Engaging Teachers in Classroom Research:

Implications for Professional Development

Janice Koch
Associate Professor
Department of Curriculum
and Teaching

What does it look like to immerse elementary school children in scientific inquiry, mathematical analysis, and problem solving and design? What are the consequences of engaging them in the design and construction of artifacts that relate to a scientific or mathematical concept, or both? Answering these questions is the mission of a professional development master's program for elementary school teachers that specializes in Mathematics, Science and Technology (M.A./MST). This program is informed by the belief that the very act of designing and building an artifact can deepen a student's understanding of a scientific or mathematical concept. The research that is explored in this article results from the interdisciplinary collaboration of engineering and education faculty at Hofstra University.

In 1996, working with Dave Burghardt from the Department of Engineering and Sharon Whitton in mathematics education from the Department of Curriculum and Teaching, we developed a master's program that would introduce elementary school teachers to children's engineering while improving their skills in teaching mathematics and science. Dave Burghardt and I began to team-teach the culminating classroom research course in this program, and this article is based on our research. Through this experience, Dave Burghardt and I have come to trust and value the perspectives on problem solving and learning that inform each other's contexts, his in engineering and mine in science education. Hofstra University's School of Education and Allied Human Services is one of only two schools of education in New York State that have added the component of design technology to the professional development of elementary school teachers. Massachusetts is the first state in the nation to mandate engineering in the preschool through grade 12 education curriculum; however, the impetus for this integration is being felt all over the country. Both engineering and science education professional communities are interested in this collaboration.

Telling Stories

Science Stories: A science methods book for elementary school teachers (Koch, second edition, Houghton Mifflin, 2002) demonstrates the use of narratives as a tool for understanding more about classroom practice. Within the text, stories of real classroom experiences, where teachers and children are engaged in doing science, are the vehicle for understanding the teaching and learning of science. These stories and their analysis provide elementary school teachers with a vision of what it looks like to do science with children. Using this model, we ask elementary school teachers in the M.A./MST program, hereafter referred to as "MST teachers," to keep a daily classroom journal and tell their stories. The context for these stories is the experience of integrating design technology into their teaching. Called "action research" or "classroom research," the teachers' stories and subsequent analysis of the events in their classrooms contribute to the final product of a six-part master's thesis.

MST teachers, in the final phase of their master's work, are required to design an integrated science, mathematics and technology unit in their classrooms and research the effects of implementing this unit on student learning and attitudes, as well as on their own pedagogical content knowledge. Their action research reports, in the form of master's theses, were studied as Dave Burghardt and I visited the classrooms of each of the teachers.

Theoretical Framework

The M.A. Program in Elementary Education with a specialization in Mathematics, Science and Technology (M.A/.MST) at Hofstra University is designed for experienced elementary school teachers who seek the skills, knowledge, attitudes and dispositions to integrate the teaching of these areas. Technology is defined as *information technology*, the integration of skills that require the use of computer applications to enhance student learning of science, as well as *design technology*, which encompasses the study of the technological world that inventors, engineers and other innovators have created. Both educational and design technology are applied to the study of elementary science to further the development of meaningful understanding in these areas.

This research addresses how the use of design challenges in their classes helped MST teachers to shift their thinking about their role in the classroom as they gave students more control of their own learning. A deep understanding of the science concepts is required for students to engage in design and construction. Research on teaching and learning addresses the importance of hands-on activities, which, supported by meaningful discussion and theory building, helps students construct meaning. Further, when students are encouraged to create artifacts, they both reflect and enhance student understanding.

The cognitive processes involved in making meaning are active ones that require the learner to continually evaluate new information and experiences against his/her current theories, rules or notions. Working closely with Jackie Grennon Brooks at SUNY Stony Brook, through an NSF-funded grant for elementary school teachers, Dave Burghardt and I explored meaning making with children and adults. I came to appreciate the role that creative design projects can play in helping children to understand MST concepts.

Becoming literate in the design process by acquiring the cognitive and procedural knowledge to create a design has the potential for enhancing students' understandings in a given science unit. One such example would be the design and construction of a model house for researchers in the heart of the rainforest. This house would need to occupy the least amount of surface area to make the smallest impact on the forest floor. In the actual rainforest, land is conserved when houses are built on stilts and the house itself occupies the space between the floor and the canopy. By engaging students in designing an appropriate model for the rainforest, they apply their understanding of the constraints of the rainforest environment. In another MST unit on the human body, second graders designed and built a model skeleton with moveable joints. In order to make a credible model, students needed an understanding of the ways in which joints operate.

Framing the Conditions for Teacher Research

Teacher research, also called action research, classroom research or teacher inquiry, is fraught with misinterpretations. This program proceeds under the assumption that teachers who study the implementation of a long-term unit with their students by collecting data, keeping a daily journal, describing the experience, analyzing their data, and finally writing about it, are engaged in research. This process deepens the MST teachers' capacities to think intellectually. By becoming thoughtful problem solvers, they enhance their own capacities for reflection.

Promoting the MST teacher-research project involves the mentoring of classroom teachers in weekly meetings. The process of engaging them in writing about their environment, describing the MST unit, and their rationale for its selection, begins their semester-long research. The expectation is that each graduate student/classroom teacher will implement an integrated unit that addresses an elementary curriculum topic by requiring their students to be engaged in design technology and related mathematics and/or science concepts. This integrated unit needs to be linked to local frameworks and reflect the culture of the geographic community in which the school is situated. After developing this unit, and before implementing it, teachers are asked to assess students' prior knowledge as well as their attitudes toward math and science. These baseline data provide meaningful information for teachers and help them to assess student progress by the completion of the unit.

For the research report, each MST teacher is required to complete a six-part master's thesis that includes:

- A description of the setting and students;
- A review of the literature related to his/her topic;
- A plan for analyzing the students' attitudes and content knowledge, before and after implementing the unit;
- A description of the experience of implementing the unit;
- An analysis of the data;
- Conclusions and Implications.

The MST teachers maintain a daily teaching journal, which serves as an important source of data as they describe the experience of teaching the unit. The professors maintain their journals about each teacher's research and use their final thesis publication as a source of data. The professors provide support through weekly meetings, daily e-mail communications, special conferencing and visits to the classrooms.

Analyzing the Teachers' Master's Theses

Three dominant themes emerged from the analysis of 25 of the teachers' classroom research reports. First, the teachers documented their own transformations by describing how they were able to shift their classroom practices from being controlling to becoming more open and allowing students to explore their own ideas as they set out to solve design challenges. Helping teachers to create "space" for students to actively seek solutions is a goal of the M.A./MST Program. It is easier for some teachers and differs according to their current setting, background experience and basic assumptions about teaching and learning. Challenging their assumptions and inviting them to critically analyze their philosophies is part of the program's pedagogical approach. Lisa notes:

"Taking into account the analysis of this total unit, the results have renewed my belief in and commitment to integrated MST teaching. Hands-on problem solving and decision making through design and construction have enabled my students to make many real-life connections and become part of the world of math, science and technology that exists outside of our classroom."

Second, teachers documented a change in their students' attitudes and learning in science. The following excerpts of teachers' research reports reveal the powerful ways in which their own and their students' thinking has shifted. The awareness that children are able to have a deeper understanding of the material and make interconnections with the world around as well as with other subject areas is demonstrated by

Donna's observation:

"By unleashing the students and giving them more control over what they were learning, more complex ideas were discussed. It was wonderful to see children integrating subject areas. Our science discussions led us to experiment, and to read literature and to do research. First graders were thinking about measurement, scale and shape as they built their projects. I saw students looking for rulers and cylinder-type materials to use for their projects. Students were making murals of the seashore at home before I even introduced the model seashore project. By the end of the unit students were attempting to write seashore poetry independently, which led to our lessons on poetry. In Writer's Workshop, students were writing books with a seashore theme before I even realized. They perpetuated the integration of subjects and benefited."

Jennifer corroborates this from observations of her class:

"Incorporating a design challenge is what made the unit come together. The students had all this information and nowhere to put it. It was during this part of the unit where everything clicked and the students began using the knowledge they acquired of the rain forest. The design portfolio and project, while relying on rubrics for assistance, was a challenging experience for the class. This was the first time students were given complete freedom to design a project with few constraints. The outcome was outstanding."

Finally, a dominant theme that emerged described the effect that integrating design technology had on children with special learning needs. Amy reports in her teaching journal:

"This unit also allowed lower-functioning students who had in the past experienced success rather sporadically, to now experience success on a daily basis. I feel that the reason for this is because the unit encompassed so many learning styles that each child was able to strive and succeed regularly. As a result, students felt better about themselves and were more willing to take risks not only during the work on this unit, but on work in other subject areas as well. Students who used to sit quietly and needed to be called on were now active participants who shared willingly and weren't afraid to be wrong. They seemed to try harder and be more enthusiastic about what was happening in the classroom."

A Work in Progress

What we have learned is that the very process of implementing an interdisciplinary, design-based unit, gathering data about it, and reporting the findings has impacted profoundly on the MST teachers' professional growth. This is consistent with the research on teacher inquiry or classroom research, which reveals that the teacher-researcher deepens her understanding of the classroom. What distinguishes this teacher-research initiative is that it is directed by the academy, but implemented by the classroom teacher. The support of and guidance for teacher research yields valuable data for the field. From this research we learn about the possibilities for professional development by studying the changes in teachers' perceptions, and we learn about the effects of integrating design technology on student learning and attitudes. What emerges is a powerful connection between graduate in-service teacher education and its impact on classroom practice.

Janice Koch's extensive experience in promoting science education at all levels of pre-college education has proven to be invaluable as she strives to introduce mathematics, science and technology into the elementary school curriculum.

Professor Koch earned a B.S. in biology from the City College of New York, an M.A. in interdisciplinary studies from Hofstra University, and a Ph.D. in education from New York University. She was the recipient of the Henry Meissner Research Award for Distinguished Doctoral Dissertation from Phi Delta Kappa. Her dissertation, "Lab Coats and Little Girls," focused on the science experiences of women majoring in education and women majoring in biology at a private university.

Although Professor Koch's primary teaching appointment is elementary pre-service and in-service science education, she has taught an environmental science course in the Department of Engineering, and she also teaches courses in gender issues in the classroom for pre-college teachers in all grade levels within the School of Education and Allied Human Services.

In 1995 Professor Koch was the recipient of the University's Distinguished Teacher of the Year Award. She most recently received the Robert S. Guttchen Memorial Award for Distinguished Faculty Service from the School of Education and Allied Human Services.

Professor Koch has authored numerous publications, including a science methods textbook, *Science Stories: A science methods book for elementary school teachers* (Houghton Mifflin Company, second edition, forthcoming 2002). She is co-author of two books informing gender equity in science, mathematics and technology education, *Gender Equity Right from the Start* and *Gender Equity Sources and Resources for Education Students* (Lawrence Erlbaum Associates, 1997), among others.

Professor Koch has served on various grant-supported projects at Hofstra. She participated in the Binational Fulbright In-service Education program for Egyptian high school teachers at the University and has also served as co-principal investigator on an NSF-funded teacher enhancement project for mathematics, science and technology in the elementary schools in New York State. Currently, she is serving as project director on a U.S. Department of Education grant designed to infuse the visual and performing arts into the middle school teaching of mathematics, science, technology and literacy. - SK