

LeTUS: Center for Learning Technologies in Urban Schools Final Due Diligence Report

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PROJECT DESCRIPTION

The Center for Learning Technologies in Urban Schools (LeTUS) was/is¹ a partnership forged between the University of Michigan, the Detroit Public Schools, Northwestern University and the Chicago Public schools to understand how “learning and collaborative technologies can serve as a catalyst in support of systemic change efforts in urban schools in the United States”(Gomez, Marx, Soloway, Schank, Clay-Chambers and Burgess,1997, p. 1, LeTUS proposal to NSF). It was one of several Centers for Research on Learning and Teaching (CRLT) funded by the Directorate for Education and Human Resources (EHR) of the National Science Foundation (NSF) through their Learning and Intelligent Systems (LIS) program in 1997.

The core concern of this partnership was the fragile and one-dimensional nature that most implementations of innovation take when attempts are made to scale them beyond a few carefully nurtured classrooms, especially when such innovations are attempted in urban settings. In particular, the collaborators felt that such innovations are often “not sufficiently sensitive to the actual context in which the innovation is to be used, and do not attend to the many problems associated with school restructuring, all of which need to be addressed for lasting change,” (Gomez, et al, 1997, p. 2). The collaborators proposed to tackle this problem by using a *client-focused* research and development effort in which the contexts of teaching and learning in the Chicago and Detroit Public Schools would shape the Center’s work. “We weren’t going to just manufacture solutions and take them to the district and try to sell them on the solutions but rather, we would work in problem solving partnerships with the district,” (Reiser interview, June 5, 2003). At the same time, they believed the introduction of innovations would *problematize* each district’s work, challenging old practices and creating a dilemma around which organizational thinking, learning and change could be catalyzed. They, therefore, hoped not only to design, redesign or adapt technological innovations to meet the districts’ needs, but also to

¹ The core funding for the LeTUS Center is over (or close to over). While much of the work is continuing under new funding streams, it is not clear whether the name LeTUS will continue.

reshape district policy and practices to better support the implementation of those innovations in classrooms.

The technologies to be introduced to the urban districts in question were those that could be useful for improving teaching and learning in middle school science classrooms. The researchers involved in writing the original LeTUS proposal all had a history of creating and integrating technology into schools in the service of supporting inquiry-oriented approaches to science education. While the science to be learned was always a critical goal in this early work, in many (though not all) cases, they considered their scholarly contributions to be about the ways in which the technology could be designed and used to meet that goal. Indeed, both the name of the Center itself and the thrust of the argument in the original grant proposal reflect this focus. Science was the context, but the use of technology to improve learning was the goal.

As will be evident in the more detailed discussion below, an interesting and important shift in priorities occurred as the university teams began working closely with district leadership. The development of curriculum and professional development to support its enactment became driving foci of the work and core referents that defined their collaboration. In the end, most of the interviewees described more than one goal for LeTUS: foster inquiry-oriented science instruction, incorporate technology to support student learning, explore the organizational and policy supports necessary to make such instruction work throughout entire school systems; and forge new and productive relationships between universities and K-12 educators. The core strategies for achieving these ends were (1) regular meetings with district administrators around Center goals and plans; (2) collaborative work between researchers and educators on curriculum design; (3) the creation of sustained trust relationships between university and school district participants; (4) the development of teacher led professional development systems for supporting teacher change; (5) the establishment of district liaisons to serve as interpreters and conduits for information from the university groups; and (6) the development of a “brand” identity for LeTUS work. Below, a short history of the conditions that led to LeTUS’ inception is provided, along with a description of the key players, and an overview of each of the core strategies.

Pre-LeTUS history and conditions

The LeTUS collaboration appears to have been generally less rocky for the contributing organizations than some earlier partnerships, such as ATLAS (Hatch & White, 2002), have been. This is not to say that the work always went smoothly. However, there were a number of pre-conditions to the collaboration that may have made their joint work proceed in a relatively satisfactory way. First, several of the researchers already knew one another as colleagues and friends. As one interviewee said, “At the end of the day, we worked well together because many of those involved are genuinely nice people” (paraphrase from Gomez phone conversation, September 8, 2003). Second, the researchers involved had similar, though not identical, theoretical commitments and practical experiences with respect to the use of technological tools to support science learning. Third, both research teams had already developed working relationships of some kind with the local urban district — Northwestern with Chicago Public Schools and University of Michigan with Detroit Public schools. Finally, each of the two districts had received grants for Urban Systemic Initiatives from NSF (1994-1999), the goals of which dove-tailed nicely with the Center’s proposed work. These conditions paved the way for the LeTUS collaboration.

Research and development context

In the early 1990s, researchers at both the Northwestern University and the University of Michigan began to explore the possibilities of project-based science supported by learning technologies. The *Enhancement of Project-Based Science: The Project Support Network* (PBS) project (1991-94) run by Joe Krajcik, Ron Marx, Elliot Soloway and Phyllis Blumenfeld explored how to make projects as an instructional form more feasible and manageable by teachers and studied teacher change in the context of implementing science projects. This project began with a review of the literature as it relates to project-based science and the formation of some basic principles for what good project work is like. Supported by funding from a series of related grants, the group also developed a suite of computational tools called the Investigators Workshop to support students' inquiry. "These tools support data collection, data visualization and analysis, dynamic modeling, planning, Web publishing and information gathering from the University of Michigan digital library and the Internet" (Blumenfeld, Fishman, Krajcik, Marx and Soloway, 2000). They then worked closely with teachers to see how their principles for project-based science along with the software tools at their disposal could be implemented and contextualized to meet the needs of teachers and students in classrooms.

Around the same time, Soloway also worked with Roy Pea and Louis Gomez to create the *Learning through Collaborative Visualization* (CoVis) Project (1992-1998).² CoVis aimed to improve teaching and learning on geoscience topics in high school classrooms. Like the group at UMich, they had a commitment to a project-based approach to science instruction, supported by computing and telecommunications technologies. In particular, they were experimenting with the development of data visualization tools for students that would enable them to explore phenomena like weather patterns and climatic change. They incorporated the use of desktop teleconferencing to support collaboration between school sites and with science experts. And they developed an on-line Collaboratory Notebook to guide students' data collection and reflection as well as provide additional support for cross-site collaboration. The project had two phases — a two year "proof of concept" phase in which they worked closely with six teachers in the Chicago suburbs, followed by a four year expansion phase in which the project grew to include nearly 150 teachers from across the United States.

At the same time, Brian Reiser at Northwestern University was developing a new research program that expanded upon his earlier work on student problem solving and explanations. The core of this work was the *Biology Guided Inquiry Learning Environment* (BGuILE) Project (1995-?). Reiser and his students constructed software tools to support students' efforts to explore and make sense of primary data about biological phenomena and to construct and communicate persuasive explanations about them. While CoVis and BGuILE were separate research teams, their members communicated about and supported one another's work quite a bit.

An earlier project, LabNet, was a touchstone for both CoVis and PBS and certainly known about by the BGuILE group. LabNet was a three year (1989-1992) teacher-support project

² Danny Edeson, a former student of Roger Schank, was hired as the CoVis project manager and, in particular, oversaw much of the software development. Edelson would later serve as one of the core members of the LeTUS team.

developed by TERC and funded by NSF to improve science education, primarily in high school physics classrooms. It had three major goals: use projects to enhance student's science learning; build a community of practice among LabNet teachers; promote the use of technologies in science teaching and learning (Ruopp, Gall, Drayton & Pfister, 1993, p. 2). Krajcik and been one of the collaborating researchers on this project and LabNet teachers and staff served as consultants during the early years of CoVis.

It is thus not surprising that the endeavors at both institutions shared some common goals and perspectives. Both groups expressed interested in improving scientific understanding and literacy by giving students more experience with the *practice* of science, in particular to engage in open-ended investigations. Both groups believed technological tools could provide strong support for students' comprehension of scientific concepts and phenomena. Finally, both groups believed in the power of collaborative work for supporting student learning and teacher change

Finally, all three groups had begun to experiment with the development of curriculum just before they came together to write the LeTUS grant. CoVis provided its initial six teachers with plenty of technological tools, and a vision of what project-based science was about, but not a curriculum. They were disappointed in this early work to find that while all six teachers experimented with some form of project-based science in their classrooms, some of the technological tools went largely unused and cross-school collaboration was difficult to foster and sustain. As they planned to scale the work to include more schools and classrooms, they decided that more concrete scaffolds would be necessary. The resulting *CoVis Interschool Activities* were project cycles (described at varying levels of detail) with suggestions for technology use described and planned. The CIAs were "run" at particular times of the year, during which CoVis central staff provided on-line forums for teachers to talk about the work as well as support for cross-school collaboration and on-line science mentors. The CIAs might be best characterized as "proto-curriculum."

BGuILE never expanded beyond a small number of collaborating teachers, but nonetheless, they also had built documentation of the classroom design work that might be considered "proto-curriculum". It served as a means of communicating to and collaborating with the participating teachers, but was not intended to be usable by teachers who were not working closely with the research team.

The hi-ce group had perhaps the most detailed early attempts at curriculum design. As they were writing the LeTUS grant, they were just finishing up the second year the *Community Science Connections* project, a collaboration with the UMich School of Public Health and Detroit Public Schools to develop science curriculum based on community needs. This was their first formal attempt at curriculum design and built upon their earlier experiences with the PBS project. Based upon the concerns and questions expressed by parents, the school district and environmental groups, they created two topic-based curriculum units — one on the local air quality and the other on the local water quality.

Thus, all three groups were at least thinking about curriculum design at the time they wrote the LeTUS grant. As Reiser describes this process with respect to his own work, "We moved outward from thinking about what do kids do with software to learn important concepts, to thinking about what the teachers need to do to set-up the activities so students will learn

important concepts, to how do we write this all down in order to communicate it to other teachers who we haven't talked to directly and how do we design professional development around this curricula" (paraphrase from Reiser interview, June 5, 2003).

Despite these similarities, there were some important differences between the groups as well. LeTUS participants describe the early work of the Northwestern team as more closely tied to the traditions of cognitive science, while they describe that of the Michigan team as more closely based on the traditions of science education and/or educational psychology. They also noted that the Michigan group had a somewhat more structured approach to project-based science than did the Northwestern researchers.

In addition, there were structural differences between the two groups. Not long after they had begun their collaboration in the early 1990s, the four core researchers at University of Michigan decided they needed a name to identify themselves and to serve as a banner under which the multiple grants and projects they were now embarking on together could be clustered. Thus, the Center for Highly Interactive Computing in Education (hi-ce) was born. This center is not a funded agency, but rather a useful description for a group of people who work on related projects together. At Northwestern, no such entity was created. Off-shoots and extensions of the CoVis and BGuILE work emerged. Other faculty at Northwestern were engaged in related research and development and sometimes collaborated on these off-shoots and extensions. However, there was no collective way of referring to this suite of related work. The inception of LeTUS would thus serve as the first unifying umbrella for the researchers at Northwestern.

District context

As mentioned earlier, both Detroit and Chicago Public Schools had received support from NSF to form Urban Systemic Initiatives. These initiatives (1994-1999) were still underway when the LeTUS grant was written (1997). The goals of the Urban Systemic Initiatives were to improve scientific and mathematics literacy, increase students' knowledge of mathematics and science fundamentals, and enable a greater number of students to pursue careers in mathematics, science and technology. These goals were consistent with the research agendas of the two university teams. Moreover, each university team had at least some experience collaborating with schools, classrooms and district leadership in their local district. Many CPS schools participated in the scaling phase of CoVis, while both the PBS and *Community Science Connections* projects involved schools and classrooms in DPS. There was interest in both districts to pursue the collaborations further.

It is important to note a striking difference between the operating styles of the two districts. CPS is a highly *decentralized* system. All curriculum decisions are made by local school councils. Thus, the district-level personnel from Chicago involved in the Center tended to serve more of a facilitative role. Gomez described their function as something like that of a matchmaker, who gives the Center advice such as, "given what we understand about what you want to do, and given what we understand about schools, you should go visit with these following people to talk about what you do" (Gomez interview, June 6, 2003).

Moreover, CPS considers its pressing needs to be basic literacy and numeracy, which is reflected in its accountability system. They assess the reading and mathematics proficiency of

all students in grades one through eight every year using the Iowa Test of Basic Skills (ITBS). These test scores, along with those from the Illinois Standards and Achievement Test in reading and mathematics given in grades 3, 5 and 8 “are the ones CPS cares about the most” (Finn email, August 7, 2003). Schools have the option of giving their students the ITBS in science, but as they must pay for this additional testing out of their own budgets, most do not. And while, Illinois assesses students in science in grades four and seven, the CPS administration does not scrutinize those scores as closely as it does those in reading and mathematics. Thus, it is somewhat harder to get the district’s attention on issues of science education as that is not where their core concern lies. Finally, the district personnel involved with science (or mathematics and science) changed several times during the course of the LeTUS grant.

In contrast, DPS is a more centralized system. The co-director for LeTUS representing the district, Amelia Gray, has been consistent through out the Center’s existence. Chambers plays a powerful role within the district administration and is both knowledgeable about and dedicated to the science education reform agenda being pursued by LeTUS. She played a strong and directive role in both guiding the Center’s plans and engaging Detroit teachers and schools in LeTUS activities. Every interviewee considered her to be a central part of the center’s success, particularly in Detroit. Finally, Michigan has state and city mandated tests in science³ that are seen as important achievement indicators by both principals and district leaders. This combination of circumstances meant that approaching their work *systemically* was more challenging for the Northwestern/Chicago team than it was for the University of Michigan/Detroit team.

Key Players

There are numerous teachers, graduate students, post-doctoral researchers, computer programmers and administrative staff involved in the LeTUS Center (and its affiliated projects), as well as faculty who play an adjunct role. The original funding proposal to NSF lists six co-principle investigators: Louis Gomez and Roger Schank at Northwestern University; Clifton Burgess at the Chicago Public Schools; Ronald Marx and Elliot Soloway at University of Michigan; and Amelia Gray at Detroit Public Schools⁴. Most of these, with the exception of Roger Schank and Clifton Burgess, are still actively involved in the work⁵. Listed below are the people who emerged as core personnel during the interviews. Those with an asterisk (*) by their names were interviewed for this report. If a fuller study of LeTUS were to be conducted, several of the other people on this list would also be important to contact.

³ The state tests, the Michigan Assessment of Educational Progress (MEAP) is give in the subject of science in grades five and eight. The city also administers the Terra Nova (CTB/McGraw-Hill) each year in the subjects of reading, mathematics, social studies and science to all students in grades one through eight (Steel, email and phone conversation, August 27, 2003).

⁴ In accordance with Detroit Public School’s regulations for research conducted in their district, all DPS employees will be referred to by pseudonym.

⁵ Schank was involved in the grant writing. However, he left the Northwestern University not long after the grant was received and never became actively involved in the center. Burgess was head of the Chicago Systemic Initiative as well as a LeTUS co-director through the spring of 2003 when Chicago acquired a new superintendent and along with him, a new organization for the district administration. Marty Gardsman, Chief Officer in Mathematics and Science, essentially replaces Burgess.

Detroit Public Schools

- **Amelia Gray:** Co-director of LeTUS representing Detroit Public Schools; works very closely with the University of Michigan group; during the course of LeTUS, DPS has reorganized the central office more than once and her title has changed several times as a result, but she's always had a strong influence on district curriculum policy.
- **Barbara Steel*:** LeTUS instructional specialist; serves as liaison between UMich and DPS for all LeTUS work; former science teacher; worked with the hi-ce team on the PBS project; conducts and oversees most of the professional development provided for the Detroit teachers in consultation with Fishman and his team; supports teachers in the classroom; plans LeTUS related professional development for principals; recruits new LeTUS teachers.

University of Michigan

- **Phyllis Blumenfeld:** Professor of Education; focus is on classroom-based research; organizes and leads much of the classroom data collection; founding member of the hi-ce group.
- **Barry Fishman*:** Assistant Professor of Education, started in fall 1997; eventually took over primary responsibility for research on professional development and acts as liaison with DPS for providing it; is interested in policy changes at the district level that need to be made to support the work—particularly to support the integration of technology into classroom activity; current member of hi-ce group; former CoVis graduate student with a Ph.D. from Northwestern; only person to cross between the sites.
- **Joe Krajcik*:** Professor of Education; a science educator by training and the heart of the curriculum design and management team at UMich; works closely with science curriculum professionals in DPS; helped design and implement early professional development for LeTUS in Detroit; founding member of the hi-ce group.
- **Ron Marx*:** Co-director of LeTUS for University of Michigan; Professor of Education; part of the core curriculum design management team; leader of UMich's efforts at devising instruments for measuring the effects of their work on student learning and motivation; founding member of the hi-ce group.
- **Elizabeth Moje:** Associate Professor of Education; studies literacy as a tool in the academic disciplines; investigates the roles of culture and community in content area literacy; works on the development of scientific literacy practices in LeTUS classrooms.
- **Jon Singer:** Former Post-doc and member of the core management team for the UMich branch of LeTUS that over saw curriculum design; no longer at UMich; Currently collaborates on follow-up grants to LeTUS from his position as an Assistant Professor at a university in South Carolina.

- **Elliot Soloway:** Professor of Electrical Engineering and Computer Science; Professor of Education; directs most of the software development and exploration of technological innovations for the Michigan team; founding member of the hi-ce group.

Chicago Public Schools

- **Clifton Burgess:** Co-director of LeTUS for Chicago Public Schools; head of the Chicago Systemic Initiative; has since left the district when the arrival of a new superintendent.
- **Marty Gardsman:** Chief officer for Mathematics and Science in the Chicago Public Schools; now in charge of the Chicago Systemic Initiative.
- **Mike Lock:** Assistant Director for the Mathematics and Science Initiative in the Chicago Public Schools; reports to Mary Gardsman; worked for two years as a post-doctoral researcher with Danny Edelson.
- **Chandra James:** LeTUS coordinator inside CPS; works with Mike Lock on science curriculum and instruction; started liaison position for LeTUS in fall of 1998-99 (she had no experience with LeTUS prior to this appointment); works closely with Lou-Ellen Finn to organize and provide professional development on LeTUS curricula and technology for Chicago teachers; assists in recruiting new teachers for LeTUS.

Northwestern University

- **Danny Edelson:** Associate Professor of Education and Computer Science; directs development of specific software and associated curricula; involved in the development of their professional development approach and their evaluation efforts; director of the Ph.D. program in the Learning Sciences and the Northwestern University contact for the Center for Curriculum Materials in Science, a Ph.D. and post-doctoral program that grew out of LeTUS.
- **Lou-Ellen Finn*:** Director of professional development for Northwestern; works closely with Chandra James; started as a LeTUS teacher; does considerable work on curriculum development, including participation in the ReNUE work circle with Greg Shrader.
- **Louis Gomez*:** Co-director of LeTUS for Northwestern University; Professor of Education and Computer Science; did much of the school/district level liaison work in Chicago; served as “Executive” director of the center for a time.
- **Phillip Herman*⁶ :** Research Assistant Professor of Education; director of Research for NWU LeTUS team; leads the effort to development, administer, score and analyze unit pre- and post-tests, as well as questionnaires and other measures of the effects of the LeTUS project on student learning and attitudes.

⁶ Phillip Herman was not part of the set of eight scheduled, taped and transcribed interviews. However, I was in correspondence with him both via email and over the phone during the fact-checking phase and he contributed significant data and insights to this report.

- **Brian Reiser***: Professor of Education; Directs development of specific software and associated curricula; helps coordinate curricula development for NWU branch; key player in the development of pre- and post-tests for evaluating the LeTUS curricula developed at NWU.
- **Bruce Sherin**: Assistant Professor of Education; involved in the classroom research for the Center.
- **Greg Shrader***: Research Assistant Professor of Education; actively involved with LeTUS during its first four years of funding; Director of Professional Development for two of those years; co-developed curricula with Chicago teachers; former CoVis graduate student; not closely involved with current LeTUS work.

The LeTUS collaboration

The collaboration began when Gomez sent a call from NSF for collaborative centers to colleagues at both Northwestern and at University of Michigan. Gomez, Reiser and Edelson, along with the hi-ce team decided to pursue the idea of putting together their collective experience in project-based science and learning technologies and, along with their partners in Detroit and Chicago, tackle the problem of implementing innovation in urban classrooms. Marx and Gomez became the core writing team, supported by their colleagues at each institution. The district participants played more of a consultative and “signing off” role at this stage of the process. While they contributed substantively to the thinking *behind* the proposal, it was the researchers who did the actual crafting of the written argument.

At the same time, Gomez and colleagues at NWU were writing a grant application to NSF’s Research on Education, Policy and Practice (REPP) program for the creation of an on-line repository of “living” curricula. The goal of the *Living Curriculum Project* was to build upon the work of the CoVis CIAs turning them (and two new project units) into “flexible curricula which stand up to, and indeed are improved by the process of local adaptation” (*Living Curriculum Project Abstract*).⁷ Rather than simply implement these curricula, participating teachers in the project were to “interact with [the on-line] materials, change them to fit their context, document those changes for others’ uses, and contribute their own content to the evolving curriculum database” (*Living Curriculum Project abstract*). The hi-ce group was also writing a REPP grant. They planned to study the impact of shifts in classroom activity to that of scientific inquiry supported by technology on students, classrooms and schools and then apply those findings to make the implementation of such innovations in urban settings more effective and efficient (*Using Information Technologies to Support Urban Middle School Students in Scientific Inquiry Project Abstract*).⁸ A core goal of this proposed research was the development of robust tools for measuring the impact of innovations on student learning.

⁷ Living Curriculum Project award abstract, obtained on June 26, 2003 from the NSF website at <https://www.fastlane.nsf.gov/servlet/showaward?award=9720423>.

⁸ Using Information Technologies to Support Urban Middle School Students in Scientific Inquiry Project Abstract, obtained on June 26, 2003 from the NSF website at <https://www.fastlane.nsf.gov/servlet/showaward?award=9725927>.

Getting Started: The pajama party

This is a story told by several of the key participants and is clearly a watershed moment in their minds. The group heard back from NSF that it was time for them to come talk about the Center proposal in person. They thought this was a final opportunity to justify and support their proposal. They assembled the entire team together in a hotel room in Washington D.C. the night before the presentation. The group included district superintendents and a few critical friends to give feedback. Slides were being printed as they worked. Soloway went out and bought a VCR because they felt they needed one. They were up until the wee hours working and planning, putting together an impressive presentation and solidifying their collective understanding about what it was they were proposing to do. It was during this period that those interviewed believe the idea of work circles was first born (see below). The next morning they discovered before their presentation that they had already been given the go ahead not only for the Center, but for the two REPP grants as well. Their program officer sent them out with a blessing to “Go and change their world” (Krajcik interview, June 5, 2003). “You’ll probably fail. But whether you succeed or fail, all of this doesn’t matter. What’s important is that we get this experience.” (Marx interview, June 4, 2003). The interviewees laugh as they tell this story, but they also clearly value the experience as an important and positive beginning to their collaboration.

For the first couple of years, the four co-directors’s functioned as an overarching management team. They all felt it was critical at this early stage that the districts have input into the work and be able to approve and support the directions they were taking. However, over time the very different work styles of the districts and universities made this kind of four-way collaboration hard to sustain. Moreover, it eventually became clear that the bulk of the initial design work was going to happen between the pairs of collaborators in each city — University of Michigan and Detroit Public Schools, Northwestern University and Chicago Public Schools.

One of the key decisions made very early on was at the suggestion of Gray. As mentioned earlier, researchers at both locations had been doing some curriculum work prior to LeTUS, but curriculum design was not an explicit focus of the original LeTUS proposal. “We didn’t propose LeTUS as a curriculum project to the NSF and I don’t think we knew how central a role curriculum was going to play,” (Reiser interview, June 5, 2003). Amelia Gray, however, sent a clear message that if they wanted to have an impact across her system, the best way to do so would be through curriculum.

Collaborative design: Work Circles and curriculum development

Curriculum design became the anchor point for collaboration between the research teams and school districts. They decided, “we’re going to build curriculum as part of this work; we were going to build it in this collaborative way, and we’re going to build it with people who, not just by our judgment, but in the judgment of people in the school district, shared our goals for this stuff, and we would build relationships with them that we could sustain, around this other task” (Gomez interview, June 6, 2003). “Work circles” consisting of researchers and educators focused on developing specific projects or units thus became the functional core of the Center.

The two branches (UMich-DPS and NWU-CPS) worked more or less separately on curriculum development for two reasons. First, they were working hard to make the curricula

they designed fit local needs, which meant working closely with local teachers and schools and learning from the specifics of their particular context. Second, they first needed to learn how to develop curriculum. As Krajcik put it, “We were not curriculum developers. We were educational researchers, but classroom instruction people. It’s not that we never worked with teachers in classrooms, but we never wrote full curriculum. ... And so, I think we had to figure out within our own environment how you do that” (Krajcik interview, June 5, 2003).

Finally, the curricular context in which they were each working was different. Detroit has a curriculum framework that lays out which of the Michigan Benchmarks teachers should focus on throughout the year. The framework consists of a set of topical guidelines along with suggested activities and resources (including a city adopted textbook) that teachers might use (paraphrase from Steel interview, June 4, 2003). This structure means that all (or most) science teachers in a given grade are covering the same topics simultaneously and with many of the same resources. In contrast, each local school board in Chicago determines what kind of curricula will be used in each school. While there is a *Chicago Academic Standards and Frameworks*, it does not provide the same kind of guidelines for structure and pacing that the Detroit curriculum framework does. Moreover, the teachers may be using very different resources to teach to those standards.

It is therefore not surprising that the form the work circles took in each site was somewhat different. The general consensus is that “work circles” was a more deliberate approach with the NWU/CPS branch of LeTUS. UMich/DPS, on the other hand, used more of a design team approach.⁹

University of Michigan/Detroit Public Schools

Curriculum materials developed by the University of Michigan and Detroit Public Schools is described by them as a “collaboration among teachers, school and district administrators, university scientists, educational researchers and curriculum specialists,” (Singer, Marx, Krajcik, Clay Chambers, 2000, p. 166). Joe Krajcik, a science educator by training, led the core curriculum design team. This team consisted of himself, Marx, Jon Singer, Gray and two DPS teachers with project-based science experience, Barbara Steel and Stella Novak. This group would decide upon the topics that each unit would explore and put together an outline or overview for them.

Gray played a significant role in helping them select topics the district would find useful. Each unit had a point person who was the central designer, usually a graduate student at UMich. The point person would work with the design team and one or two collaborating teachers to build an initial unit framework and sequence. Then they would bring in teachers to pilot the ideas and basic activity designs. Initially, there were just a handful of pilot teachers (three or four) and they were often working with a sketchy framework of inquiry activities and so needed to be capable of working “with the craziness of it” (Marx interview, June 4, 2003). The following

⁹ It just so happens that the UMich research team, with the history of collaborative and coordinated work through hie was a somewhat more centralized organization prior to LeTUS than the NWU research team, a rough parallel to the more centralized Detroit district and less centralized Chicago district. I wonder how useful such parallel organizational structure was when devising their curriculum development teams? Did it provide for similar viewpoints about how to proceed with the work?

summer, they would tear apart the pilot curriculum and rebuild it. Every summer afterwards they would do some tinkering based upon what they had seen in classrooms or heard back from teachers. “This drives teachers insane because there’s always new curriculum. It’s never what they did last year,” (Fishman interview, June 4, 2003) and eventually the district asked the UMich team to stabilize the curriculum so it would not need such frequent revision.

Topics were chosen carefully so that they corresponded with the timeline that DPS’ standard curriculum dictates for which topics should be taught when. Initially, they built their curriculum by starting with a driving question or general topic that seemed to fit with the Michigan benchmarks. Then they created a set of activities to support the chosen investigation. At the end of this process, they compared what they had designed to national and local standards. Now they begin the design process by looking closely at the local benchmarks or standards. “That’s one of the changes that was made on the university side. ... They were accommodating the needs of the teachers because the first thing a principal asks is, ‘How is this going to help my MEAP scores?’ The first thing a teacher is going to ask is ‘How is this going to prepare my kids for the standardized test?’”(Steel interview, June 4, 2003). The shift made it easier for teachers to justify spending long periods of time on a single investigation. Instead of creating their own lessons based upon the DPS framework and resources, teachers could use the LeTUS curricula as essentially replacement units and be secure they would be covering the topics the city and district felt were necessary.

At this point, the researchers at University of Michigan do most of the writing and revision of the curriculum. They get feedback from the practioner community through three major conduits. First, they choose some portion of the teachers working with the curriculum to interview at the end of a unit in order to get detailed feedback. These interviews often occur during the monthly professional development meetings and discussions within the meeting itself serves as another conduit. (Representatives from University of Michigan generally attend the monthly meetings, sometimes simply taking notes, at other times video-taping or interviewing teachers.) Finally, the lead teachers who run the professional development sessions review the revisions and give the researchers feedback based on their own experience and their conversations with the other teachers.

Northwestern University/Chicago Public Schools

There was no core design team at Northwestern and the initial choice of topics to be explored tended to be driven by proto-curriculum already at hand (e.g. from CoVis or BGuILE) and core pieces of software that were available. Later, there were units developed simply because someone thought it would be a good topic to cover. These units might use off-the-shelf software and/or the technological tools from UMich or NWU. In at least one such case, new technological tools were developed specifically to meet the needs of that unit. As at Michigan, each unit had an advocate who was in charge of the work circle doing that design work. Typically, work circles consisted of one or two of the university researchers along with a number of teachers. The “advocates” for each work circle were usually a member of the research team, such as graduate students or post-docs. The units were designed collaboratively, however, the advocates often did the initial “write-up” of the designs. After pilot testing, the teachers frequently took over the task of cleaning up, rewriting and refining them.

For example, the ReNUE work circle in which interviewees Greg Shrader and Lou-Ellen Finn both participated, consisted of two Northwestern researchers, four teachers and one school technical coordinator. Originally, they had wanted mathematics and literacy teachers to also be part of the teams, but could not make that coordination happen. As a result, the teachers on each team were all science teachers.¹⁰

They met every week for 2-3 hours at one of the teachers' schools beginning in January of 1998. Many of the groups started with a project design from previous Northwestern work, such as CoVis or BGuILE or else with a piece of software that was particularly good at exploring some topic. They looked at the content standards they were to meet (*Chicago Academic Standards and Frameworks*) and where the seed curriculum they had matched up with those standards. When possible, they also heard from teachers who had used the curriculum before about what they felt did and did not work. Then they began restructuring it. In the case of the ReNUE work circle, the unit they ended up with looked very little like the CoVis seed project from which it began.

As the ReNUE work circle began to rebuild their unit, they were simultaneously piloting some of the activities in Finn's classroom beginning in March of 1998. This piloting activity required a certain amount of both bravery and flexibility on Finn's part, as the curriculum design was not complete when she began the unit. When asked how the piloting went, Finn said, "It was fly by the seat of your pants kind of thing. ... All things considered, it wasn't bad. (laughter) I mean there were literally days when Greg would show up at my classroom door with stuff that he had printed out up here [the Northwestern campus] that morning. ... And so it was sometimes a challenge" (Finn interview, June 6, 2003). Thus, as in Detroit, those teachers who initially tried out the fledgling curriculum ideas, had to be capable of dealing with "the craziness of it all."

What she learned and experienced from trying those activities out was fed into the design of the rest of the unit, as well as plans for redesigning each activity tried. At the same time, Shrader was video taping all this early piloting work for both research data and feedback into the design. Based on the pilot data, the group worked over the summer to revise the unit and then it was piloted with other teachers that fall. The work of most of these teachers was not observed¹¹, but the students were given pre- and post- tests and a focus group was run with the teachers in January. Then, the teachers involved in the work circle redid the curriculum one more time.

Use across sites

The LeTUS curricula and associated software generated by these teams of teachers and researchers were not often used across sites. This lack of transfer is at least in part because the curricula were tailored to the standards, guidelines or frameworks for each district and thus did not often fit well in the other district. (See *Appendix B: LeTUS Curriculum Overview* on page 37.) ModelIt, a dynamic modeling program created at University of Michigan, was used in some

¹⁰ Interestingly, the teams often consisted of teachers from a range of middle school grades. Some of these teachers did not have students for whom the unit they were designing was targeted. They nonetheless participated fully in the design work.

¹¹ Many graduate students were graduating and they were short of people to be in classrooms. Finn's classroom was an exception as it was being filmed for use in the Living Curriculum Project.

of the NWU/CPS curriculum development. It is a general purpose tool for modeling that could be applied to students' inquiry work in a variety of domains. Its flexibility with respect to content may have facilitated its use across sites. Likewise, NWU/CPS was able to use the Water Quality unit devised by the UMich/CPS team as one of its offerings. The more decentralized nature of science curriculum in the Chicago Public Schools may have been part of the reason.

Building sustained trust and mediating power relationships: Starting on educators' ground

Gomez described one of the Center's core strategies as a focus on building "multi-tiered trust relationships across the levels of our [university] organization as a project and the levels of the school system in both cities" (Gomez interview, June 6, 2005). In order to have sustained relationships with these districts, they felt they could not *just* work with their "friends" — teachers and administrators which they knew from prior work — but also must engage new people in the endeavor. "We explicitly as a strategy in the building of the Center wanted to create relational trust with people we didn't know prior to the work" (Gomez interview, June 6, 2003). To do so, they needed to establish regular practices that respectfully engaged DPS and CPS educators in the work and began to break down the traditional power relationships between researchers and educators that might hinder collaboration.

They started by making certain the Center was conceived of as a partnership between four equal institutions, each of which participated in its direction and management. Thus, there were four co-directors: Louis Gomez representing Northwestern University, Clifton Burgess representing the Chicago Public Schools, Ron Marks representing University of Michigan and Amelia Gray representing the Detroit Public Schools.

It was clear that we couldn't succeed at this if the researchers were the directors and the people in the districts were sort of the users of the stuff. The only way to get viable usable products out of this and usable for K-12 people and for researchers was to have a coordinated team. We needed the input from the district and as much as possible, the designing endeavors that came out of this, the R and D, had to have a balance of K-12 and higher ed people on it (Marx interview, June 4, 2003).

Initially, these four served as the central management team for the Center and met frequently, either in person or over the phone via conference calls. Due to the difficulty in making the very different working styles and paces of university researchers and district leaders, they found regular meetings of the four coordinators hard to maintain. Instead, as the work progressed, each district/university team collaborated closely and then the two university teams served largely as the coordinating vehicle between the two cities.

Almost all the interviewees commented that the vast majority of meetings between researchers and educators occurred at locations within the districts. This was a purposeful strategy on the part of LeTUS to signal how important they felt the practitioners were to the work. The Center also attempted to ensure practitioners' voices were heard by having them play central roles in curriculum and professional development design, development and delivery. For this participation, district teachers were paid for their services above and beyond their classroom work. Finally, the researchers began all their conversations by asking the educators what *they* felt the Center had to do if they were going to develop effective mathematics and science curricula.

The two educators interviewed, Steel and Finn, both believed these to be important and successful practices. Steel believes that a strong trusting relationship has been built between DPS and the UMich team that is productive for both of them.

I think the biggest thing that makes this work so well for us is this level of trust between the two entities. When the university wants to try something, we trust them that they're not going to do something that's detrimental to our children, that they're not trying to exploit us but that they're actually looking at and they want to do what's best for us. By the same token, they know that we really appreciate the work that they do for us and when they need something from us, we'll do it and when we need something from them, they're open and available if we need their help with something (Steel interview, June 4, 2003).

Finn noted that she really did *not* feel like she was following a researcher's pre-planned agenda, but rather her expertise was truly valued.

I've been teaching a long time, over 30 years, when I got involved with them, and so it is not the first time I've been involved with researchers. And my previous experiences with people who wanted to do research or wanted teachers to use a curriculum or a piece of curriculum had never been really positive. I mean, it was never horribly negative, but I always felt like it was -- we're going to come in; we're going to use you and your kids and we'll walk out the door and that's the last time we ever see you. And you never heard anything about what they found out about what you were using or any report on their research. It was just like this stop along the way and they needed you but they really didn't want you to be part of it. So at first I was somewhat skeptical of getting involved with these guys. (Finn interview, June 6, 2003).

Her involvement in LeTUS has been quite different. "Clearly from the beginning, we were a part of what was happening. None of us ever felt that this was their agenda and we had to fit into their agenda. And Judy [another member of the ReNUE work circle] and I talked about this many times, the fact that we always felt like we were heard," (Finn interview, June 6, 2003). When during the summer of 1998, she and several other teachers spent some time doing curriculum design work at Northwestern, she was impressed by the accessibility and friendliness of the senior researchers on the project. "People around here don't make those distinctions in rank. And they're there. I mean, how could they not be? But it's not apparent and everybody's office door was always open and if you had a question and Louis was in his office you could go in. That was, again, it just added to that whole feeling of everybody being part of the same group," (Finn interview, June 6, 2003)¹².

Shrader commented that the researchers sometimes had to remind themselves that they also had important insights to bring to the design table. Early on in the ReNUE work circle's endeavor's, he and his colleague Rich Halverson realized that the group did not have a common understanding about what a project was. Halverson said that they should tell the teachers in their group what they thought a project was. Shrader thought this wouldn't be participatory, but Halverson convinced him to do it. They wrote up a one page description and brought it to the next meeting. To Shrader's surprise, the teachers appreciated it. They spent the rest of the

¹² There were about 20 teachers involved in the work circles Northwestern and CPS constructed in 1998. Their involvement in the Center's work was very deep. It would be interesting to know how teachers who were less involved in the design of the curricula or the design and implementation of the professional development associated with that curricula perceive the researcher-practitioner relationship in LeTUS.

meeting fleshing out their collective understanding of what a project was and then creating a set of decision rules for how they would go about making their project design decisions.

I learned a lot from that. I learned that we do know something and just because we're trying to build capacity doesn't mean we should forget what we know. A lot of times at the beginning of a work circle, the teachers would want to defer to what they thought was the expertise. That's why I was sensitive to them in the first place. You had to almost train them and you had to train yourself to know when it was one of these things that we were really going to care about and without it, it doesn't respect the larger intent and when is it that I just want it this way because I think it's important and I'm not hearing what they're telling me about why it won't work (Shrader interview, June 6, 2003).

As Shrader's comment indicates, the traditional researcher/practitioner power relationships did exist within the Center, despite the group's efforts to mediate them. Gomez believes they have not truly unpacked all of the implications of those relationships for their work. Nonetheless, it is clear that their mediating efforts have had a worthwhile influence.

Communicating across the traditional divide: District liaisons

In both districts a former science teacher was hired (using the district's LeTUS funds) to serve as a LeTUS curriculum specialist within the district and liaison with the university community. Barbara Steel and Chandra James both support the professional development of LeTUS teachers involved in their district. They also recruit classrooms and schools. When "control" classrooms are needed they locate them and provide the initial contacts. I was fortunate to hear Steel negotiating with one such school about participation as a control. She did a better job than most university researchers at explaining the essential focus of the study and the role she was asking them to play. She has a clear and deep understanding of the wide range of grants, research projects and questions being explored under the LeTUS umbrella. She also has strong relationships with many of the members of the research team and UMich. These relationships enable her to contact the right researcher about questions or concerns from particular teachers and principals and to request support from graduate students and LeTUS staff in some classrooms.

Likewise, Chandra James has been an essential ingredient in NWU's work with CPS. The decentralized nature of the district means that teacher recruitment is often by word of mouth and personal contacts. James is clearly well respected within the CPS science education community and her word has weight. Resier noted that when teachers were asked why they had chosen to participate, more often than not they replied, "Chandra told me to come" (Reiser interview, June 5, 2003). Thus, in many ways Steel and James *are* the face of LeTUS within their district communities.

Working toward scale and sustainability: Professional development

Those interviewed agreed that as the Center's work progressed, it became increasingly clear to all the collaborators that the need for a strong professional development infrastructure to support the work was critical. To create one, they needed to bring the same careful attention to the design and provision of professional development as they did to that of curriculum and technology.

We *design* curriculum and technology and then we *do* professional development. That's been the approach, pretty much in all of science education and most of the learning sciences. ... It made sense that we declare teacher learning and professional development as an area for close design and development. Just like anything else. And that we employ the same methods to understand teacher learning in this context and try to design better professional development in this context (Fishman interview, June 4, 2003).

Both locations have been struggling with how to make the professional development activities relevant and satisfying for both novice and experienced LeTUS teachers and have deepened the work done in those activities to something beyond a simple introduction to the contents of the curriculum. Both sites have engaged “core teachers” in the design and provision of professional development work. In the final year of the grant, nearly all the professional development in both cities was provided by teachers. They note that this has increased the credibility of the professional development in the eyes of the participating teachers and improved the capacity for showing how practical modifications can be made to suit various classroom contexts. “They’re [the teacher leaders providing professional development] saying, ‘This is what I did last week and this is how it worked with my kids. This is how I did it last year and this is how it worked with my kids.’ So it has a much higher level of credibility for the other teachers” (Steel interview, June 4, 2003). Both sites make summer institutes or conferences available to the teachers and they provide individual support for those teachers who ask for it¹³, but otherwise their professional development structure was quite different.

Northwestern University/Chicago Public Schools

The Chicago group has essentially two kinds of professional development opportunities in addition to individual support and summer workshops. First, before each unit is run, there is a “kick-off” meeting held in one of the participating schools. The kick-off meetings are often largely attended by teachers new to the unit being covered. However, there is a core of about ten teachers who tend to continuously come to most or all of them. Many of these ten teachers now help to provide the professional development.

In order to provide the teachers with the opportunity to delve into the ideas of technology-enriched project-based science more deeply, NWU also offers teachers semester course (10 weeks) for graduate credit. These courses are taught by a LeTUS teacher, but organized and planned in collaboration with NWU faculty.

In addition, Finn notes that the work circles served as a powerful form of professional development for the teachers involved. She explains that designing curriculum provided a regular, structured time and place for deeply reflecting on practice. “This we wouldn’t have thought about before, or maybe thought at some buried level, ... got pused to the front. How much do I really know about where my kids are? Do I really take time to think about what they’re bringing into the classroom and what their prior knowledge is? What do I do with the kids who are going off and all of that? ... To provide teachers with that opportunity is huge (Finn interview, June 6, 2003).

¹³ Individual support is largely provided by Lou-Ellen Finn and Chandra James in Chicago and Barbara Steel in Detroit. Brown seems to have better access to students and LeTUS staff in addition to herself to provide extra support when needed.

University of Michigan/Detroit Public Schools

As in Chicago, a group of core interested and dedicated to LeTUS emerged within the Detroit Public Schools:

It was clear we had a group of very committed teachers who were coming to everything. It was like LeTUS was their social life. They came to all of the Saturday workshops. They came to the summer thing. They came to all of the other kind of extra things that we were putting on and they were getting very knowledgeable and when they were meeting with teachers, they were saying “We can’t do it this way. We’ve got to do it this way. And don’t let the university tell me that this is a good activity; it’s not a good activity. Just don’t even bother with those things. Do it the way I think you should do it.” (Marx interview, June 4, 2003).

However, the Detroit group decided to build upon the work and expertise of these dedicated teachers in a slightly different way. They also offer graduate course work for teachers on issues related to the LeTUS curriculum and underlying pedagogy. But the bulk of their efforts have focused on creating a cohort of teachers who regularly attend monthly Saturday professional development meetings. These meetings were open to all LeTUS teachers, whether they participated in just one unit or several. The meetings are run by a group of seven teacher leaders who have participated deeply in the LeTUS curriculum for several years. The same teachers also been tapped to help advise the UMich research team on revisions done to the curriculum during the summer and so they have a particularly deep knowledge of it.¹⁴ This group is led by Barbara Steel, but they design their monthly plans in consultation with Barry Fishman and his team.

A week before each monthly meeting, Fishman and his team meet with Steel and her group of teacher leaders. Fishman brings research data in the form of teacher surveys from last year’s professional development related to the curricula they are about to cover, and the results of last year’s pre- and post-test measures of student achievement for the unit. He also brings summaries of findings from the research on the design of high quality professional development. Steel and the teacher leaders use this information to discuss ways they could improve each session from the way it was run last year.

At first, the Saturday professional development meetings focused solely on the current upcoming unit of the LeTUS curriculum and in this respect bore some resemblance to Chicago’s kick-off meetings. Some teachers came every Saturday, but others only came before the unit they were going to teach. Steel wanted to develop a more continuous and cohesive professional community among the LeTUS teachers and so she decided to expand on the professional development offerings. Now the Saturday meetings cover not only the LeTUS curriculum, but also the up and coming topics and activities for the “standard” DPS science curriculum. Through this shift in focus, she hopes to encourage more regular attendance and thereby develop a strong cohort of professionals (beyond the core lead teachers) who can support one another in implementing project-based science supported by technology.

¹⁴ They support curriculum rewrites as reviewers. The UMich team does the rewriting and sends them new versions to review and comment upon.

Focus of Professional Development

As LeTUS' work with professional development has deepened, it has also become more multi-faceted. Fishman notes that as the curriculum has become more refined, some of the principles underlying its design have become implicit. Teachers easily shift their focus from understanding the nature of project-based science and inquiry, to the steps necessary to enact the curriculum. In the process, the goals of this pedagogical change can be lost in the *doing* of the curriculum. "It started to appear to us like a lot of teachers might be measuring their success ... in terms of how many activities they survive, as opposed to thinking about how the activities fit together to form a coherent inquiry" and what core learning their students had gained (Fishman interview, June 4, 2003). The professional development work thus needs to be able to help teachers unpack those principles which have become implicit in the curricular design and help them keep the learning goals foremost in their minds.

Steel notes that the relationships between the activities within the units, the curriculum benchmarks required by the city, and the knowledge and skills students need to prepare for the state and city tests also need to be made evident. "I help them look at the LeTUS units and identify the most important points that they need to make sure they bring out with the kids so that they are prepared for the state-wide testing. ... What are the parts that you need to make sure you are focusing on that are related to our DPS objectives and our state-wide objectives," (Steel interview, June 4, 2003).

Finally, Reiser notes that curriculum based professional development is becoming a context for supporting teacher development of general strategies, such as ways of guiding brainstorming or asking students thought provoking questions

... [The lesson] becomes the particular context in which you get to talk about some deeper issues like "yes, there's questioning of kids but there's questioning and questioning." And the kind of questioning in IRE patterns are very different than the kind of questioning that helps the kids get their thinking out on the table when they're having trouble putting their ideas into words. Those are very different kinds of questioning (Reiser interview, June 5, 2003).

As a result of these needs, the professional development offerings have been designed to deepen teachers understanding of the goals, purpose, structure and enactment of the LeTUS curriculum.

*Principals and professional development*¹⁵.

Principals also received some form of professional development within the context of LeTUS. However, it appears that the offerings for principals were neither as extensive nor intensive as they were for teachers. More details need to be collected, but in Detroit, the major professional development activity was in the form of a meeting held each spring with all the

¹⁵ During data collection, the extent to which principals were engaged in LeTUS — as partners, objects of study or recipients of support, such as professional development — was rarely a topic of discussion. In a full case, this area would deserve some closer study. A review of the results of two projects affiliated with LeTUS, the Distributed Leadership Study (PI's Jim Spillane and John Diamond, funded by NSF and the Spencer Foundation) and the Administrator's Reform Community or ARC (PI's Barry Fishman and Louis Gomez, funded by the Joyce Foundation), might be useful to this end.

principals of schools participating in LeTUS. During this meeting, which was organized and run by Steel, members of the LeTUS team reviewed what principals needed to know or do in order to support teachers using LeTUS curricula in the coming year. At the same time, they were also provided a report on how well the work in LeTUS went in the current year, including information about student achievement in LeTUS classrooms. No information on the professional development offerings for principals in Chicago was collected.

Cross site synthesis: From planning meetings to grant and paper writing

Initially there were a lot of in person meetings to support collaboration between the two sites. Eventually, the groups settled into a loosely coupled collaboration, each working in detail on the needs of their individual district. At this point, writing papers for conferences and publications, and most especially, writing grants, is how the two university sites exchange information and consolidate their learning. One of the more interesting means of cross-site collaboration is a trend toward dissertation committees that have at least one faculty member from the sister institution sitting on it.

“Branding” the research-practice relationship: LeTUS Banners proudly displayed

For the districts, the term "LeTUS" has become a form of branding¹⁶ signifying all relationships with the respective universities that relate to efforts at improving middle school science instruction — regardless of the name given to each effort on the university side. This could be considered another strategy for sustaining and scaling innovation in the districts. Even projects that were not officially associated with LeTUS are introduced to schools and classrooms under that name. For example, Nancy Songer at University of Michigan also does work with innovative science instruction. She is not a part of LeTUS or of the hi-ce group. However, she has collegial relationships with that group and when she wanted to do work in the district, it was introduced under the “LeTUS” banner. And, there are in fact, big LeTUS banners up on the walls of some schools. This “branding” makes the work of districts and universities feel more continuous and less piecemeal than does the typical ebb and flow of related, but differently labeled, research projects. It may be that the “LeTUS” name itself is part of the organizational culture which enables sustainability of the work.

USE AND SPREAD OF KNOWLEDGE

Sources of knowledge

Research knowledge

Theories of learning from cognitive and socio-cultural psychology serve as the deep underpinning of all the design work the researchers involved in the LeTUS project do. They have also reviewed what other researchers have learned about curriculum and professional development design. Most of the literature they have read about curriculum development

¹⁶ Branding was not brought up as a “strategy” by any of the LeTUS interviewees. However, it became clear early on in the interviews that the LeTUS label was serving a larger role than simply as the name of a research project. I asked about it explicitly in the following interviews and think it is a theme worth following.

appears to come from researchers similar to themselves who started out from educational psychology or cognitive psychology perspective and moved into curriculum design as a natural extension of their efforts to make their work more viable in real classrooms. They do not appear to have studied curriculum theory or any design recommendations that might follow from that literature.¹⁷ General design theory and technical design theories, particularly that of learner centered design (an idea pioneered by Soloway and his students) and classroom centered design (an idea Edelson and Reiser have been working on), also inform their work. While they have not made deliberate attempts to strictly base their designs on any given theory of learning, they have done some post-hoc analysis which maps theory onto their designs. For example, a graduate student did a dissertation mapping ideas about epistemic forms and games onto their work. Their work is also strongly informed by both formal and informal data collection about the impact of their materials and supports on students and teachers.

Practioner knowledge

They bring practioner knowledge into the work primarily by involving practioners as key designers and producers of both curriculum and professional development. The two major conduits for passing that knowledge back to other teachers is (1) through the curricula and (2) through the conversations and interactions that occur within the professional development settings. The LeTUS researchers believe they have learned a lot of practical knowledge about curriculum development, designing professional development for teachers, forming productive working relationships between districts and researchers, and understanding and shaping the policy contexts for supporting innovation. However, they feel they have articulated and published only a small portion of that knowledge thus far.

School reformer knowledge

They have studied some of the school reform literature, but have not used it as a blue print for their own work. The researchers at Northwestern, however, have noted that two colleagues with significant experience in the Chicago Public Schools — Tony Bryk and Fred Hess — have provided them with valuable insights into the particulars of the history and challenges of reform in Chicago. They have found many of the recommendations useful for successfully managing their relationship with the district, but have only recently been able to make progress on some of the substantive recommendations (e.g. you have to tie your work into mathematics and literacy if you want Chicago to care).

Curriculum development knowledge

No one interviewed at either site mentioned hiring professional curriculum developers to help with their work. On the other hand, at least one of their publications (Singer, Marx, Krajcik, Clay Chambers, 2000), describes “curriculum specialists” as among those collaborating on

¹⁷ Curriculum theory tends to be a very theoretical and philosophical field, currently somewhat divorced from practice. Marx, who is familiar with this area, felt it would not have been of much practical value to them (paraphrase from phone conversation with Marx, August 26, 2003). Gomez, who is not familiar with the area, mentioned that by the time they had begun to think of themselves as curriculum developers, they were knee deep in the task and had already developed their own ways of approaching it (paraphrase from phone conversation with Gomez, September 8, 2003).

curriculum development. It is not clear from this initial data collection to what extent the Center explored and learned from the practices of professional curriculum developers.

Software development knowledge

The role of professional software developers in LeTUS' endeavors was not discussed explicitly with any of the interviewees. Nonetheless, there is substantial knowledge about computing and software design among the Center's primary research faculty. Edelson and Soloway are computer scientists by training. Edelson and Gomez hold cross-appointments in computer science. Soloway's main appointment is in the College of Engineering with a cross-appointment to Education. Most of the software development appears to have been done in house and the LeTUS website indicates that computing professionals were on staff.

Mechanisms for learning

When asked about the mechanisms they have in place for learning along the way, the researchers generally mentioned meetings with one another and district leaders, grant writing and crafting papers for conferences and publication. The last two in particular were stressed. The researchers seemed to feel that their real learning was done during the process of reflection and consolidation necessary to write papers or grants. Interestingly, they seemed to feel that they learned more when writing grants than when writing papers. However, it's clear they have other mechanisms in place as well. For example, they do collect a substantial amount of data about both students and teachers which feeds into their design and redesign work. Also, their district liaisons seem to serve as informal sources of insight into teachers' "on the ground practice" when and where they have less formalized research instruments in place.

Storing and passing on knowledge

The Center has had much turn-over among teachers, graduate students and post-docs, but very little among its core leadership positions. The central researchers have remained essentially unchanged and, with the exception of the co-director for CPS, the leading district personnel has also been highly stable. As a result, they have so far avoided some of the pitfalls that befall projects when core personnel with key knowledge, skills or interpersonal ties leave.

Still, the turnover at the "lower ranks" does have an impact. The curricula serves as a major source of knowledge within the center — it serves as a common referent, language and repository of what the group knows about conducting projects in middle school science classrooms. However, it does not function entirely on its own. Early on, when an "advocate" for a particular curricular unit moved on to a new position (as post-docs and graduate students are likely to do), the unit they were in charge of would sometimes "fall off the radar screen" of the organization as a whole. Under these circumstances, the unit might not get promoted as well within the district, nor be revised and updated along with the others, nor the professional development for the unit be put together as well. This was more of a problem at Northwestern University, where they did not have a team devoted to overarching curriculum oversight. This is less of a problem now that Reiser is taking on that role.

Teacher turnover also creates a problem in that both districts constantly have new teachers as well as experienced teachers involved in the LeTUS project. The spread of experience and success each teacher has with the different units makes professional development challenging as they each need different kinds of support. On the other hand, the existence of the more experienced teachers creates a natural repository of knowledge and experience for the novice teachers to tap into if only the connections can be made. In some cases, informal mentoring of novice teachers by experienced LeTUS teachers has been known to happen within individual schools and there has even been some exchange between teachers across schools. However, they do not have the kind of data collection necessary to know how often such exchanges happen or what the impact of them may be.

At this point, the typical process for new researchers to gain knowledge is generally by looking at the curriculum and research papers and “talking to people”, while the process for new teachers is to look at the curriculum and participate in the professional development activities. In the early days of the project, another vehicle for the exchange of knowledge was regular in-class support from graduate students and post-docs. During the period when units were initially being piloted, the piloting teachers often had a graduate or post-doctoral student in their class daily, either explicitly there to provide support or else to collect research data. Even when present in the capacity of collecting research data, the researchers were able to provide assistance when difficulties arose. In this way, researchers learned more about what the teachers needed and how well the curriculum and technology were functioning and the teachers learned more about how to implement the use of the curriculum and technology. Steel notes that as they expand the number of classrooms they are serving and funding drops, there is less of this kind of in-class support available and so the newer teachers appear to “ramp up” with the curriculum more slowly than do the early ones.

They have also been experimenting with on-line repositories to help them make useful information about enacting the curriculum available. These include Northwestern’s *Living Curriculum* project mentioned earlier, and *Knowledge Networks On the Web* (KNOW, <http://know.soe.umich.edu/>), a professional development system build around the LeTUS curriculum that “adds a collection of videos, student artifacts, and other enhancements designed to help teachers understand how to interpret curriculum so that it becomes more useable in their local context” (Fishman vitae, July 2003).

THE CENTER’S SUCCESS

The eight interviewees mentioned many different potential measures of success for the project, which have been broken down into six main categories: scholarly contributions; deepening relationships; development of usable materials; changes to district policy, organization or goals; improvements in student performance; and scale and sustainability.

Scholarly contributions

Most of the researchers mentioned scholarly contributions of one kind or another as being an important goal for the work. Marx noted the importance that their work have academic merit, theoretical coherence and be known and respected by colleagues. He feels they have made

progress on all three fronts.¹⁸ Krajcik felt a strong measure of their success was the amount of learning the researchers believe they have done during their work with LeTUS. He notes that he himself has learned much about what is *really* possible with respect to project-based science in classrooms. They and others see these achievements as being reflected in their success at publishing their findings and insights from the work, as well as in their ability to receive funding to continue and extend it.

At the same time, several of the researchers noted that their publication rate was not quite what they would like. They cite the complexity of conducting the work itself as well as the need for new forms of reporting appropriate for this work as being barriers to publication. They feel there is increasing evidence that their style of working with these districts is important and of interest to colleagues. Unfortunately, they haven't clearly articulated a description of what that style consists of for themselves, much less for the rest of the academic world (paraphrase from Gomez interview, June 6, 2003).

Deepening of relationships

Relationships were central to the plan and they hoped to strengthen them in many directions. They found it difficult to cultivate relationships between the two districts. While they did succeed in building fledgling relationships between each district and the non-local university, what generally happened was that relationships already in existence became stronger. In particular, the relationship between each university team and its local district became stronger and the relationship between the two research teams became *very* strong.

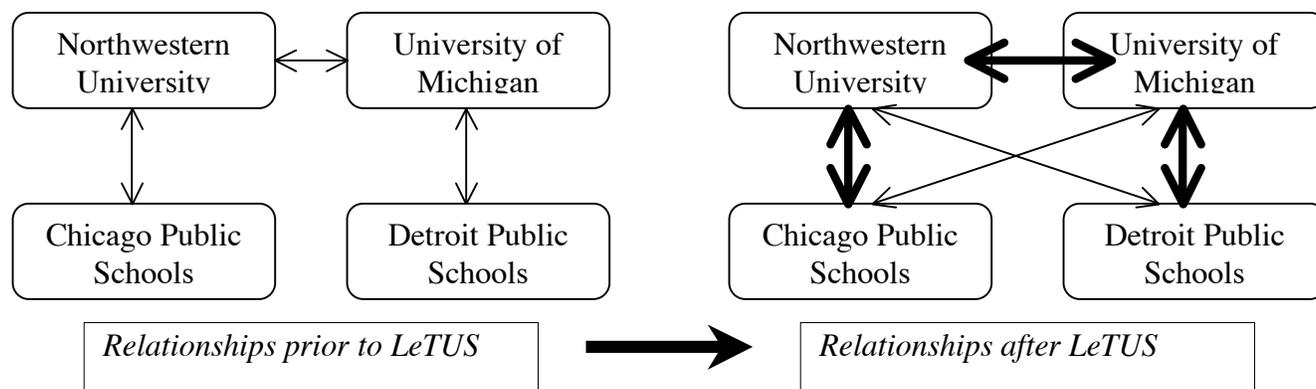


Figure 1

Joe Krajcik's Diagram of Changes in the Relationships within the LeTUS Organization Over Time

¹⁸ The breadth and focus of their scholarly work was not covered deeply in the data collected for this case and warrants closer attention. They appear, however, to be making contributions to both theory and practice on a number of fronts, such as the relationship between student motivation and achievement, effective design of inquiry based curricula and associated technologies, teaching and teacher learning, effects of inquiry techniques on student learning, the organizational structures necessary to support systemic change, etc.

Development of materials that are usable by K-12 teachers and students

Usability of the materials

There seems to be wide agreement about and relative satisfaction with the usability of the materials among the interviewees. They are also pleased with the amount they have collectively learned about how to develop strong curriculum materials. However, Gomez notes that they have not yet solved the problem of making the materials generative rather than simply found objects.

Teacher Participation

Since the LeTUS curriculum units are optional, one measure of success is the extent to which they are used. Unfortunately, estimating use is somewhat difficult since it is not clear to what extent teachers who no longer participate in professional development and are not in some kind of contact with project staff continue to use the materials. UMich estimates that approximately 30% of DPS middle school classrooms use at least one of the LeTUS units and that between 25%-30% of middle school students are enrolled in these classes. Fishman believes about 85 teachers are currently involved in their professional development work and they have worked with around 100 altogether. None of the teachers who are still teaching in the district have discontinued using the LeTUS curricula. Those who are no longer involved with the Center have either left teaching or left the district. They continue to have teachers interested in joining and those who want to take leadership roles. “When I have other teachers who are not in LeTUS call me and say, ‘How can we get in the program?’ Then I know that other people are talking about it and having good things to say” (Steel interview, June 4, 2003).

In Chicago, the numbers are a little harder to pin down. Finn estimates that between 50-70 Chicago teachers are involved in any given year, but the turnover rate is fairly high. Most teachers only come to the workshops or kick-off events once. Since many of the faces she sees are new ones, it is hard to estimate how many teachers continue to participate. Shrader and Finn believe the total number of teachers involved over the course of the Center may have been around 200. However, the typical LeTUS teacher is only clearly on the Center’s radar screen for about eighteen months. Shrader guesses that of those who stop coming to regular LeTUS professional development, about 25% probably continue to use the LeTUS curricula, while the rest are “caught up in the next big thing” (Shrader interview, June 6, 2003). On the other hand, the core of 40-50 teachers who continue to participate form a strong “professional network of teachers inside of the Chicago Public Schools who get to know LeTUS, who run our courses, and who run our professional development” (Shrader interview, June 6, 2003).

Changes to district policy, organization or goals

Official adoption of LeTUS projects/units

In both school districts, the LeTUS curriculum is considered an approved and official option for middle school science teachers. More than one interviewee cited this as either the most important or one of the most important successes they have had.

Shifts in allocation of district funds to support infrastructure for LeTUS

In both locations, the science curriculum offices have been looking for more money to continue support of the infrastructure LeTUS has put in place (e.g. funds for professional development and support personnel). Gomez notes that one of the true impacts of LeTUS on the Chicago Public Schools is the hiring and training of key district personnel. CPS recently hired an assistant director for the district's mathematics and science initiative, Mike Lock, who worked for two years as a LeTUS post-doc with Danny Edelson. "One might argue that two-thirds of the core leadership in science in Chicago right now [Lock and Chandra James], were people who spent multiple years in our organization," (Gomez interview, June 6, 2003).

Moreover, the district is currently using the Northwestern graduate courses designed for LeTUS teachers and the work circle method as models to inform their non-LeTUS professional development offerings in mathematics and science. They have the network of core LeTUS teachers to help them provide those offerings. Through the provision of these models and the close work they've done with core district personnel, they feel they have "really built serious capacity in the district to understand the general science and math pedagogy issues that are important here and that's what drives the district's math and science initiative right now" (Shrader interview, June 6, 2003).

Shifts in district curricular objectives

Joe Krajcik was asked to join with educators in Detroit Public Schools on a revision of their curricular objectives for science at each grade level. This collaboration enabled a synergy to emerge between the design work on LeTUS curricular units being led by the university researchers in collaboration with teachers and the overarching curriculum framework the district leaders were putting into place.

Work is owned or valued by members of the district

Gomez feels that in CPS, LeTUS is considered a valuable resource by district leaders and that teachers who are involved feel ownership of the work, however, principals, in general, are merely aware of the project¹⁹. Likewise, Marx notes that there is strong support for the LeTUS work from the central administration of DPS, despite superintendent changes during the course of the project. Gray's consistent and supportive role is at least part of their success in this respect. Marx believes such support is essential to making any progress in the classrooms. However, he also noted that they have never really focused their efforts on cultivating strong relationships with school administrators and have developed them with about only 20% of the principals in the district.

¹⁹ Given the decentralized nature of CPS, it seems a little strange that the principals would be so little involved. One would think that cultivating enthusiastic and committed principals would be critical to ensuring strong teacher participation. A fuller case might wish to explore this question further. (See footnote 15 on page 18).

Improvements in student performance

Impressive student work

Gomez notes that they have collected impressive examples of student work done within the context of LeTUS classrooms that show urban students can engage in reasoning and produce work as accomplished as that of students in more privileged settings, or indeed, in any setting.

Gains on pre-post unit tests

Pre and post tests designed by research staff to go along with the curriculum units show learning gains. The UMich group had begun developing such assessments fairly early, at least in part because of the REPP grant they received aimed explicitly at developing assessments of student learning. The paper and pencil assessments they created consisted of both multiple-choice and free response items. Some of these items were designed to capture students' *curriculum content knowledge*, while others assess their *science process skills*. The content and process items were further categories as belong to one of three cognitive levels: *lower* (e.g. recalling information), *middle* (e.g. shifting between representations such as verbal and graphical) and *higher* (e.g., defining or isolating variables in a given scenario).

In a paper currently under review with the Journal of Research in Science Teaching (Marx, et al, under review), the LeTUS researchers at Michigan review findings from the pre and post test data collected for five different units over three years (from 1998-99 to 2000-2001). These data show statistically reliable gains in both content and process skills and across all three cognitive levels for all five curricular units in all three years.²⁰ Furthermore, the effect sizes of these gains were more robust in 1999-2000 and 2000-2001 than they were in 1998-99.

Because of mutually agreed upon procedures established with Detroit Public Schools, the UMich does not collect, nor do they report data based upon the racial or ethnic identities of students. The research team at Northwestern, however, has been able to compare pre and post test differences in achievement between boys and girls, black and white students and those from impoverished versus more affluent backgrounds. The development of pre and posttests at Northwestern did not begin in earnest until they had hired Phillip Herman to oversee the work. As a result, their data do not go back quite as many years and they are still in the process of completing some of their analyses. Thus far, their work shows gains between the pre and posttests overall as well as gains for both impoverished students and those from middle-class or affluent backgrounds (Herman, Mackenzie, Sherin & Reiser, 2002; Herman, Mackenzie & Rose, 2003; Herman, Mackenzie, Reiser & Sherin, 2003).

Herman and Marx both shared methodological concerns about their findings from the pre and posttest data. Marx points out that the pre posttests are designed specifically to assess what the units are meant to teach, "So in a sense, it's not surprising that we're able to get decent effect sizes" (Marx interview, June 4, 2003). He notes that the districts might find such data somewhat

²⁰ Exceptions are: the process score for the 1998-99 administration of the Water Quality unit; the "low" items for the 1998-99 Air Quality unit and the "high" items on the 1998-99 Water Quality unit. Also, the gains on content items were more robust than those on the process items.

self-serving and are much more concerned with the results of the politically important tests required by the state.

Herman points out that it is difficult to interpret the pre and posttest data without knowing something about how each teacher enacted the curriculum. He explained that the Northwestern team works hard to get the results of the pre and posttests back to teachers quickly — a difficult task considering the labor involved in scoring the open-response items on the tests — and discussing those scores with them. During those discussions, the teachers often talk about how they think the choices they made in enacting the curriculum may relate to the scores their students' received. Herman says it is not uncommon for the teachers to look at the tests and how they were scored and say something to the effect of, "Oh, I didn't know that this is what the curriculum was about!" (phone conversation with Herman, September 16, 2003). Since the pre and posttests only *sample* the content and processes students are to learn, there is some concern about the effect the test results will have on how the teachers enact the curriculum in the following year. Will it be a positive one? Or will it somehow constrain their vision of what the curriculum is about in unfortunate ways?

Gains on standardized tests

There are two kinds of standardized test data available from Detroit. The city administers the Terra Nova (CTB/McGraw-Hill) in mathematics, reading, science and social students for all students in first through eighth grades. In addition, the state administers their Michigan Educational Assessment Program (MEAP) in science in grades five and eight. University of Michigan looked at the impact of participating in LeTUS units on student achievement on science MEAP in both 2000 and 2001. Middle school aged students are tested in science in eighth grade and may have participated in up to three LeTUS units (two available in seventh grade and one available eighth grade). The students in Detroit classrooms where at least one LeTUS unit was run performed 13.2% better than did other middle school students throughout the Detroit Public Schools (effect size = 0.4, $p < 0.001$) in 2000 and 13% better in 2001 (effect size 0.38, $p < 0.001$), (LeTUS Team, University of Michigan, 2003).

Generally, not every classroom in a school was using the LeTUS units and some schools had no middle school classrooms in which the LeTUS curriculum was used. To make certain that the differences in achievement were due to the LeTUS curriculum and not other contextual factors associated with particular schools, they also reviewed a subset of the data which included only those schools in which at least one classroom was using the LeTUS curriculum. In 2000, these data showed that students in classrooms in which at least one LeTUS unit was used performed 15.5% better on the 8th grade MEAP in science (effect size = 0.45, $p < 0.001$). The effect was somewhat smaller in 2001 yet still substantive, with LeTUS students doing 10.8% better than their counterparts in the same school (effect size = 0.31, $p < 0.001$). This change may be related in part to the larger number of participating schools, some of which were higher performers in general (LeTUS Team, University of Michigan, 2003).

Standardized test data in science for Chicago students has been more difficult to access. The NWU research team is currently waiting for data for some years and in the process of analyzing it for others and so the findings are not yet available. They have explored to some

extent students' performance on literacy test scores and see some indication that the LeTUS units are having a positive effect.

Student engagement and motivation

Marx notes that generally students' academic motivation drops across the middle school years. In Detroit's LeTUS classrooms, they are seeing not seeing this drop. While motivation "is not necessarily going up, it isn't going down," (Marx interview, June 4, 2003). They are currently working on path models that enable them to look at students' perception of their instructional environment, motivation and science achievement (Middleton, Blumenfeld & Marx, in review). The story these models tell is a rather complex one and does not indicate much of direct relationship between student's motivation levels and academic achievement in LeTUS classrooms. Marx notes that this is a common finding within the field of motivation and achievement.

Likewise, Herman describes their findings on the links between student motivation and achievement in Chicago LeTUS classrooms as complex. They can explain some of the variance in achievement via motivation, but there are a number of constructs one can use to capture different aspects of motivation. Whether they see effects or not depends upon which constructs are being examined and in which classroom contexts. He notes that in some LeTUS classrooms they still see the drop in motivation that middle school children typically exhibit. In others they do not. Currently, they are interested in untangling what kinds of LeTUS enactment or classroom circumstances lead to a lack of drop (or a rise) in motivation and which of the motivational constructions go up or down.

Teacher growth

In Michigan, they've been looking at trends in student learning over time as a way to measure improvements in individual teachers. The trajectories vary greatly. Some teachers have slow, but steady improvements in their students' learning gains, others experience periods of little to no improvement followed by sudden, strong gains and still others show no improvement at all. Overall, however, they are pleased with the impact that involvement in LeTUS appears to have on teaching as measured by student achievement.

They have also been looking at teaching practice directly in a subset of the classrooms. Fishman and his students have been studying the links between professional development, teaching practice and student achievement with respect to a particular unit (Communicable Diseases). Likewise, Blumenfeld and her team are working with a small number of teachers on closely examining specific teaching strategies that make the units more effective ones and collecting research data on these efforts. The data collected for this report did not include any information on the findings from these two studies.

The Northwestern team has attempted to collect *direct* data about the enactment of the LeTUS curricula. However, the number of classrooms involved makes it difficult to collect such data in a useable and useful form. Based on her observations of teachers in LeTUS classrooms and LeTUS professional development activities, Finn believes they have changed teacher practice in positive ways. Gomez notes, however, that their formal data collection on teacher

enactment and instruction has thus far not been a robust one from which they can make generalized statements.

Scale and sustainability

More than one interviewee indicated that the Center focused more on building sustainable change with a large and significant core of each district than on scaling broadly. So far, their efforts at scale could be considered “moderate” (affecting approximately 30% of middle school science classrooms in the participating districts) and all the interviewees seem fairly satisfied with the level of sustainability they have achieved.

Scale is generally considered in one of three ways: take on more classrooms; take on entire school or district systems; or extend the innovation to cover more subject matter. The nature of the early pre-LeTUS work of many of the researchers focused on very specific curricular topics. With the exception of CoVis, they also mainly worked with a relatively small number of teachers.²¹ Although CoVis scaled to many classrooms, they never really grappled with the problem of implementing reform throughout a school or district. The hi-ce group had some fledging experience in building close working relationships with schools during its *Community Science Connections* project, but they had not yet tackled an entire district system.

LeTUS attacked the issue of scale on all three of these fronts at once, but in a relatively modest way. They took on two districts and *only* two districts and allowed each university team to focus on just one of them. They expanded their curricular repertoire, but did not endeavor to create a *complete* middle school curriculum. Moreover, their strategy of creating replacement (i.e. optional) curricula allowed them to work with a slowly increasing pool of *willing* teachers within each district.²² Thus, they were able to scale to many more classrooms, but without needing to tackle the problem of teachers who are truly uninterested in or resistant to change. These modest attempts at scale enabled them to learn about the infrastructure supports necessary to facilitate their curricular and technological innovations without over taxing their own ability to provide it.²³

Even these modest attempts at scale required the researchers on the LeTUS team to make significant shifts in their perception of their work. For example, robust curricula and professional development became necessary vehicles for supporting classroom change in a way they were not when the researchers worked closely with much smaller numbers of teachers in their pre-LeTUS work. Moreover, their research plans and instruments had to be tenable at this level of scale as well as accountable to the political realities their district partners faced. For example, when describing the challenges of building sound assessments that could be used in large numbers of Chicago classrooms, Herman and his LeTUS colleagues note an important shift they had to make in their own thinking about how to best measure student learning

²¹ PBS did hold summer institutes toward the end of their grant, each of which involved about 75 teachers across the state, but this was considered a dissemination piece rather than the core of their work.

²² I'm not sure to what extent *all* teachers were willing participants in Detroit. Gray handpicked schools to participate and it may be that all teachers in those schools were required to do so.

²³ ...Or at least not to the extent that they floundered in their efforts. Most of the interviewees mentioned being stretched to the limit and beyond in one way or another.

These “realizations” [about test format, item difficulty, etc.] may seem trivial to some readers, but they represent a difficult but important shift for those in our research tradition. We believe in engaging individual students in meaningful scientific inquiry, and in fostering deep conceptual change. Within this tradition, qualitative methods focused on relatively small numbers of students are the norm. But, as we have attempted to evaluate the impact of LeTUS units on students learning in hundreds of classrooms, we have increasingly felt the need to develop and administer written tests to students, with relatively straightforward items. (Herman, MacKenzie, Sherin & Reiser, 2002).

Likewise, Fishman notes that one of his major research goals at the moment is to design less labor-intensive measures of teacher practice as it relates to professional development that are nonetheless richer than very simple teacher self-report questionnaires. In a fuller case, such shifts in the methods and practices of the researchers might be worth exploring in more depth, particularly as they relate to making the research/practice partnership a viable one.

THE FUTURE OF LETUS

The funding for LeTUS is either over or near-over. However, both of the groups (UMich-DPS and NWU-CPS) currently plan to continue their relationships in some form. At the same time, the researchers at NWU and UMich have written and received several grants — in particular, two for the development of middle-school science curricula — which will allow the cross-site collaboration to continue. Moreover, many of the units produced for LeTUS continue to be available to the teachers in both locations as district sanctioned “alternatives” or options to more traditional curricula.

Follow-up grants: A shift to large-scale curriculum design

The research teams at UMich and NWU have received two large curriculum development grants. One of these, which they refer to as IQWST (Investigating Questions in Our world Through Science and Technology), is an instructional materials grant from NSF to develop the next generation of middle school science materials. It has an eight to ten year time frame for completion. The second grant, also an instructional materials development grant from NSF, which they refer to as the “Kolodner grant” is a collaboration between LeTUS researchers and Janet Kolodner’s group at Georgia Tech to take the middle school units they have each already developed and make them publishable. This second grant has a three to four year time frame for completion. There are a number of other related grants and activities, but these two will clearly form the core of their collaborative work for the next few years.

Because these new materials are to be made available to school districts across the country, they will necessarily not be as context bound as the original LeTUS materials were. As mentioned earlier, the two districts were rarely able to use the units one another created. While the new materials will be based upon *national* standards, they will most likely not have the careful link-up with *local* standards that LeTUS curriculum currently enjoys. This creates an interesting question about the extent to which the locally contextualized design was an important feature to the success of the units in Detroit and Chicago.²⁴

²⁴ The current versions of the written curricula do not have these localized links spelled out explicitly. They do have an indication about what national standards are covered by each unit, but they are not described lesson by lesson. Steel indicates that links to national standards alone wouldn’t be sufficient for her teachers. “I think that even if they

What's in a name?

Interestingly, as they go forward, there is some discussion about what will happen with the LeTUS name. Some researchers, who see the work as shifting now in substantive ways, are in favor of new names that will effectively label or brand that new work. As they point out, their *academic* colleagues will want to keep separate the early design work done in LeTUS from the more formal curriculum design they are doing now. And clearly, the two streams of publishable curricula need to be kept identifiable for the sake of publishers and potential purchasers. Marx notes that Detroit would like to keep the name consistent, "They would like to keep that brand name there. From the school district's point of view, this is LeTUS," (Marx interview, June 4, 2003). Steel, representing DPS, clearly believes that the LeTUS name should stay. "We're not changing any titles for our teachers. It's LeTUS. It will always be LeTUS. ... The name is not going to change because if we do that, it would be chaotic" (Steel interview, June 4, 2003). It will be interesting to see how the group decides to balance the branding needs for supporting district-university relationships versus those necessary to converse with publishers and academic colleagues.

Changes in leadership

There are two major changes currently occurring in the top-level leadership of the LeTUS collaboration, both involving the university co-directors. However, neither change seems likely to derail the effort. First, Louis Gomez has been less centrally involved in the work during the last couple years of the grant. His research interests have diverged somewhat from that of the rest of the Northwestern team. As the work shifts more into a curriculum development focus, Brian Reiser and Danny Edelson have taken on the leadership role for the Northwestern team. Gomez continues to work with the others. In particular, because he has long-standing and cordial relationships with many of the central administration in CPS, he continues to serve as a liaison in that respect. This appears to have been a gradual shift and a generally smooth transition.

Second, Ron Marx was recently offered a deanship at a university in Arizona. He will be starting that position in August of 2003 and is currently in the process of wrapping up his work at University of Michigan and preparing to move. This will be a more abrupt transition. The other hi-ce members I talked to indicated that they will miss him, but seemed cheerful and supportive of his move. Marx is curious about how his leaving will affect the functioning of the team. He sees himself as the generalist in the group — the others each have clear niches, while he participated somewhat in everything. It is not clear to what extent this meant he served as a kind of social glue for them and therefore helped them create the seamless face of LeTUS for Detroit Public Schools and whether or not that role will be missed when he is gone.

It is significant that these changes are coming simultaneously with a shift in the focus of the work. As the group has begun to move their efforts to focus more on large-scale curriculum development, Krajcik and Reiser have taken on the lead roles (Gomez phone conversation ,

did [spell out the links by lesson] by national standards, it wouldn't necessarily be helpful for our teachers because we really don't work at the national standards level on the day-to-day teaching. They really look at the Michigan's benchmarks because the Michigan benchmarks are already tied to the national standards, or the DPS objectives which come from the Michigan benchmarks, so they are at a more finite level" (Brown interview, June 4, 2003).

September 8, 2003). The new leadership may represent logical affinities and strengths among the research team as much as they do changes in Gomez's and Marx's professional careers.

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Phone calls and email correspondence with Phillip Herman.

LeTUS website (www.letus.org)

Award abstracts from NSF for LeTUS, the Living Curriculum Project, and Using Information Technologies to Support Middle School Students in Scientific Inquiry Project

Brochure for the Center for Curriculum Materials in Science.

My own experiences as a former graduate student on the Learning through Collaborative Visualization Project

APPENDIX A: LETUS PROJECT PROPOSAL ABSTRACT

LeTUS Project Abstract

NSF Award Abstract Database

Retrieved June 18, 2003

<https://www.fastlane.nsf.gov/servlet/showaward?award=9720383>

The Center for Learning Technologies in Urban Schools will help urban school communities integrate advanced technologies for teaching and learning with their education reform plans. The goal of the Center is to help these technologies become pervasive in science curricula and routine components of the learning experience. The Center is a partnership among the Chicago and Detroit Public Schools, and education and technology researchers at Northwestern University and the University of Michigan. The Center's premise is that urban schools represent a challenging and important setting for shaping and assessing new organizational and teaching practices supported by technology, and the technologies that optimize such support. Schools in Chicago and Detroit are currently developing and implementing new curriculum frameworks, new standards and practices for professional development, and new community-based structures that support teaching and learning in classrooms. The Center will capitalize on these efforts and on research at Northwestern University and the University of Michigan to develop models of science learning based on science practice, modeling and simulation, scientific visualization, and tools for computer-supported collaboration that can enrich urban schools. The Center will encourage schools to create challenging implementations for learning technologies, and support the schools in such endeavors. Teams of teachers and researchers will work to understand how to make new technologies work in urban and non-urban communities across the nation. The result of the Center's efforts will be new technologies, and improved school organizations that are better structured to facilitate the adoption of new technology and rigorous, new science curricula.

APPENDIX B: LETUS CURRICULUM OVERVIEW

Chicago and Northwestern Curricula	Detroit and U. Michigan Curricula
<p>Behavior Matters (6th grade)</p> <ul style="list-style-type: none"> • <i>Question:</i> What is animal behavior, how do we study it and how does it relate to conservation? • <i>Science content:</i> Animal behavior, conservation principles and scientific method <p>Earth Structures (6th grade)</p> <ul style="list-style-type: none"> • <i>Question:</i> How will the movement of tectonic plates affect the earth's crust? • <i>Science content:</i> Earth's crust, plate tectonics, earthquakes, volcanoes, latitude and longitude, modeling, map reading, geography <p>Struggle for Survival (6th grade)</p> <ul style="list-style-type: none"> • <i>Question:</i> What is causing an island ecosystem crisis, and how are some animals managing to survive? • <i>Science content:</i> Complex ecosystems, natural selection, species interaction 	<p>BioKids (6th grade)</p> <ul style="list-style-type: none"> • <i>Science content:</i> Ecosystems and biodiversity <p>Kids as Global Scientists (6th grade)</p> <ul style="list-style-type: none"> • <i>Question:</i> What makes our weather? • <i>Science content:</i> Clouds and humidity, wind, temperature, precipitation and pressure, energy transfer, Earth as a system <p>Simple Machines (6th grade)</p> <ul style="list-style-type: none"> • <i>Question:</i> How do machines help me move big things? • <i>Science content:</i> Force, motion, distance, simple machines
<p>I, Bio (7th grade)</p> <ul style="list-style-type: none"> • <i>Question:</i> How well do my school lunch choices meet my body's energy needs? • <i>Science content:</i> Cells, energy transformation, organ systems, human biology, health, physiology, physics, cell structure and function <p>ReNUE (7th grade)</p> <ul style="list-style-type: none"> • No longer in use? (Not on LeTUS website) <p>Solar Energy (7th grade)</p> <ul style="list-style-type: none"> • <i>Question:</i> Can you design a habitable house using only passive solar energy? • <i>Science content:</i> Energy transfer, heat transfer, renewable and nonrenewable energy resources, insulation 	<p>Air Quality (7th grade)</p> <ul style="list-style-type: none"> • <i>Question:</i> What affects the quality of the air in my community? • <i>Science content:</i> Chemical and physical properties of pollutants <p>Communicable Diseases (7th grade)</p> <ul style="list-style-type: none"> • <i>Question:</i> How can good friends make me sick? • <i>Science content:</i> The biology of disease, how diseases spread and how our bodies fight them; also covers STDs. <p>Water Quality (7th grade)</p> <ul style="list-style-type: none"> • <i>Question:</i> What is the water like in our river? • <i>Science content:</i> Watersheds, erosion and deposition, how chemistry and biology affect water quality
<p>Global Warming (8th grade)</p> <ul style="list-style-type: none"> • <i>Question:</i> Why do scientists think people are making the Earth's climate warmer? • <i>Science content:</i> Temperature, energy balance, population, and carbon emissions <p>Planetary Forecaster (8th grade)</p> <ul style="list-style-type: none"> • <i>Question:</i> What are the major factors that affect surface temperature and how do each of these factors affect temperature? • <i>Science content:</i> Curvature of the Earth's surface, the tilt of the Earth's axis, land/water differences in specific heat, surface elevation <p>Water Quality (8th grade) (They use the UMich/DPS unit.)</p>	<p>Bike Helmet (8th grade)</p> <ul style="list-style-type: none"> • <i>Question:</i> Why do I need to wear a bike helmet? • <i>Science content:</i> Motion, force, velocity, acceleration

Notes: Grade levels for Chicago are those suggested by the Center based on their match to CPS' Standards and Frameworks. However, because the curriculum is not standardized, teachers in the district, often use them at grade levels other than those suggested. BioKIDS and Kids as Global Scientists are both projects run by Dr. Nancy Songer at University of Michigan, who is neither a participant in LeTUS nor a member of hi-ce. Nonetheless, her curriculum and activities are offered to district teachers under the LeTUS umbrella.