations from their data towards claims and scientific conclusions. Learning technologies can play essential roles in these steps, as will be illustrated with specific examples later in this paper. In each case, an essential starting place is a focus on how the technology is used to guiding learning towards central concepts, as opposed to focusing on proficiency with technology or amount of time with the tools.

Another reason to select a specific discipline and audience was to encourage research leading to clear evidence of student learning. An important LeTUS-partnership priority is to improve the number of students reaching satisfactory levels on state and national standardized tests in science. Research results for DPS from 1997-1999 indicated that while 37% of 5th grade students performed at a passing level on the state standardized test, only 13 % of 8^{th} grade students passed [www.detroit.k12.mi.us/data/2000data/testscores.htm]. To help realize stronger learning outcomes, LeTUS focused professional development activities on technology-infused curricular activities, leading to strong learning gains as hoped (e.g. Songer et al, 2002).

LeTUS stakeholders also value the goal of making science relevant to students' lives, and saw meaningful uses of technology as one vehicle to obtain relevance. DPS students are largely African American, (91%), and a majority of students tend to come from moderate to low-income households, with approximately 70% of DPS students eligible for free or reduced-price lunch. Like many urban children nationwide (e.g. see Barton, 1998), many DPS students tended to see existing science classes as irrelevant to their lives, neighborhoods, and communities. With such discontinuity, perhaps it is not surprising that a very low number of urban students hold favorable attitudes towards classroom science (25%; Atwater and Wiggins, 1995). Our previous research (e.g. Lee and Songer, in press) suggests that technological tools can be one good means for helping students to find more relevance in classroom science through carefully-scaffolded visualizations, online dialogue with scientists, and real-time data collection uses.

<u>Ongoing, Sustained Relationships</u>

Another central tenet of our approach is the establishment of ongoing relationships. The professional development workshops are not one-shot deals, but two weeks of concentrated work with science units each summer, followed by monthly Saturday workshops throughout the school year when that particular curricular unit is taught in classrooms. Teachers' work consists of ongoing dialogue about the curricular units including dialogue focusing on learning goals, pedagogy, science content, management, and technological use and support. Cohorts of teachers enacting the same curricular program are supported by several individuals, including one university researcher assigned to each teacher, peers enacting the same program at the same time who meet in small study groups on weekends, and a team of LeTUS technology support staff to person and assist in smooth implementation of network technologies, CD-ROMs, and PDA resources. Therefore, LeTUS personnel provide professional development resources in a sustained, ongoing manner. Professional development workshops and study groups foster discussions in and around classroom implementation so that each teacher can find assistance, and find means to interpret and rework the curricular program for their own audience towards the high standards we have collaboratively established. Our professional development model is also growing in its own knowledge base. After three years of work within DPS, most of our teachers have enacted our curricular programs at least two times, thereby serving as essential resources for newcomers on the curricula, pedagogy and technology. At this time, the LeTUS partnership has implemented seven science curricular units between 5-8th grades, and has worked with approximately 50% of the middle schools in the district.

In summary, we support curriculum-focused professional development as a cornerstone for meaningful learning with technology. In the LeTUS model, teachers, administrators and university researchers experience learning-focused, content-focused professional development over multiple years and multiple curricular units, all within the same schools and towards the same high goals. Our model of professional development is also consistent with current research on reform that stipulates that large-scale educational development projects that address multiple aspects of the school system in concert are necessary if the goal is long-term success (Vinovskis, 1997).

MLT Lessons Learned Through Curriculum-Focused Professional Development

Our professional development model uses curricula and technologies focused around congruent learning goals to help urban teachers challenge the constraints of meaningful learning with technology. What have we learned from three years of within the Detroit Public Schools? The next sections address this question through four lessons learned, illustrated with examples from our own classrooms.

Lesson One: Use Strong, Inquiry-Fostering Curricula Integrated with Technology

As discussed earlier, the focus of professional development workshops are enactment and reflection on the inquiry-fostering curricular units. What do these cornerstone curricular programs look like? We have designed units of six to eight weeks of inquiry-based activities that follow an activity structure known to foster enduring inquiry understandings among K-12 students (Huber, Songer and Lee, submitted; National Research Council, 2000). Our activities build rich content understandings through students' engagement in scientifically oriented questions, some of which are guided by the activities and some of students' own choosing. After questions are selected, students are guided in the exploration of this question through data gathering, data analysis, explanation building, and real world predictions. The following section illustrates general principles through examples from an ecology/biodiversity curricular unit.

Our newest unit designed for fifth graders is called BioKIDS: Kids' Inquiry of Diverse Species (Songer et al, 2000). In this standards-based unit focusing on ecology and biodiversity, students explore questions of species abundance and richness relative to the collection of animal distribution data in their own schoolyard. Students collect animal data using PDAs, small handheld computers commonly used for organizational activities such as keeping phone numbers or a daily calendar. In our case, the class set of PDAs have been loaded with a piece of software called CyberTracker [http://www.cybertracker.co.za/], an icon-based software tool developed by professional animal trackers to track the location and diversity of African animals in the field. Using a version of CyberTracker that we have rewritten to contain only Michigan-regional animals, students take on the persona of a real African animal tracker to explore the

Figure 1: Display of Detroit-Region CyberTracker Data through an Aerial Photograph of the Schoolyard

question, *What Animals Live in my Schoolyard*? To track and record the animals, the Detroit 5th graders are equipped with binoculars, collection jars, butterfly nets, field guides, magnifying glasses along with the PDA computers and the Michigan-based CyberTracker sequence. These budding zoologists find, record, and identify about 50 animals in their schoolyard in each 50-minute period. When specimen gathering is complete for the day, PDA data are downloaded to a central classroom computer through the syncing process, allowing animal data to be available for analysis and reflection in each of two possible display formats. As shown in Figure 1, students' data can be displayed on aerial photographs of the schoolyard so that students can ask questions about animal location, interdependence, and ecology.

In all our inquiry-focusing activities, the learning technologies such as CyberTracker are used exclusively to promote deep conceptual understandings of science concepts and scientific reasoning, such as building explanations from evidence. In the BioKIDS activities for example, CyberTracker is used to gather data, summarize data, and provide tangible evidence of species location and characteristics. Each of these roles are essential in supporting fifth graders' development of inquiry reasoning skills as outlined by the NRC (2000) such as "using appropriate tools and techniques to gather, analyze and interpret data", and " think critically and logically to make the relationship between evidence and explanations" (NRC, 2000; p. 19).

Lesson Two: Integrate Software through Cognitive Transformations

Complimentary to our first lesson is the careful integration of the technology, ensuring that all uses for the technology advance student understandings towards challenging learning goals. Notice that in our example of animal data collection and analysis using PDA data, the technology's role in the learning environment was towards learning goals, not towards another goal, such as an “add on” or reward after the curricular unit, nor as remedial drill and practice resource for those needing additional skills training. The PDA data collection and the analysis of students’ data are meaningful uses of technology that are embedded in the unit, and that contribute towards student understanding of the science content and the scientific thinking skills. In this unit, using technology is essential to obtain an understanding of biodiversity, explanation building, and data analysis. Similarly, the learning goals of ecology, biodiversity, and explanation building are made more meaningful and relevant to students as a result of the technology. To quote one teacher’s view of this idea,

> “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…[the technology] brings it, [the learning], more into their world.”

An essential step towards obtaining strong, inquiry-focused uses of technology is realizing that transformations were required to turn technological resources into powerful cognitive tools. The following section briefly outlines the steps we performed to transform our technological resources into powerful cognitive tools. For more information on this topic, see Songer (2002).

Our first transformation was of the digital resources themselves. Early on, we recognized the educative potential of the CyberTracker software that would allow even young children to participate in the gathering of animal data over a particular geographic region. While the potential to use CyberTracker was evident, we also recognized the need to transform the original CyberTracker sequence created for professional animal tracking in Africa into a learning resource for fifth graders focusing on tracking Michigan-based species (e.g. we did not expect to be able to find too many Kwagga, the Afrikaans word for Zebra, around Detroit). As a result, we worked with computer programmers and zoologists, especially Dr. Phil Myers of the University of Michigan’s Museum of Zoology, to rewrite the CyberTracker code into a tool that would promote fifth graders’ ability to develop comprehensive understandings of their data towards state and national science standards.

The transformation of CyberTracker consisted of us asking three basic questions: Who is our intended audience? What is our learning goal?", and What level of support of guidance is needed?" To address the question of audience and learning goal, we identified goals that were consistent with the National Science Standards (National Research Council, 1996) and the Michigan Curriculum Framework Science Benchmarks (2000). Table 2 illustrates a sample of the science content and scientific inquiry goals we identified as central to this program.

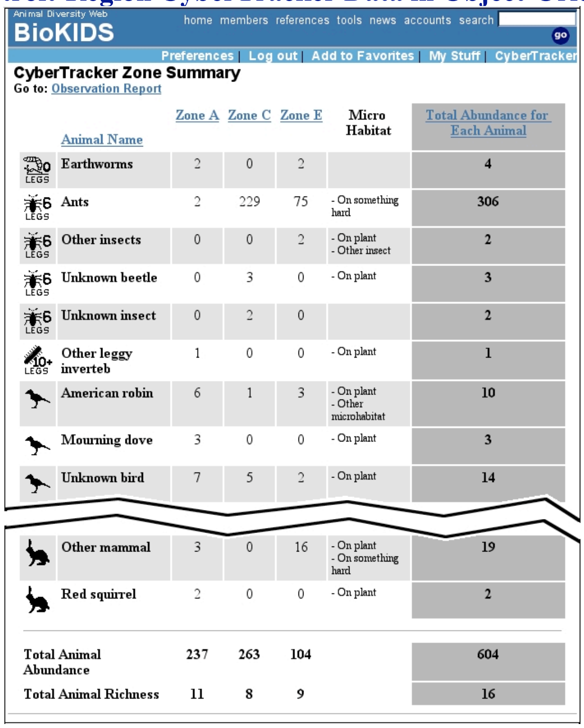
Table 2: Science content and inquiry standards addressed in the BioKIDS program

Science Content Standards • Food webs identify the relationships among producers, consumers, and decomposers in an ecosystem. • Millions of species of animals, plants and microorganisms are alive today. • Students need to develop an awareness and sensitivity to the natural world, including an appreciation of the balance of nature and the effects organisms have on one another, including the effects humans have on the natural world.
Science Inquiry Standards • Learner engages in scientifically oriented questions • Learner gives priority to evidence in responding to questions • Learner formulates explanations from evidence

In examining the level of guidance needed, we looked carefully at the kinds of data students gathered with CyberTracker then developed scaffolded curricular activities that would utilize these data towards specific inquiry goals, such as 'building explanations from evidence" (Songer and Wenk, 2003). Knowing that many children have trouble distinguishing salient information from irrelevant data when looking at authentic science data, (Lee and Songer, in press), we also recognized that our data collection interface would need to be organized in a simple and powerful way so that students could find and use the information they wanted.

Following these guidelines, we reworked the CyberTracker sequence into a simpler sequence focused on a handful of data on each specimen identified, including the kind and location of the animal, the number of animals, and the microhabitat in which they were found in their schoolyard. Figure 2 displays a sample database record illustrating total amounts of animals, total amount of animal groups, and numbers of individual animals for students to aid in their questions about species abundance, richness, and diversity.

Figure 2: Display of Detroit-Region CyberTracker Data in Object-Orientated Spreadsheet



Animal Name	Zone A	Zone C	Zone E	Micro Habitat	Total Abundance for Each Animal
0 LEGS Earthworms	2	0	2		4
6 LEGS Ants	2	229	75	- On something hard	306
6 LEGS Other insects	0	0	2	- On plant - Other insect	2
6 LEGS Unknown beetle	0	3	0	- On plant	3
6 LEGS Unknown insect	0	2	0		2
10+ LEGS Other leggy inverteb	1	0	0	- On plant	1
American robin	6	1	3	- On plant - Other microhabitat	10
Mourning dove	3	0	0	- On plant	3
Unknown bird	7	5	2	- On plant	14
Other mammal	3	0	16	- On plant - On something hard	19
Red squirrel	2	0	0	- On plant	2
Total Animal Abundance	237	263	104		604
Total Animal Richness	11	8	9		16

The final transformation necessary to support enduring understandings in science and technology was the transformation of a set of curricular units into a multi-year, coordinated sequence. Research in science education, such as that discussed in the Science Education Standards (National Research Council, 1996) document that fostering scientific inquiry thinking among K-12 students and teachers takes time. Especially in our current climate of intense accountability on standardized tests heightened in many urban schools being threatened for school failure, many teachers have only a few days for each science topic. In addition to not enough time, science curricula rarely coordinate towards a larger goal or are designed to build productively on one another. Most frequently teachers are asked to teach from a set of worksheets from one author for one unit, then adopt a completely different curricula and approach for the next.

Our research suggested that we should combat this problem directly through coordinated inquiry-fostering formats that built upon one another in consecutive science units (Songer, 2003; Jeong, Songer and Lee, submitted). Our ongoing research focuses on working with cohorts of students utilizing these units over their 5th, 6th 7th and 8th grade years. Parallel assessment systems have also been designed that are sensitive to inquiry development over multiple units and years (Songer and Wenk, 2003). To provide one example, units might all emphasize the inquiry thinking, "building scientific explanation from evidence", but with different science data and increasing levels of complexity with later programs. Each unit will also use emerging technologies for meaningful uses, however the same technological tool will be adapted for different science content and scientific questions. For example, we expect to utilize the Model-It software to model both key components of weather in the 6th grade weather unit, as well as components of water quality in the 7th grade unit.

In summary, the work of our professional development includes the iterative development, refinement, and enactment of technology-rich, inquiry science curricula and assessment systems. Our ability to develop ongoing, sustained relationships with partners engaging with a four-year coordinated, technology-rich science program will allow us to provide tangible evidence of the effectiveness of coordinated systems geared towards meaningful learning with technology.

Lesson Three: We need clear evidence of success of MLT

In order to make compelling arguments about the value of MLT, researchers and educators needs to provide clear evidence that students have learned important concepts and developed rich understandings. What kinds of evidence of "meaningful use" might serve as compelling evidence?

To address these questions, we have designed measures of MLT based on learning theories of how children learn (e.g. Bransford et al, 2000) and how to measure student understandings. Our current assessments measure three kinds of understandings that are often intertwined: knowledge of science content, knowledge of scientific inquiry, and meaningful use of technology. Assessment instruments come in three formats, including multiple choice items released from national or international tests, open-ended items, and practical exam items that have students visit stations to do practical problem solving activities with technology tools like CyberTracker Assessment systems are also organized around particular inquiry thinking, such as “building explanations from evidence”. Research results demonstrate that even with the first fifth grade unit, students demonstrate strong learning gains, with over 40% of urban students demonstrating a complex understanding of inquiry about biodiversity without any scaffolds or guidance (Songer and Wenk, 2003).

Our research continues to fine-tune our assessment tasks to become more valid and reliable measures of content, inquiry and meaningful use of technology. While this work is ongoing, our efforts to develop measures of fluent use of technology in particular contexts is an important advance in MLT assessment, as opposed to the more common practice of measuring students’ fluency only in tool use. Our work also helps advance our understanding of how and when appropriate roles for technology should occur within our programs.

<u>Lesson Four: Promote flexible means for meaningful uses of technology</u>

Our final lesson ends with the idea, or more correctly the ideal, of science inquiry. When people talk about inquiry there is an implication that there is a clear and somewhat monolithic idea of how these activities should look in classrooms. For example, there should be small groups of student engaged in a variety of more or less self-guided activities with the teacher moving from group to group acting as a resource and guide. While this is a nice image, it is not realistic within the constraints of some schools, so we believe that the definition of what inquiry looks like needs to be broadened. One example is our work to redefine what small group inquiry activities could look like in a class size of 35, as is common in urban schools in our region. (The bottom line answer is that inquiry can work very well without small groups). We advocate teaching the same essential components of inquiry, but we encourage variations that allow teachers or students to have appropriate guidance when appropriate. In our sixth grade weather program, students use our Internet browser and visualization software to obtain live weather maps and movies prior to making forecasts of tomorrow’s weather. Without carefully scaffolded observation of particularly salient weather features, students’ ability to forecast live storms remains unattainable (Lee and Songer, in press). This example reminds us that we need to continue to develop multiple exemplars of inquiry and good inquiry pedagogy and guidance within our MLT tools and professional development communities, so that teachers in a variety of environments can have strong and successful models to follow. We believe this approach can help a wide range of teachers to be effective as agents of successful inquiry without being forced to adopt a single, unattainable model of the one "right way" of doing inquiry science.

Conclusions

Meaningful learning with technology involves the cognitive transformation of technologies into powerful tools for learning. Such transformations involve coordination between learning goals and the resources utilized to foster those goals, including the curricular activities, the professional development workshops, and the technologies themselves. Also important, fostering deep conceptual understanding of science concepts and meaningful uses of technology takes time, often much longer than any one unit or tool is present in a given classroom. Sustained relationships are needed to support longitudinal learning, and coordinated curricular and assessment systems to provide concrete evidence of learning and success.

References

Agron, J. (1998) The urban challenge. *American School and University 70* (11). P. 18-20.

Atwater, M. and Wiggins, J. (1995) A study of urban middle school students with high and low attitudes towards science. *Journal of Research in Science Teaching, 32*(6)*,* 665-677.

Ball, D. L., & Cohen, D. K. (1996). Reform by the book: What is - or might be - the role of curriculum materials in teacher learning and instructional reform? *Educational Researcher, 25*(9), 6-14.

Barton, A.C. (1998) Reframing "Science for All" through the politics of poverty. *Educational Policy (12).* 525-541.

Becker, H. (2000) Who's wired and who's not: Children's access to and use of computer technology. *Children and Computer Technology* 10 (2).

Blumenfeld, P. C., Fishman, B. J., Krajcik, J. S., Marx, R. W., & Soloway, E. (2000). Creating Useable Innovations in Systemic Reform: Scaling Up Technology-Embedded Project-Based Science in Urban Schools. *Educational Psychologist, 35*(3), 149-164.

Bransford, J.D., Brown, A.L., and Cocking, R. (2000*) How People Learn: Brain, Mind Experience and School*. Washington. D.C.: National Academy Press.

Cohen, D. and Ball, D. (2001) Resources, Instruction and Research. In Boruch, R. and Mosteller, R. (eds.) *Evidence Matters: Randomized Trials in Educational Research.* MA: Brookings.

Cuban, L. (2001) *Oversold and Overused: Computers in the Classroom.* Cambridge, MA: Harvard University Press.

Haberman, M. (1991) *The pedagogy of poverty versus good teaching*. Phi Delta Kappan 73, 290-294.

Huber, A., Songer, N.B., and Lee, S.Y. (submitted) BioKIDS: A curricular approach to teaching biodiversity through inquiry in technology-rich environments. *Journal of Research in Science Teaching.*

Jeong, H., Songer, N.B., Lee, S. (submitted) Diagnosing urban sixth graders' inquiry skills and understandings. Science Education.

Lee, H., and Songer, N.B. (In Press) Making Authentic Science Accessible to Students. *International Journal of Science Education.*

Michigan Curriculum Framework Science Benchmarks (2000)

Mistler-Jackson, M., and Songer, N.B. (2000) Student motivation and Internet technology: Are students empowered to learn science? *Journal of Research in Science Teaching (37)* 5, 459-479.

National Research Council (1996). *National Science Education Standards.* Washington, DC: National Academy Press.

National Research Council (2000). *Inquiry and the National Science Education Standards.* Washington, DC: National Academy Press.

Songer, N.B. (2002) From Digital Library to Cognitive Tool: Steps and potholes along the transformative road. Paper presented at the National Science Digital Libraries Meeting, Washington, D.C., December.

Songer, N.B., Lee, H., and McDonald, S. (in press) Research towards an expanded understanding of inquiry science beyond one idealized standard. *Science Education.*

Songer, N.B., Lee, H., and Kam, R. (2002) Technology-Rich Inquiry Science in Urban Classrooms: What are the barriers to inquiry pedagogy? *Journal of Research in Science Teaching.*

Songer, N.B. and Wenk, A. (2003) Measuring complex reasoning in science. Paper presented at the American Educational Research Association annual meeting, April.

U.S. Department of Education, National Center for Educational Statistics (2000). *Characteristics of the 100 Largest Public Elementary and Secondary School Districts in the United States: 199801999,* NCES 2000-345, by B. A. Young. Washington, D.C.

Vinovskis, M. (1997) An Analysis of the Concept and Uses of Systemic Educational Reform. *American Educational Research Journal* 33(1). 55-85.