What comes first?

Helping teachers integrate technology into their teaching

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RUNNING HEAD: What comes first?

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Calls to integrate technology into teaching are far reaching. Organizations including those dedicated to technology in education (e.g., International Society for Technology in Education (ISTE) and the Milliken Foundation), others dedicated to students at a specific age (e.g., National Association for the Education of Young Children), and subject matter associations (e.g., National Council of Teachers of Mathematics, National Council of Teachers of English) have all addressed the need to increase and improve the use of technology in our classrooms.

Although the calls to integrate technology are relatively new, school districts have been increasing the amount of technology in schools and classrooms for some time. And, at the same time, families have brought more technology into our homes. The CEO Forum (1999) recently reported that we now have over 6 million computers in our nation’s schools and that 80% of our schools are connected to the Internet. The forum also reported that over 40 million homes now have personal computers, and that Email access has increased 400% from 1996 to 1999. These statistics only add to the urgency of integrating technology into our classrooms. Yet, in light of these statistics, only 20% of the teachers surveyed reported feeling ready to integrate technology into their classrooms.

Although the need to integrate technology into teaching is evident, what teachers must know to use technology successfully is still unclear. This paper reports the work of a team of elementary school teachers and administrators, university faculty members and university student technology interns working to integrate technology into elementary school mathematics classrooms. The situation documented here is unique and unusually complex in that the school district adopted a new mathematics curriculum, was working to integrate a new set of state standards, and began integrating technology into their mathematics instruction at the same time. All of these mandates came together to create an interesting and perplexing situation in which to
think about technology integration. Along the way we found many things diverted our attention from our initial, simple agenda. These things included administrative concerns, competing mandates, and our conceptions of mathematics. In the following sections we provide our conceptual framework entering the project, an overview of project activities, and the results and conclusions of our first year in this project.

**Background**

Although the calls for technology integration are ubiquitous, different voices in the calls have targeted different aspects of teaching. In different places, teachers are asked to re-visit their knowledge of technology, their beliefs about learning and teaching, and their knowledge of and about the subjects that they teach.

Learning to use technology is represented in two ways. First, teachers must learn how to use the machines; that is, how to turn it on, use a mouse, organize files, troubleshoot minor problems, etc. There is considerable evidence that teachers know how to do these things. Cuban (1999) has pointed out that many if not most teachers currently use computers to plan lessons, send and receive email, compose letters, and to carry out various household projects. The second use of technology focuses on how to use it in the course of their instruction. Even though we have evidence that teachers use technology, there is less evidence of it being used in instruction. Instructional use of technology requires much more than knowing how to use the machines. Teachers must know about various software programs and packages and their classroom potential. It also requires teachers to consider questions such as “Whose machine is it, the teacher’s or the student’s?” and “How can I fit technology into an already crowded class schedule?” These questions determine the computers’ role in the classroom.
The second voice in the calls for reform suggests that teachers must review their beliefs about learning and teaching. In most cases, it is suggested that teachers adopt constructivist teaching methods.¹

Constructivist theories hold to four tenets (Clements & Battista, 1990). These four tenets include: a) knowledge is actively created or invented, not passively received from the environment; b) we create new knowledge by reflecting on our physical and mental actions; c) no one true reality exists; and, d) learning is a fundamentally social process through which we grow into the intellectual life of those around us. Teachers who accept these tenets arguably must adopt their practice to match their beliefs. Technology in constructivist classrooms should provide students with an opportunity to create knowledge, engage in physical and cognitive activity, reflect on that activity, and interact with other people thinking about the same ideas.

Phillips and Soltis suggest that constructivist teachers create classrooms in which students will be “actively engaged with interesting and relevant problems; they will be able to discuss with each other and with the teacher; they will be active inquirers rather than passive; they will have adequate time to reflect; they will have opportunities to test or evaluate the knowledge that they have constructed; and they will reflect seriously about the constructions produced by other students and by the teacher.” (Phillips & Soltis, 1998, p. 52)

This scenario of constructivist teaching is common in the educational technology literature c.f. (Sprague & Dede, 1999). In the literature, constructivist approaches to teaching are defined in opposition to traditional instructional strategies.² Traditional non-technology using teachers it

¹ The notion of “constructivist teaching methods” is problematic in itself. Constructivism is a theory of learning and, as such, seeks to describe how we learn in all settings. As a result, no connection can be made between the theories and classroom activities.
² John Dewey warned us of the dangers of defining ourselves in opposition to past practice. In his monograph Education and Experience, Dewey wrote that defining the new pedagogy in opposition to traditional practice was the
is suggested, subject their students to “Single sense stimulation; single path progressions; single media; isolated work; information delivery; passive learning; factual, knowledge-based learning; reactive response; and isolated, artificial contexts” (International Society for Technology in Education, 2000). These teachers lecture and carry out classroom activities in ways they have for many years going so far as to plan how they will care for their lawns as they speak (Sprague & Dede, 1999). Constructivist teachers, on the other hand use technology to explore students’ thinking, engage students in meaningful activity in which students conduct authentic inquiry and construct their own understanding of content rather than mimicking the teacher’s knowledge (Reineke, 1999; Sprague & Dede, 1999). Constructivist teachers engage their students in multisensory stimulation; multipath progressions; multimedia; collaborative work; information exchange; active, exploratory, inquiry-based learning; critical thinking and informed decision-making; proactive, planned action; and, authentic, real-world contexts (International Society for Technology in Education, 2000).

Although the drastic comparisons of traditional and constructivist teachers in the literature and the standards documents may not accurately portray current practice, teachers may need to question their own ideas about teaching and learning to successfully integrate technology. Indeed this was a seminal finding of the Apple Classrooms of Tomorrow (ACOT) research (Sandholz, Ringstaff, & Dwyer, 1997). After studying teachers over ten years, the ACOT researchers documented a developmental trajectory in teachers’ use of technology that includes five stages: entry, adoption, adaptation, appropriation, and invention. As teachers progress
through these stages, they gradually change their beliefs and pass authority for classroom activity and learning onto their students.

Finally, calls for technology reform also argue for a re-conceptualized curriculum (Papert, 1994; Rochelle & Kaput, 1999). Proponents from this perspective argue that teachers should not use technology to teach “the same old things,” but should recognize the opportunity technology offers to study traditional content in new, engaging ways. Technology—maybe not today, but soon—offers the potential for “deep curriculum reform” (Rochelle & Kaput, 1999). To meet this goal, teachers must understand content in ways that allow them to recognize technology’s value in helping students construct a more sophisticated understanding of important ideas. Software and hardware often present content in ways that deviate from teachers’ past experience. In mathematics, for instance, technology-enhanced instruction has provided opportunities for teachers to lessen their emphasis on computation and, instead, to assist students in analyzing mathematical situations and using mathematical tools to understand the situations.

These voices come together in the new National Educational Technology Standards for Teachers (NETS-T) document produced by the International Society of Technology in Education (ISTE), in conjunction with many content area associations. NETS-T was developed as an accompaniment for the NETS standards for K-12 students.

The NETS-T prescribe technological skills for teachers and teacher education students at various points in their careers. The skills included in the standards are divided into six broad categories including: a) technology operations and concepts; b) planning and designing learning environments and experiences; c) teaching learning, and the curriculum; d) assessment and evaluation; e) productivity and professional practice; and, f) social, ethical, legal, and human issues. For teachers to successfully integrate technology into their classrooms, they must, meet
the requirements in each of the six categories. Although the standards grow progressively broader and incorporate much more than using machines, they focus primarily on technological skill.

But, what comes first? If teachers are expected to fundamentally change their teaching practice—their knowledge of and about technology, their beliefs about learning and teaching, and their conceptions of subject matter—how do these changes come about?

Project activities and organization

This project was funded by the Rural Integration of Technology into Teaching (RITE) project, a 1999 United States Department of Education Preparing Tomorrow’s Teachers to Use Technology grant. The RITE project brings together four Minnesota State Universities in a collaborative effort to increase the presence and quality of technology in teacher education programs. The RITE project has four major goals:

1. To collaboratively infuse technology into four Minnesota State College and University (MnSCU) teacher preparation programs in ways that will ensure student mastery of technology competencies and standards endorsed by ISTE, INTASC, NCATE, Minnesota Board of Teaching, and individual professional organizations and institutions.

2. To develop and provide a variety of relevant and up-to-date professional development activities that will support State University faculty in developing their own technology skills and abilities.

3. To ensure that appropriate technology use will be systematically infused in a variety of courses to enhance the educational experience and provide benefits for the teacher(s) and student(s).
4. To cooperatively create rural field placements with area schools to ensure students will be supported when incorporating appropriate technology in their field experiences (including student teaching), as well as to ensure the sharing of new technologies and related strategies by the student teacher with the reciprocal mentors.

To address the fourth goal of the RITE project, we developed teams of teachers, university faculty members, and students to explore uses of technology in education. These teams explore ways in which technology will help them in their current situation. The teams meet regularly to discuss new ideas about technology—new software packages, successes and failures of technology in their classes, etc. This paper documents the work of one of these groups and its struggles to learn about technology, mathematics, and bringing the two together.

Context

The site described in this paper was a K-12 consolidated school in rural Wisconsin. The school district covers 450 square miles and has 800 students enrolled. The project team at this site comprised the elementary school principal and representatives from Title 1, Special Education (K-8), first grade, 6th grade, a university student technology intern, and a mathematics educator. This team explored ways in which they could use technology to teach mathematics. This content area was chosen in part because of a new mathematics curriculum—TERC Investigations (elementary) and the Connected Mathematics Project (middle school). The 1999-2000 school year was the first year the Investigations curriculum was being used.

Investigations is an innovative mathematics curriculum developed by the Education Research Collaborative in Science and Mathematics at TERC. TERC defines the curriculum this way:
Investigations in Number, Data, and Space is a comprehensive, K-5 mathematics curriculum whose goals are to: offer students meaningful mathematical problems; emphasize depth in mathematical thinking rather than exposure to a series of fragmented topics; communicate mathematics content and pedagogy to teachers; and widely expand the pool of mathematically literate students. The curriculum consists of a set of modules at each grade level. Each module offers a series of connected investigations of major mathematical ideas within the areas of number, data collection and analysis, geometry, and the mathematics of change. These investigations offer significant content and encourage students to develop flexibility and confidence in approaching mathematical problems, proficiency in evaluating solutions, and a repertoire of ways to communicate about their mathematical thinking.

(FIND TERC URL)

The Investigations curriculum includes a collection of computer software that can be used in conjunction to the text and other materials. The committee set up for this project believed the Investigations software would be a good place to begin our discussions.

**Wisconsin Model Standards.** In addition, Wisconsin had recently passed a new set of state standards. The new state graduation standards were foremost in teachers’ thinking. Understanding the graduation standards was essential because of the high stakes attached to them. Students must document their success in relation to the standards to receive a diploma. Although technology might be useful and encouraged, it was not necessary to meet the standards.

The Wisconsin Model Academic Standards for Mathematics are built on a foundation of beliefs including a) mathematics should be conceptualized as a unified system of inquiry rather than a set of discrete computational rules; b) mathematics’ importance lies in its application to various problems, c) mathematical reasoning should replace computation as the primary focus of
What come first?

study; d) students must be able to communicate their ideas to others; and, e) technology must play an integral role in teaching and learning mathematics. The standards define mathematical power as “the ability to explore, to conjecture, to reason logically, and to apply a wide repertoire of methods to solve problems.” [Governor's Council on Model Academic Standards, 1998 #1391, p. 33]. At the end of fourth grade, Wisconsin students should be able to perceive patterns, identify relationships, formulate questions, justify their actions, and assess the reasonableness of their results. At the end of eighth grade they should be able to evaluate information and defend their work in addition to the skills and abilities listed at fourth grade.

**TIC Meetings**

The first meeting was held in January 2000. During that meeting, the committee members agreed to hold regularly scheduled meetings every other Wednesday throughout the semester. To minimize the disruption to the class schedules of all participants, meetings were held at 2:30 PM. This arrangement made it possible to have regular, full attendance at the meetings. The members of this group also came to refer to it as the TIC (Technology Integration Committee). At each meeting the team discussed new ideas about technology—new software packages, successes and failures of technology in their classes, and other questions that arose.

**Software review sessions**

In addition to her participation with the TIC, the university student technology intern assisted the teachers in other ways. First, she spent time in classrooms as teachers worked to integrate technology into their teaching. Second, she explored the software that accompanied the new mathematics curriculum. After working through the software, she helped the teachers fit it into their teaching. Finally, she brought other commercially produced software packages from the university to the school for the teachers to review. Based on their short experience with the
software, the school district purchased programs they believed would help them reach their mathematics goals.

**Software included with the Investigations curriculum.** Four software programs accompany investigations math curriculum: *Shapes, Geo-Logo, Tumbling Tetromonies*, and *Trips*. *Shapes* is a computer manipulative of pattern blocks and tangrams. With this program students can create as many copies of each shape as they want and use computer tools to move, combine, and duplicate these shapes. They can also create pictures and designs to solve problems.

The group focused primarily on the Geo-Logo program. Geo-Logo is used for geometric exploration. Students are able to construct paths and geometric shapes. As with other logo programs, Geo-Logo asks students to “teach the turtle;” that is, to program the turtle to move, turn, and draw. Students learn to write a list of instructions—a program—for constructing a shape. This encourages the students to think carefully about geometric properties and to use geometry-oriented language. (Clements, et al, 1998)

**Commercially produced software.** Two software presentations were given during the semester. One was for the primary level (K-3) and the other, for the intermediate level (3-6). These software presentations were about forty minutes in length and covered the eight software programs, shown in tables 1 and 2. Following the presentation, the teachers explored the software to see the advantages and disadvantages of each program.

**Table 1**

**Software packages included the primary grades software demonstrations**

<table>
<thead>
<tr>
<th>Software</th>
<th>Synopsis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numbers Undercover</td>
<td>measurement, time, money, and number patterns</td>
</tr>
<tr>
<td>Activity</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Mirror Symmetry</td>
<td>spatial sense, making use of numbers, measurement, fractions in addition to geometry, and making connections with math concepts</td>
</tr>
<tr>
<td>Ice Cream Truck</td>
<td>students assume the role of the driver of a ice cream truck, stocking up on products given the day of the week, time of day, temperature, and location</td>
</tr>
<tr>
<td>Combing Shapes</td>
<td>concrete experiences in combining shapes and building a foundation for understanding more abstract concepts such as number, measurement, and estimation in addition to geometry</td>
</tr>
</tbody>
</table>

Table 2

Software in the Intermediate Grades Software Presentation

<table>
<thead>
<tr>
<th>Activity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fraction Operations</td>
<td>creating a common denominator, ordering red carpet, repairing a bridge, creating a house plan, and preparing for an experiment</td>
</tr>
<tr>
<td>How the West was One + Two * Four</td>
<td>math strategy game in which students are introduced to the order of operations and the importance of using parentheses as they expand their problem solving strategies</td>
</tr>
<tr>
<td>Fraction Attraction</td>
<td>transition from whole numbers to fractions and decimals, ordering, equivalence, relative size, understanding fractions as representing distance on a number line, addition and subtraction of fractions, &quot;counting on&quot; with fractions</td>
</tr>
<tr>
<td>Hot Dog Stand: The Works</td>
<td>use of variety of mathematics, problem solving, and communication skills including arithmetic operations, recognizing</td>
</tr>
</tbody>
</table>
The School purchased two software programs. The first program, Numbers Undercover, was used in a first grade classroom. It provided an entertaining blend of mystery and mathematics for primary grade students. The program features an exciting variety of activities and captivating settings to motivate early learners. (Numbers Undercover)

Students collected clues by completing various levels (selected by the teacher). When students successfully completed an activity, they were rewarded with a number clue and a trip to the Suspect Line-Up screen. Students analyze their clues to find the guilty suspect. Each mystery includes four activities and four clues. Activities in Numbers Undercover introduced students to math and problem-solving skills such as measurement, estimating measurements using non-standard units, and exploring length and volume; time, reading analog and digital clocks, comparing analog and digital time, and finding elapsed time; money, finding values of sets of coins, finding sets of coins equal to a given value, making change; and last, number patterns, counting, skip-counting, finding missing numbers. (Numbers Undercover)

One teacher expressed concern about concepts first graders were studying at the beginning of January. Those areas were money, time, measurement, and problem solving. Her concern led me to a software program titled “Number Undercover.” After using Numbers Undercover, the student’s knowledge of those areas increased dramatically along with their computer skills.

Fractions Operations was used in a fifth-grade classroom. Students create common denominators, ordering red carpet, repairing a bridge, creating a house plan, and preparing for an
experiment. This follows a learning model: Into, Through, and Beyond. Into students explore fractions operations through animated graphics and real-world contexts. Through students create common denominators for fraction bars in preparation for fraction operations. And beyond, students solve fraction operations problems in real-world fanciful settings.

The teacher liked the way the students were able to manipulate the software to get a better visual sense of problem solving with fractions. She disliked the way some students seemed to be guessing at the answer and clicking until they received feedback that they got the correct answer.

Fraction Operations contains a journal where students can copy their work. Here they can record audio comments, hear comments spoken, print their journal page, and get help from a glossary. The journal puts the pages in numerical order by date.

Technology Workshops

The university faculty member conducted a series of workshops on integrating technology into teaching. The workshops focused on a goal of having 2-3 lessons integrating technology in a mathematically meaningful way prepared and ready to go for the 2000-2001 academic year. This would be the second year using the curriculum and we believed that the teachers might be more willing to take the time to investigate the software provided with their curriculum. To facilitate the development of these lessons the WSU faculty member held three full-day workshops. A total of 5 sessions ranging from 3 to 4 hours were held and all teachers were required to participate in their grade level session. Table 2 summarizes the workshops.

Table 2

<table>
<thead>
<tr>
<th>Date/Time</th>
<th>Grade</th>
<th>Software</th>
</tr>
</thead>
</table>

Faculty Technology Workshops
May 30

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
</tr>
</thead>
</table>
| a.m.  | 2 and 6 | Shapes, Geo-Logo: How far, How long (2<sup>nd</sup>)  
        |         | Geo-Logo: Picturing Polygons (6<sup>th</sup>)  
        |         | Patterns of Change (Trips) (6<sup>th</sup>) |
| p.m.  | 5       | Geo-Logo: Picturing Polygons  
        |         | Patterns of Change (Trips)  
        |         | Table Top Sr. (Not available) |

May 30

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
</tr>
</thead>
</table>
| p.m.  | 5       | Geo-Logo: Picturing Polygons  
        |         | Patterns of Change (Trips)  
        |         | Table Top Sr. (Not available) |

May 31

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
</tr>
</thead>
</table>
| a.m.  | 1       | Table Top Jr.  
        |         | Shapes |
| p.m.  | 4       | Geo-Logo: Sunken Ships and Grid Patterns |

June 1

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
</tr>
</thead>
</table>
| a.m.  | 3       | Tumbling Tetrominoes  
        |         | Geo-Logo: Turtle Paths |

A committee debriefing of the workshop activity occurred on Monday, June 5 at 1 p.m. It was noted at this, the last meeting of the semester that each grade level had 2-3 lessons outlined with the appropriate software and that these lessons would be used during the 2000-2001 academic year. In addition, the sixth grade will use the 5<sup>th</sup> grade geo-logo software in its Connected Mathematics Project curriculum.
Results

Initially, the TIC meetings were informal and our discussion focused on the needs and concerns of the participants. No formal minutes were recorded. The informal environment was important to the rapport of the committee since it provided the participants a forum to express concerns. As our conversation continued, three strands emerged: a) competing mandates, b) the necessity for communication among all participants, and c) how our conceptions of mathematics influenced the technology used in classrooms. Together these strands led us to conclude that teachers work in extremely complex environments where changing expectations require them to react almost immediately. The decisions they make about technology are not indicators of their knowledge of technology, mathematics, or learning alone. Rather, each of their decisions must be understood in the context in which it is made. And many issues must be considered before the use of technology can be seriously considered. Each of these strands is described in more detail below.

Competing mandates

The teachers with whom we worked were asked to think about integrating technology into their classrooms, to adopt a new set of state graduation standards, and to implement a new mathematics curriculum at the same time. The interaction of these mandates led to situations in which the requirements competed for standing. Although some of the positioning may have been political, most resulted from the team’s sincere attempts to address each mandate. The teachers were willing and interested in integrating technology into their classrooms. But, this mandate was often subordinated to the other mandates and issues of students’ learning that held higher stakes. In general, the teachers’ concerns focused on a) Investigations’ alignment with
Wisconsin’s Model Academic Standards and b) Investigations alignment with their previous curriculum.

**Alignment with the Wisconsin standards.** The Wisconsin Model Academic Standards carry high stakes. As in surrounding states, Wisconsin High School students will graduate only when they pass a graduation exam based on the standards [Governor's Council on Model Academic Standards, 1998 #1391]. The teachers were concerned about preparing their students for the impending test. Many voiced concerns that Investigations, currently without assessments available, would not adequately prepare students for the 4th grade testing. In particular, teachers were troubled by the apparent lack of emphasis on learning basic math facts.

**Figure 1: Content Analysis**

### Standard A: Mathematical Processes

<table>
<thead>
<tr>
<th>A.4.1 Use reasoning abilities to justify strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kindergarten</td>
</tr>
<tr>
<td>Lesson 1.3</td>
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<tr>
<td>Lesson 1.4</td>
</tr>
<tr>
<td>Lesson 2.1</td>
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<tr>
<td>Lesson 2.2</td>
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<td>Lesson 2.3</td>
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<td>Lesson 3.2</td>
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<td>Lesson 3.3</td>
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<tr>
<td>Lesson 4.3</td>
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<tr>
<td>Lesson 5.1</td>
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<td>Lesson 6.1</td>
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<td>Lesson 6.2</td>
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<td>Lesson 6.3</td>
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Consequently, the teachers wanted to determine which aspects of the standards were not being addressed by the new curriculum. This was accomplished through a tedious review of the
stand and the Investigations curriculum series. The university representative analyzed the content and documented which lessons at each grade level fit under the strands of the Wisconsin standards. An example of this analysis is shown in figure 1.

Once these areas were identified, the teachers targeted them with technology. The software reviews and technology workshops were designed to address the areas the teachers identified. Their choice of software fit a perceived need and was not just a new technology that may or may not be helpful. The belief that the technology could help immediately helped the teachers accept technology as a viable alternative.

Alignment with past curriculum. The teachers were also concerned about how Investigations fit with their previous curriculum. This issue stemmed from their concern that older students were being thrust into this new curriculum without the necessary background. Intermediate-grade students were expected to conduct mathematical inquiry in ways that were introduced in the earlier grades. Without this background, the teachers were afraid the students would not be able to complete their assignments. These students became identified as the “transition students” because of their lack of exposure to the instructional foundation provided through Investigations in grades K-3. The software reviews and technology workshops also addressed ways in which technology might be help the transition students

Communication among participants.

As we began our collaboration, it became apparent that people responsible for various the various mandates were not being informed of the project activities. Not informing them created temporary roadblocks that created uncomfortable situations at best. The representatives have a strong stake in seeing that the mandates are implemented successfully. Any activity that threatens the mandates’ successful completion presents a threatening situation to the
representative as well. Although the TIC’s focus had been on aligning the technology initiative with both the Wisconsin standards and the Investigations curriculum, to their colleagues closely aligned with other initiatives, the RITE project was threatening.

In one particular situation, the teachers’ concerns with Investigations (i.e., a plan for transition students and the curriculum’s alignment with the state standards) were shared with the cooperative services (CESA) representative for the district—the administrator responsible for purchasing the Investigations curriculum. Immediately, she asked to attend the next meeting and to see minutes of past meetings.

As a result, the CESA representative, the principal, and the university representatives met to address her concerns about the direction of the project. In particular, this informational meeting was designed to provide RITE project general information and discuss the rationale behind the direction of the committee to date. This step was necessary to the continued functioning of the committee and resulted in a general movement toward formalized committee activity. From that point on, the CESA representative provided a secretary to record the minutes of our meetings. The secretary would distribute the minutes to the CESA representative, the principal, and the university representatives. This activity would ensure on-going communication between administration and the TIC.

Other situations that required better communication among project participants were diffused through swift and thorough explanations of intentions and justification of project goals and plans. Although we were unable to identify the people who needed to be informed of project activities when we started, we believe our informal organization of the project created the supportive relationship necessary to conduct this project. The important structure that is now in
place could only emerge from our interactions. Any formal structure placed on the group would have damaged the groups’ cohesiveness.

Teachers conceptions of mathematics

The teachers with whom we worked were exceptionally insightful into their students’ progress in mathematics. Their insight helped them identify areas that might be strengthened by technology. But finding technological solutions was difficult. This difficulty arose in two ways, both of which focus on teachers’ and university representatives’ understanding of mathematics.

First, conceptions of mathematics led to certain types of software. Teachers who believed mathematics was solely computational would only choose software that emphasized computation. Second, our understanding of mathematics made it difficult to “see” the mathematics in some software packages. The district’s new mathematics curriculum came bundled with proprietary software. None of this software emphasized computation. Rather the software emphasized a more conceptual understanding of shapes and logic. As a result, much of the software was initially judged useless. Not because it did not embody important mathematical ideas, but because we could not see the ideas in the software.

The perceived mathematical needs of the students, however, appeared to make the fifth grade teacher more willing to investigate alternative software during the first year. The 4th and 5th grade students had not been exposed to the Investigations Curriculum in previous grades and the possibility of utilizing supplemental software for these “transition” students was explored. In particular, the fifth grade teacher was concerned with the students understanding of rational numbers and the operations using rational numbers. One of the strong points of the software chosen was the ability to keep a journal. This capability allowed the teacher the opportunity to engage in standards-based assessment activities by providing an active forum for the students to
express their thinking surrounding his or her problem-solving process. The fifth grade teacher also liked this option but indicated that the time required to access and comment on individual student’s work might be time prohibitive.

Although this teacher expressed concern about the student’s understanding of rational numbers, her utilization of the software appeared to be at a procedural level. With the many cognitive decisions faced by the classroom teacher on a daily basis and in spite of the level of dedication to achieving student learning, the level of the individual’s mathematical understanding appears to interfere with the ability to “see” the mathematics in some software packages and impeded creative ways to incorporate the software. This finding indicates integration of software into the school curriculum hinges on the teacher’s conceptions and/or beliefs of both the technology and the mathematical content. Therefore, professional development opportunities in both the technology itself and the mathematics involved should be provided to aid in the successful integration of technology into the mathematics classroom at the K-6 level.

Conclusions

What comes first is the organization of the situation into which technology is to be integrated in a way that addresses all of the immediate concerns in teachers’ professional lives. It is not merely a matter of learning theory, conceptions of content, or learning about machines. Those things can only come into play after other, larger issues are considered and teachers, administrators, and other interested people are assured that their interests are accounted for.

The calls for reform do not address the complexity of teachers’ lives. Rather, the calls represent one more interest group—a groups that has a stake in the use of technology in teaching. Although their concerns are important and there is reason to believe technology can enhance
student learning, the calls must be tempered by the other demands on teachers, schools, and school districts. Only when they all are brought together—and all are satisfied—will technology integration be successful.

Dewey (Dewey, 1895/1964) suggested that all learning must reduce friction or increase efficiency for it to be valuable. In addition, he argued that teachers have the responsibility to “psychologize” the subject matter for their students (Dewey, 1902/1971); that is, to understand what is occupying their time and make the subject matter fit their circumstances. We found the same to be true for staff development in technology. Integrating technology might add friction, and reduce efficiency if the broader picture and technology’s role in that picture is not carefully considered. In our case, until we had resolved other more pressing issues in the teachers’ practice and until we fully understood each other’s conceptions of mathematics, we could not integrate technology into their classrooms.
References


