Editorial

Teachers Researching, Children Designing

Gary Benenson

Why Research in Technology Education must Involve Teachers

The recent AAAS Research on Technology Education Conference (see Cajas, 2000) established both the need for research and some of the directions it should take. There was general consensus among the participants that research needs to focus on what actually happens in the classroom: how teachers teach and how students learn. Research should begin with some conception of the goals appropriate for technology education, and then look for the ways in which these are or are not achieved. Schoenfeld (1998), Lewis (1999), McCormick (2000) and Hennessy & McCormick (1994) also make the case for investigations grounded in classroom practice.

However, as so often happens in education, there is a wide gap between intention and implementation. Karen Zuga's paper (2000) showed that very little of the current research is focused on teaching and learning in technology classrooms. Moreover, participant Mark Sanders pointed out that the problem is compounded by a shrinking pool of researchers. Its importance notwithstanding, it is unclear who will actually do this research.

There is an obvious, but largely overlooked answer to this question. Even in the United States, teachers are gradually becoming attracted by the promise of technology education. Several large NSF-funded projects are demonstrating the potential role of technology as a spur to literacy, both as motivation for math and science, and for teaching general problem-solving strategies. The standards may also help in this regard. The *Benchmarks* (American Association for the Advancement of Science, 1993) clearly express the importance of technology in the curriculum while the national standards for mathematics, science, and English call for contextual learning that can easily occur within the contexts of technology. As teachers experiment with this new subject material, many issues about teaching and learning will naturally arise. With appropriate support, teachers can play key roles in exploring many of the research questions in technology education.

There is an even more important argument for teachers' participation in educational research. Too many educational research projects have little to do with the day-to-day realities of the classroom teacher. Teachers are sometimes seen as irrelevant to "larger issues" such as standards, curriculum, or children's cognitive development. This point of view is reflected in cynical terms such as "teacher-proof curriculum." At best, the traditional researcher regards the

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teacher as a "subject of study" rather than as a partner in the research effort. Partly as a result of these attitudes, few teachers think that educational research could be of much use in informing classroom practice. As Torbert (1981) pointed out, educational research that ignores the classroom is unlikely to have much meaning for classroom teachers.

Every classroom has its own accepted beliefs and norms, its own dynamic patterns of interactions, and its own authority structure. As in other primary groups, the individuals in a classroom develop shared perspectives that sometimes enable them to solve problems and negotiate differences (Charon, 1998). There are also larger social units that interact with the classroom; these include the school, the community and the school system. All classroom teaching and learning occur within complex social and cultural environments. Research that ignores these factors cannot provide much insight into how and what children learn in school.

Moving the research venue into the classroom is only a partial solution. Unless they have the time to live and breathe in the room for extended periods of time, researchers alone are unlikely to understand much of what is going on there. As Ball and Lampert point out, only an insider can be "aware of decisions we face ... rhythms of timing ... cues we read off students' faces ..." (1998, p. 379). Furthermore, there are many research questions that only teachers really know about. These kinds of questions abound in the reflections of teachers about teaching. Examples from the areas of math, language arts, science, and art, respectively, are found in Schifter & Fosnot (1993), Gallas (1994), Doris (1991), and Cohen & Gainer (1995). Some examples from technology are presented later in this paper.

Teachers are generally not trained in research methods, nor are they likely to be experts in technology or other disciplines bearing on classroom practice, such as sociology, linguistics, or environmental psychology. The contributions of both teachers and researchers in the research effort are nicely summarized in the *Benchmarks* (1993, pp. 327-329). Research should draw on the widest possible range of knowledge and talent, both from inside and outside the classroom. "Partnership research" is a term that suggests the need for collaboration across disciplines and institutions, including K-12 schools and universities. However, as everyone knows who has tried, effective partnerships are easy to advocate but difficult to achieve. The next section explores some of the cultural barriers to collaboration, and suggests some ways to deal with them.

Understanding the Cultural Barriers

In the previous section, I argued that teachers and researchers need to collaborate, but is this really possible? Greeno, J. G., McDermott, R., Cole, K. A., Engle, R. A., Goldman, S., Knudsen, J., Lauman, B., Linde, C. (1999) discuss the often conflicting interests of three groups: teachers, researchers, and curriculum developers, but provide examples of collaborative work. At the end of the process, however, divisions still existed among these groups. As one teacher expressed it, "For the reform to make sense, we have to have more working with teachers and researchers, not two separate camps." (p.330)

The existence of "camps" is a well-known feature of projects that involve both classroom teachers and university faculty. The daily experiences of these groups are very different, as are the power relationships, reward structures, and opportunities for professional recognition and growth. Sarason (1990, pp. 49-76) has written eloquently about the powerlessness of teachers and its consequences for educational reform. Ironically, the recent emphasis on standards has only made matters worse. Increasingly, K-12 classroom teachers are being robbed of professional dignity by overt and covert messages that say, "We don't trust you."

Compounding the internal problems of school systems are the complex and ambivalent relationships between schools and universities that Sarason includes in his description (1990, pp. 65-66). Many teachers are deeply mistrustful of university folk, whom they assume to be distant from the classroom and often in league with administrators. Professors who ignore this context are unlikely to establish successful collaborations with teachers. Asking a teacher for self-critical reflections, for example, can easily be misinterpreted as a ruse for finding evidence against her or him.

My own experience in doing professional development illustrates this ambivalent relationship. From 1992-1995, I was the Project Director of City Science Workshop, a professional development project located at the City College of New York. Its purpose was to develop strategies for using the urban environment in elementary science. During the first year of the project, we found it difficult to elicit reflections by the participating teachers. They were generally unwilling to evaluate their own work publicly. It now seems obvious that this reticence was one symptom of a larger problem of demoralization and mistrust. The demographics of the project staff and the participants were also factors: the three college professors leading the project were white men, while about 85% of the teachers were women of color.

The project staff discussed the problem of eliciting self-evaluation and came up with a plan. We decided that we needed to model the process of evaluation ourselves, so that the teachers would know what we were asking for. But, what should we evaluate? It would have to be an experience we had all shared. The only such experience was our own workshops. So, we decided that each of the three of us would prepare and present a brief evaluation of our own work in conducting the workshops. We would do these evaluations independently, without comparing notes.

At our next teacher workshop, we presented these evaluations as we had planned. Although each of the presentations was very different, all three were highly self-critical. We were probably more critical of ourselves than the teachers were of us. They paid very close attention. When the evaluations were over, there was a stunned silence among the teachers. Finally, one of the teachers broke the ice. She said, "Gee, you guys sound like real teachers!" Unwittingly, we had accomplished something more than modeling self-evaluation. By publicly offering reflections on our own practice, we had removed ourselves from the role of "experts" who had nothing to learn from the teachers. As a result of this session, the morale of the group began to improve noticeably.

A much bigger improvement came the following year, when we invited two of the teachers to join the project staff. They participated in all workshop-planning sessions and helped to lead the workshops. These teachers each had one foot in either "camp." In helping to plan the workshops, they did more than bring their own perspectives and experiences. By their presence, they also challenged us to consider things from the teachers' perspective and required us to speak in a language that was more accessible. They not only contributed valuable ideas and classroom experiences to the workshops; they also helped to make us better workshop leaders.

There is also a reverse side to the ambivalence that teachers feel towards professors. As I have already illustrated, teachers often believe that professors are too far removed from the classroom to be able to add much of value. At other times, teachers tend to think that we know more than we really do. An example of the latter occurred near the end of the City Science project. We held a final dinner for all of the teachers who had participated in the project. At this event, we distributed copies of some curriculum guides we had written, which described some of the topics we had explored. Looking through the guides, one of the teachers said, "Hey this is great! Why didn't you give it to us before?" I responded, "We couldn't have written this, except after working with all of you." I was surprised that she hadn't seen the role that she and the other teachers had played in *our* learning.

One more example of "culture shock" comes from our current project, City Technology Curriculum Guides, which is described in the next section. The project includes a Research Team from the Center for Children and Technology (CCT). Early in the project, I became concerned because I hadn't seen the CCT staff recording some of the workshop activities. I asked Dorothy Bennett, the lead researcher from CCT, about this record keeping. She explained to me that the researchers were not the only people keeping records. In addition, the CCT staff had also been teaching the teachers to document the workshops, because the documentary record should be written partly from the viewpoint of the participants, not just that of the professional researchers. Also, documenting the workshops would help prepare the teachers to document their own classroom activities. This approach makes perfect sense, but it had completely escaped me!

The City Technology Project

The purpose of the City Technology Curriculum Guides is to produce materials for teachers to support the teaching of technology in the elementary grades. The project is based on the following basic ideas about technology and technology education:

- Technology is everywhere and includes all of the artifacts and most of the environments and systems experienced in daily life;
- Because it is so common, technology can be studied at little or no cost;
- This study includes both the analysis of existing technologies and the design of new ones.

Five teachers' guides have been produced in draft form and are currently undergoing field testing (refer to the reference list). A Professional Developers' guide will be produced during the year 2001.

The City Technology Curriculum Guides provide contexts as well as content and activities. Each guide begins with a chapter called "Appetizers" that suggests ways the teacher can get started in exploring the topic. The chapters that follow offer technical background information, stories from classrooms, activities developed by the teachers, literature links, and information on assessment, classroom management, and standards.

The guides were developed through a collaborative process, which included three different groups:

- Two college professors, one from the City College School of Education and the other from the School of Engineering;
- Two educational researchers from the Center for Children and Technology (CCT) of the Education Development Center (EDC);
- Thirty elementary educators, who work in the South Bronx, Harlem, and Washington Heights;

We began the project by recruiting 20 teachers to work with us as "Teacher Associates" and "Co-authors." We used these terms to emphasize that this was not the typical professional development project. The Teacher Associates would learn new ideas, to be sure. However, their primary tasks would be to modify and develop the ideas further, try them out in their own classrooms, and document the outcomes, for possible inclusion in the curriculum guides. The group included science specialists, an early childhood educator, a special education teacher, a language arts specialist, and regular classroom teachers from grades two through seven. In experience, they ranged from first-year teachers to some with more than 20 years in the classroom. Several teachers from the original cohort left the project during the first year. The recruitment process for the second year included interview sessions with Teacher Associates who were already in the program. The Teacher Associates who joined in the second year included a math specialist, a special education teacher, and an early childhood teacher.

During the first two years of the project, we developed curriculum ideas and pilot tested them in the classrooms of the Teacher Associates. We began each year with a summer workshop, which engaged the Teacher Associates in exploring each of the City Technology topics first as learners, and then as curriculum developers. In the initial sessions, the Teacher Associates engaged in "warm-up" activities designed by the project staff. These included "Map Your Desk," "Physical Controls Scavenger Hunt," "Decoding Bar Codes," "Make a Folding Box for a Toy Block," and "Explore the Inside of a Cylinder Lock." Each teacher subsequently selected one of the City Technology topics for further investigation. Working in groups, and with the support of project staff, the teachers elaborated upon their ideas, raised further questions, and developed their own investigations related to a topic. These explorations culminated in each group designing an activity for all of the Teacher Associates and Project Staff to do and reflect upon. At the conclusion of each summer workshop, the

Teacher Associates wrote down ideas for activities and curriculum units which could be pilot-tested in the Teacher Associates' own classrooms. Project staff collected all of these ideas into a "Big Idea Book", which became the basis for the pilot tests.

During each of the two academic years, the Teacher Associates pilot tested the ideas from the Big Idea Books as well as new ideas developed during the year. Project staff, including the research staff, met regularly with the Teacher Associates during the two academic years. These meetings included both hands-on activities, and opportunities for discussion and reflection on the pilot tests. The Teacher Associates kept portfolios of their classroom experiences, which later became the basis for the "Stories" and "Activities" chapters of the guides. Currently, the guides are being field-tested by teachers and professional developers in New York City, suburban Westchester and Putnam counties, Saginaw, Michigan and Las Vegas, Nevada. The next section describes the process of collaboration among the three groups in greater detail.

A Model for Partnership Research

Greeno, *et al* (1998) described a project in which there were three collaborating groups: teachers, curriculum developers, and education researchers. In the City Technology project, the lines were drawn somewhat differently. Our collaboration, like Greeno's, includes teachers and professional researchers. However, we describe ourselves, the two college professors, as "content specialists" rather than curriculum developers, because all three groups contributed significantly to the development of curriculum. The major roles and responsibilities of the three groups are described in the following paragraphs.

The Content Specialists included a mechanical engineering faculty member and a science educator. We provided overall direction to the project, proposed curriculum topics and themes, led the workshops, and did most of writing of the curriculum guides and all of the editing. In workshop planning sessions, we presented our initial ideas and then they would be modified considerably in discussions with the Research Staff, and sometimes with Teacher Associates who dropped in on these sessions. In the workshops, we wanted to provide starting points for what we thought could happen in the classroom. The workshop plans were never static. We often abandoned or modified our original plans to dwell on a topic in greater depth or respond to issues as they came up. The teachers made major revisions as well to the activities before implementing them in their classrooms. Some ideas were dropped altogether, others were modified, and still others were extended and developed in ways we could not have imagined.

The role of the Teacher Associates was to tailor the new curriculum ideas to their own situations, try them out with their students, and document the outcomes. The primary form of documentation took the form of portfolios, which included the following elements:

- Lesson worksheets describing the activities and units they had implemented, including materials used, teacher tips and strategies, and self-evaluations of the units;

- Samples of students' work, including writing, maps and drawings, and dialogue; and
- Teacher reflections, including preparation for the activities, tips and strategies, ideas for further extensions, and assessment techniques.

To capture additional information that did not appear in the portfolios, we held semi-annual Roundtable Portfolio Review sessions, where each teacher shared portfolio materials. After each presentation, the staff and Teacher Associates raised questions and comments in two categories. First, there were the "warm" comments, complimenting the presenter on aspects of the work, identifying ideas that could be used elsewhere, and suggesting larger significance for what had been done. Here are some examples of "warm comments":

- "There was excellent attention to children's language and ideas."
- "I especially like the way you made the City Technology topics into integrative year-long-themes."
- "You enable them to revisit the activity as they get new ideas."
- "It was wonderful that you had child-motivated extension activities."
- "You observe how kids naturally approach materials. Through open exploration, kids discovered that pumps have a function in a tangible way - e.g., when the kids used pumps to get water out of the water table. You give a real flavor for what a pre-K/K class is like."
- "It can be hard to see where children are taking an activity, especially when you don't expect it. I liked it when you said, 'I had them figured out all wrong.' "
- "You struggle to reach kids 'by any means' ".
- "You write down all of the kids' ideas."

These were followed by "cool" comments, requesting information that had been omitted, suggesting ways in which the work could be improved, and offering critical insights. Here are some examples of "cool" comments and questions:

- "What kinds of guiding questions did you have for them?"
- "What did they get out of it?"
- "What evidence do you have for their learning?"
- "How will the analysis lead to redesign?"
- "How did they collect and report data?"

The third group in the partnership was the Research Team. They developed a set of guidelines and worksheets for documenting classroom activities and units. These instruments were modified several times, based on comments and suggestions from the teachers. The researchers suggested the idea of having the Portfolio Roundtables, developed the format for them, and led these sessions. They conducted periodic interviews with the teachers about key issues identified from portfolios and journals, and provided advice to the Content Specialists regarding the appropriateness of various themes and activities. Perhaps most important, the Research Team attended all of the workshops and planning sessions, where they frequently raised critical questions both of the teachers and of the content specialists. While strongly supportive of the goals of the project, the researchers maintained an intellectual distance from the Content Specialists, making it easier for the teachers to challenge them as well.

The participation of the Research Team in the workshops, and the mechanism of the portfolio reviews, helped create an atmosphere of critical reflection that benefited everyone. It was possible to raise serious questions and criticisms without offending anyone or deepening the divisions between the three groups. This atmosphere of critical reflection also provided a model for teachers working with children. They were encouraged to listen more carefully to their children's ideas, to include these ideas in their portfolios, and to explore issues about children's learning. Although formal research was not a goal of the project, some teachers did collect valuable data about how children learn and understand technology. Some examples are reported in the next section.

Two Examples of Classroom Research

The most basic activity of technology is design, and the purpose of designing something is to address a human need. A fundamental goal of technology education, expressed most clearly in the *Standards for Technological Literacy*, is the understanding that "Everyone can design a solution to a problem" (ITEA, 2000, p. 93). Problems arise frequently that could be solved by a design or redesign, but few adults or children have learned to think of themselves as designers. One very powerful approach to redesign is outlined in the ITEA Content Standards: "All products and systems are subject to failure…. Troubleshooting helps people find what is wrong with the product or system so it can be fixed" (p. 107). Both of these standards are intended for children in grades K-2. To what extent and under what circumstances do young children actually learn these ideas about design?

Theresa Luongo is a pre-K/K teacher at a small alternative school in East Harlem. She has a large classroom with many distinct "areas" which afford many opportunities to explore and discover. Every day during "Work Time" Theresa allows her students to choose the area in which they want to work and the activities that interest them (Benenson, Neujahr, Bennett, Meade, Diez, Flores, Gatton, Gonzalez, Luongo, Odinga, Piggott, Purnell, Rivera, Skea, Smith, and Williams, 1999, p. 63-64). Theresa reported on how testing the strengths of shopping bags led to repair and redesign of bags and other objects (p. 67-71).

Theresa asked the students who chose the Block Area to see how many blocks some small shopping bags could hold. Eventually, the handle tore off of one of the bags. Two Pre-K students, a boy and a girl, offered to fix the broken bag, and this team was soon at work mending any bag that broke. Theresa extended this activity by asking these youngsters how a small paper lunch bag could be turned into a shopping bag. Repairing broken things and redesigning them so they won't break next time quickly became major activities in Theresa's classroom. After watching the repair and redesign of bags, another Pre-K student volunteered to repair book covers!

This story contains some powerful ideas about how troubleshooting, design, and redesign might become part of the everyday practice in early childhood classrooms. By encouraging children to explore the properties of a familiar artifact, the shopping bag, Theresa laid the basis for her students to experience technological failure firsthand. By providing opportunities for them to discover and explore for themselves, she implicitly motivated them to look for solutions when the bags failed. By posing the question, “How could I turn this lunch bag into a shopping bag?,” she suggested a small-scale design problem related to the issues they were already exploring.

The design process is rarely a linear progression from problem to solution. Initial efforts at design are rarely the best, and children need to develop a willingness to revisit and re-do a design. This idea is expressed in the *Standards for Technological Literacy* in the following words: “It is important that students learn that applying the design process involves iteration. They should learn to use repetition and recurrence techniques to obtain the desired solution to a problem” (International Technology Education Association, 2000, p. 118). Unfortunately, the iterative problem solving notion runs counter to the prevailing paradigm in education that holds that an answer is either right or wrong, leaving little or no room for students to work their own way toward better solutions. The standard cited above is for grades 3-5. It would be very useful to know whether students in these grades actually accept the idea that design should be iterative, or if they see design in the more conventional terms of “right” and “wrong” answers.

Mary Flores is a Special Education teacher from a large school in the South Bronx. Mary works with small groups of children from grades three to five to develop basic literacy. She uses technology activities extensively in her classroom because they provide her students with many opportunities to discuss their ideas and express them in writing. Through multiple experiences in analysis and design, her students develop a strong sense of their own abilities to come up with solutions to problems. Mary wrote an account of how her students designed and redesigned “Rube Goldberg devices” as the culminating activity of an extended fourth and fifth grade unit on mechanisms. This unit had begun with brainstorming and scavenger hunts related to simple machines (Benenson, Neujahr, Bennett, Meade, Aguiar, Flores, Gonzalez, Monterroso-Nieves, Purnell, Rivera, and Williams, 1999, pp. 120-131).

In Mary’s class, students recognized the need for iteration in design. One student built and tested a windlass made from a broomstick, a plastic crate, and a ruler. Then the student redesigned it using a cardboard box instead of a crate. One night the school custodian mistakenly discarded the mechanism the students had been working on. Mary was more upset than her students, one of whom stated, “ Don’t worry, Ms. Flores. We’ll just do it again, and this time, we’ll do it better!” Although her students accepted the need for iteration, they sometimes found it frustrating, as Mary discovered by interviewing her students. One girl remarked, “ It’s making me angry because I tried hard to make my mechanism work, but now I have to make another one.” At the same time, several of her students were able to describe in detail the problems they encountered, and the steps they took to improve their designs.

Although neither Mary nor Theresa was engaged in a formal research project, both of their accounts provide valuable data for answering fundamental research questions. Both Mary and Theresa were pleasantly surprised by what happened in their classrooms. Theresa had not anticipated that bag testing would lead to the repair and redesign of bags, or to the repair of other items such as books. Mary had not expected her students to be so willing to evaluate and redesign their mechanisms. Nevertheless, these discoveries did not occur completely by accident. Both teachers see enormous potential for technology education in their classroom. Each in her own way, Mary and Theresa had laid the groundwork for what Eleanor Duckworth calls "the having of wonderful ideas." As a result, they were both prepared to recognize the significance of their students' work, and to document it in a way that could gain wider exposure.

Towards a Common Culture of Design and Research

The accounts in the previous section reflect not only the learning process of the children, but that of the teachers as well. Both Mary and Theresa listen to their students well and are sometimes surprised by what they hear. In the future they will approach these units with new understandings of how their students think about design and redesign. Both Mary and Theresa are very reflective teachers who try things out in the classroom, see what happens, and change what they do next time. They develop these classroom units in very much the same way that their children design things: they come up with an initial plan, try it out, and redesign it based on the outcome.

Near the beginning of this paper, I emphasized the cultural barriers that separate researchers and university professors from classroom teachers. As the City Technology project proceeded, these barriers began to disappear. There was a convergence of cultures, as it became clear that all of us were exploring uncharted territory, and that we needed one another's help in doing so. "It's another design project," became the theme for all of the work that we were doing. While children were designing artifacts and classroom environments, teachers were designing classroom activities, the content specialists were designing professional development activities, and the research team was designing methods of data collection and analysis. Each of these designs was being tested by the other groups in the project, and subjected to analysis and criticism, and consequently being redesigned. This process of design-test-redesign occurred in the planning and implementation of the workshops, the design of curriculum by the teachers, the design projects undertaken by the children, and the design of research methods. Out of our separate cultures, a common design culture evolved.

There is considerable overlap between research and design, as is suggested by the frequent pairing of the words "Research" and "Development." Research, at least in the applied sense, is usually a component of design. It is usually necessary to gather data about the problem to be solved, the materials that might be used, and the comparative worth of alternative solutions. Likewise, nearly every research project includes elements of design such as the design of the research plan, of the research methods and instruments, and of the means of presenting the results. Design and research have different purposes, but they share much of the same mind set. Because technology education is concerned with design, it is a relatively small step to apply design thinking to classroom research and development.

This paper suggests that teachers, content specialists, and researchers ought to collaborate in areas of common concern, such as classroom research and curriculum development. Many might argue against this notion. Doesn't each of these tasks require special training, which non-specialists are unlikely to have? Doesn't it blur the lines of responsibility to have everybody doing everything? Shouldn't everyone stick with what they do best?

Quite the contrary, there is a growing body of literature calling for collaboration in a variety of design professions. For example, in designing software for a Danish radio station, Bodker and Pederson (1991) realized that they had to first understand the culture of that particular workplace. Their discussion of the "insider-outsider dilemma" has close parallels with my own discussion of what insiders and outsiders can bring to classroom research. Similarly, Norman (1988) argued strongly for the "user-centered design" of consumer products. According to Norman, involving ordinary users in the design process is necessary, because no designer can anticipate all of the difficulties users will face in trying to make sense of the design.

In the area of engineering design, Pacey (1983) cited numerous examples in which new technologies failed, for reasons that were entirely non-technical. For example, more than 100,000 electric water pumps were introduced in India during the late '60's. By 1975, more than two thirds were not in use because there was no social system for maintaining them. The designers had focused on the technical aspects only, and ignored the social and cultural contexts of the users. Pacey's account raises an issue that is equally relevant to classroom research: how much weight should be given to user expertise, as compared with technical expertise? On a more hopeful note, Zeisel (1984) presented a variety of examples of successful collaborations between behavioral researchers and environmental design professionals. For example, in a chapter titled "Research and Design Cooperation," he described how behavioral research played a role in the design of an assisted-living facility for the elderly.

Collaboration between teachers and researchers, for the improvement of education, fits squarely in this movement towards collaboration in research and design. Technology education, furthermore, is the logical place to do it, because technology is about the analysis of problems in order to design solutions.

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