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Challenges in Linguistically and Culturally Diverse Elementary Settings with Math Instruction using Learning Technologies

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This research effort reports the findings of an empirical study focusing on the ways in which technological tools are implemented specifically in mathematics education in a Title I school. The purpose was to identify the perspectives and actions of the school's mathematics specialist and the multi-graded (grades 2–3) classroom teacher as they attempted to deliver instruction with technology for both English Language Learners[1] (ELL) and non-ELL students. Findings showed that a critical factor in access to mathematics education and technology for ELL students in a multi-graded 2–3 classroom in a Title I (K-5) school setting was *language*. Although potentially powerful technolo-

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gies—analog (concrete objects) and digital (software) were used, many ELL students could not access the content solely because of language difficulties. Teachers used the concrete objects as modeling tools, to reveal students' thinking, and for communication of foundational mathematics. Conversely, the software used served none of these functions because the available software did not do the kinds of things the manipulatives did, teachers' knowledge of exemplary software was insufficient, the school used an impoverished model of technology integration, and teachers were constrained by the school district's policies of English immersion for ELL students.

KEY WORDS: English language learners; English immersion settings; learning technologies; mathematics education; elementary grades.

INTRODUCTION

The technology exists. Nearly all schools in our country have access to some form of computer laboratory, and more than half of the classrooms have one or more computers (Education Week, 1998). Manipulatives, measuring devices, and other concrete tools are in place. Exemplary practices have been identified. So, what is happening with regard to math education with these forms of learning technologies? At a gross level, we know that computer technologies are implemented differentially across grades and across schools serving populations of differing socio-economic levels (Milken Family Foundation, 1999). An acknowledged problem is that schools that serve families at or below the poverty level usually have fewer resources (Porter, 1991). In many cases, this may mean a small number of computers and a large number of children. The same might be said of schools serving large numbers of English Language Learners (ELLs). It is an unfortunate reality in the US that second language learners and poverty are closely associated (DeVillar, 2000). Language issues, however, do not just come in tandem with poverty, nor do they enter the technology-in-education mix in some straightforward fashion. On the one hand, language differences present an often-untapped resource that can contribute to constructive learning. On the other, schools with ELLs can be sites of conflict and contradiction, sources of misrepresented identity, and places with frequent misunderstandings between teachers and learners.

According to DeVillar (2000, pp. 324–325) ethnicity, income level, reading achievement, and access to technology are all tightly interwoven. In fact, there is considerable evidence that second language learners generally have even less access to technology-enriched instruction than native English speakers (DeVillar, Faltis, & Cummins, 1994). The decrease in access is not just due to constraints from not understanding the language of instruction, but also to the lack of availability of material resources, and to less cognitively and even linguistically engaging instructional practices at schools or in classes with high rates of ELL students. Both English speakers and English learners suffer from the lack of a coherent instructional model (e.g., a process approach that conceptualizes mathematical tools in relation to the kinds of learning they afford). In fact, regardless of the language background of the students, most mathematics technology in classrooms tends to revolve around drill and practice software, and the goals and outcomes are more narrowly defined to learning basic calculations. (See Weiss, Banilower, McMahon, & Smith (2001) for a comprehensive survey of the nature of mathematics teaching in the United States, including the role of technology in such instruction.) But English learners receive narrow drill-and-practice instruction to an even greater degree than do English speakers (Hunt & Pritchard, 1993; Skeele, 1993). Moreover, teachers frequently do not group ELLs with other students who might help them gain access to the more coherent, process approaches available in some classrooms. Furthermore, given that teachers at high incidence ELL schools often are less qualified, these teachers may select software programs for content instruction that fail to promote the use of the new "languages" (the language of English, the language of mathematics) while at the computer (DeVillar et al., 1994; Young, 1988). This web of language/ethnicity, income, and access to technology is especially problematic in mathematics instruction where ELL students have to learn both the language "of the street" and also the academic language of instruction. If they do not learn these forms of English early on, including the written language of story problems and directions, they are likely to suffer increasing gaps in understanding and achievement as they grow older (Khisty, 2001). It also must be acknowledged that although mathematics may be perceived as having its own language or as language free, learning in math requires academic English learning.

Presumably, technology—not only computational technology but also analog tools that amplify our natural capacities (Pea, 1987)—can help lighten the learning burden for ELLs as well as create opportunities for extended understandings in mathematics and other subject areas. It can assist teachers in creating a supportive, affective environment in the classroom (Butler-Pascoe, 1997). The interactive game features of computer programs and the exploratory quality of the Internet can motivate students to use their second language. The untiring, non-judgmental nature of the computer makes it an ideal tool to help second language learners feel sufficiently secure to make and correct their own errors without embarrassment or anxiety. Additionally, technology can provide students with language experiences as they move through the various stages of second language acquisition. Early in the second language learning process, multimedia or coordinated sets of manipulatives, calculators, and other conceptual aids can help students deal with mathematical patterns, and also represent and communicate their ideas with little demand for translation. Later, students may progress to tasks that require limited written or oral responses, and in the more advanced stages use their second language as they manipulate technology collaboratively to solve problems. It is through such technology-based experiences, by translating among forms of representation (e.g., from written text to symbols to graphs to oral exposition) that students develop both competence in the English of math instruction and also competence in mathematics. With this orientation in mind, we engaged in a study to understand teachers' actions in a linguistically and culturally diverse Arizona classroom at Park Elementary School (pseudonym, as are all names for people and places in this article), particularly as they used both, analog and digital, technology in mathematics education. Park Elementary was selected for this study because it was the only public elementary school in Maricopa County, Arizona, to have a dedicated mathematics specialist, Mrs. Turner, who was also a technology specialist in charge of a computer lab. Moreover, this mathematics specialist had received The Math Teacher of the Year award by the Arizona Department of Education. The State of Arizona defines a mathematics specialist as a teacher, who by virtue of extra content specific practical experience and 24 h of graduate coursework, possesses an extensive knowledge of mathematics, including the specialized content knowledge specific to the work of teaching, as well as knowledge of the mathematics curriculum and how students learn. These teachers have developed a wide range of research-based teaching and assessment strategies, and continually use data to drive instruction (Arizona Department of Education, 2006). A technology specialist is defined similarly, possessing knowledge and skills related to teaching technology and teaching with technology (e.g., ISTE, 2000). The combination, therefore, of these two suites of knowledge and experience, was expected to provide a case by which we could come to understand how mathematical *content* can be facilitated by the use of technological *tools*, to help students with limited technical English better understand, communicate, and ultimately achieve in subject matter with considerable political capital.[2]

The literature on equity in the use of technology has historically painted a pretty dismal picture for minority, economically disadvantaged, and inner-city children. Access to powerful learning technologies is more limited for urban schools (Anderson, Welch, & Harris, 1984; Ascher, 1984; Becker, 1986; Gorski, 2001; Hayes 1986), access once the computers are installed appears to be poorer, with students who are perceived to be of high ability getting more or better access to computers than students who are low achieving or at risk (Becker, 1990). Moreover, there is disturbing evidence that some classroom practices that assign struggling students to drill exercises at the computer and assign more competent students to higher order thinking-related tasks, differentially affect students of lower socioeconomic status when compared to affluent students (Watt, 1982). When combined with the literature on mathematics instruction for ELLs (Secada, 2000), we can begin to see that all things being equal (e.g., availability, access, etc.), the instructional practices of teachers becomes a critical variable in determining the quality of instruction children receive. In particular Khisty (2001) showed that effective teachers of mathematics in second-language classrooms engineer linguistically sensitive learning environments by integrating effective principles of literacy development and second language acquisition. They do this by beginning with high expectations for their students that are ''actually manifested in the curriculum'' (Khisty, 2001, p. 229), contextualizing the mathematics, and through the conscious use of pedagogic talk such as probing questions, they draw out students' mathematical talk as windows into their thinking. These patterns were evident for teachers whether or not they used Spanish in the classroom or taught in English-only situations. The key innovation in our study was to combine the qualitative study of mathematics practices in Second-language acquisition situations, with practices incorporating technological tools that, purportedly, help students learn mathematics better by providing contextual, visual, and structural supports.

While there is considerable information about inequities in access and practice regarding using technology in math instruction for ELLs, there is less on why teachers believe they do what they do regarding the technology and range of instructional practices available to them. These frames of reference are critical if we are to understand how available technology is used, and to what extent the actual on-the-ground use of technology in classrooms contributes to or inhibits equitable treatment of children. Observation can provide insight into the ways a configuration of people; resources, policies, and practice interrelate, and can suggest possible causes and effects for educational outcomes. The structure of these causes and effects can then be articulated into more formal hypotheses regarding how teachers might improve instruction and technology use to provide equitable instruction to ELLs. We believe that what we learned from a study such as the one we conducted cannot be interpreted without a thorough understanding of the social context within which the teacher's practices occurred. The setting for our story is a 2nd-3rd multi-grade classroom in Park Elementary School, a Title I[3] school, where the teacher, Mrs. Kaminski, was dealing with issues of language, poverty, technology, and external demands to meet certain standards, in an attempt to help students learn and understand mathematics. Mrs. Kaminski was supported by Mrs. Miller, the school's ELL specialist[4] with helping the ELLs gain knowledge, proficiencies, and experiences in English that will enable them to move to a greater level of academic competency. We hoped to gain knowledge of Mrs. Turner, the school's mathematics specialist, and Mrs. Kaminski's perspectives on the use of technology in math education in this linguistically and culturally diverse classroom.

METHODS

This is a qualitative study conducted with attention to the assumptions and traditions of interpretive research recommended by Erickson (1986). Observational studies have an immediate utility for the reader in that they provide an exemplar by which the reader's own practices can be seen as if in a mirror. For that reason, our study is situated within an interpretivist perspective (Erickson, 1986). Data collection over 2 years' time was comprised of participant observation in Mrs. Kaminski's classroom, the computer lab, and the pull-out ELLs classroom; semi-structured interviews with the math specialist, the classroom teacher, and the ELL specialist; and analysis of documents. Each of these methods is described in detail.

Researchers' Roles

The first author had a long-term relationship with educators and students at Park Elementary. His spouse completed her student teaching and worked as a full-day kindergarten/first grade teacher in this school from 1997 to 2003. With frequent visits to the school for formal field-work and informal visits for field-trips to the zoo, museums, and other school events provided the opportunity for this researcher to become thoroughly familiar with people, the school, and school procedures. He also participated in once a year math and science day, a multicultural day, and end of the school year class performances, and became an active part of this school community. This role facilitated access to teachers, classrooms, and documents for this study over the long-term and helped establish trust between the researcher and the school community. Data collection for this study occurred regularly for approximately 120 h over a period of two school years. In addition, this researcher conducted further research on changes in instructional practices as Park Elementary responded to changes in state and national level policies related to accountability and English-only[5] instruction. The first author of this research report conducted the field-work and the second author assisted the former with the data record keeping, methods of interviewing, analysis, and construction of the research report.

Participant Observations

At the start of each school year, over 2 years, the first author conducted ten day-long observations to become familiar with the setting and the daily routine. Subsequently, this researcher spent approximately 2 h, 2–3 times a week for 20–30 weeks each school year in the field, observing the interactions in the classroom, the computer lab, and the ELL groups. Under the assumption that the primary purpose of computational media in the mathematics classroom is to provide ways of communicating ideas, exploring claims, and articulating arguments (Piburn & Middleton, 1998), the aim for each observation was to capture the classroom discourse as it pertained to these issues. The aim for each observation was to capture the classroom discourse as it pertained to (a) technological tools used, (b) mathematical representations developed, (c) arguments made (by students), and (d) teacher facilitation. The teacher was audio taped continuously to obtain a verbatim record of her interactions with students. These tapes were transcribed and integrated with the observation notes.

Semi-Structured Interviews

Semi-structured interviews geared towards gaining an understanding of each participant teacher's philosophy and practice as related to technology for mathematics instruction in the context of a linguistically diverse setting were conducted. Informal and formal conversations with the teacher participants occurred frequently over the period of the long-term fieldwork. Open ended statements/questions were posed such as, "Please share with me information about your classroom. What are the school and district goals for mathematics? Please share definitions of technology. How do you envision the use of such technology in the classroom?" The classroom teacher, the mathematics specialist, and the ELL specialist were interviewed regularly at intervals of every 2–3 weeks over the course of the study. The teachers were asked to describe their approach to mathematics education with technology in concrete terms with examples. The interviews progressed from indirect to direct questions, with the idea that the most valid and least knee-jerk responses related to the study's aims would come from non-directive probes. The prompts were intended to be neutral with the objective of seeking data in teachers' own words as it related to the purposes of the study. Teachers were assured that their names and school affiliations would not be revealed. As the researcher became more familiar with the setting, the teachers seemed to appreciate the opportunity to share their perspectives about facilitating mathematics education to both ELL and non-ELL students in their English-immersion setting.

The semi-structured interviews lasted 30–45 min each. These interviews were audio-taped, transcribed, and formed a part of the data corpus. Further interactions via face-to-face meetings, email, and phone conversations occurred in informal interactions while the researcher was at the school and during report construction after the initial data collection period.

Document Collection

The researcher collected artifacts from the district, school, teacher, and student levels, including grade level thematic units, the district's curriculum with district articulated learner outcomes for mathematics, model mathematics lessons, and related scoring guides. In addition, district-compiled assessment results (the Stanford achievement test), state academic standards, the school's assessment plan, and school goals were collected as well. These documents added to our understanding of the academic and social context in which the teachers' practices occurred.

Analyses of Data

According to Erickson (1986, p. 146) qualitative data analysis is a process of establishing evidentiary warrant of empirical assertions generated through a process that is largely inductive. A number of initial propositional assertions regarding the induced hypotheses were developed after a thorough reading of the entire data corpus which was formed from the three data sources (participant observations, semi-structured interviews, and document collection) described above. The formation of the initial assertions was aided by researcher notes and memos during fieldwork. From this reading and the initial research questions raised before the study began, two assertions that were supported empirically survived the subsequent search for disconfirming evidence. The evidentiary warrant for these assertions was established by repeatedly reading the data corpus to test the validity of the assertions and searching for confirming and disconfirming evidence. During this process of warranting the assertions, we sought what Erickson (1986, pp. 147–48) called "key linkages among many items of data as analogous instances of the same phenomenon." In this manuscript, these assertions are presented with evidentiary samples that embody the data corpus. To the degree possible, evidentiary samples from a particular source, for instance teacher interviews were verified with data from other data sources, observations and documents. Following Erickson's (1986) approach, to establish the validity of interpretations, real data were rearranged to make obvious to the reader that described events occurred by creating vignettes. These samples are in the form of quotations from teachers and students, descriptions of teaching methods, classroom interactions from the observations, excerpts from teacher interviews, and descriptions of classroom structure.

Enhancing Credibility

In qualitative research efforts such as this, the notions of validity and reliability are about credibility and authenticity and are intricately interwoven with the researcher's role, whether participants know that the researcher is observing them, the participant–researcher relationship, adequacy of theoretical and methodological conceptual frameworks, appropriateness and adequacy of research design, adequacy of data and data collection methods among a host of other issues. Validity of the study's inferences rests on coherence. Coherence indicates credibility, comprehensiveness, and authenticity. Inferences drawn in the study, have to be based on multiple sources of data—a synergistic whole of data. When the work is looked at as a whole, it is necessary for all the different pieces of the study to add up to a lucid account. If the participants can recognize the account then it is said to be authentic.

We worked to enhance credibility and authenticity in this study. In qualitative research, the belief about knowledge is that knowledge is not an edifice separate from reality of participants' lives. We collected data from multiple sources (classroom teacher, mathematics specialist, ELL specialist, and students) using multiple methods (interviews, formal and informal discussions with participants, observation occasions, and document collection). As interview data are primarily self-reported, we used data from other sources such as observations and document collection to relate stated views with observed practices. In constructing this research account, we have provided descriptions of the settings and happenings with the intent of allowing the reader to vicariously participate in the happenings. The study's coherence is aimed at creating a research report that allows the reader to function as a co-analyst.

The researcher engaged in long term field work over 2 years. This prolonged engagement in the field led to persistent observation. In order to confirm the observations and interviews, teacher participants were provided with transcripts of observation records and interviews. In addition, an initial draft of this report with vignettes supporting the developed assertions was shared with the teacher participants. Teacher participants used these forms of exchanges to provide clarification where necessary and helped further researchers' understanding of happenings in the field. During field work, observation records, interview transcripts with researcher's interpretive analysis including notes on low and high inferences, and a reflective journal created during fieldwork were shared with Smith (1987, 2004), a qualitative research methodologist and senior scholar at Arizona State University. These consultations facilitated improved interview techniques, and focused and selective participant observation. Further the researcher (first author) conducted peer-debriefing[6] with a doctoral candidate at Arizona State University. Lastly, drafts of this report were shared with other senior researchers: Casanova (1991), DeVillar (2000), Edelsky (1999), Faltis (1997), Flores (2002), and Young (see Hinchman & Young, 2001). These interactions with scholars, while serving as a form of peer review, also helped strengthen the quality of interpretations and the trustworthiness of our study's inferences.

THE SETTING FOR THE STUDY

The School

Park Elementary School, Arizona, located in an urban setting in the Phoenix valley, offered an ELL program that pulled out qualified students from their regular language arts classes for English language instruction. These students happened to be mainly monolingual Spanish speakers, some of whom were recent immigrants, students with primary home language other than English as reported on the home language survey, and qualified for ELL services based on their performance on the Woodcock Munoz Language Survey (Woodcock & Sandoval-Munoz, 1993). These children were known as "immersion children," referring to the belief that the more they are exposed to English, the more English they will learn. Nearly 85% of Park Elementary's 800 students received free or reduced price lunch. Park Elementary's student population was, 62% Hispanic American or Latino, 25% European American, 5.2% Native American, 4.3% African American, and 3.5% Asian American; of these 30% were classified as ELLs. The school buildings are approximately 50 years old. The school had a considerable transient population, with families moving in and out of the area. Park Elementary reported a mobility rate of 59% and absentee rate of 6.3%. An abundance of motels, trailer parks, and pay-by-the-week housing, surround the school and account for the mobile nature of the student population.

Each classroom had one or two Macintosh computers. Park Elementary had a mathematics specialist, Mrs. Turner, who was paid from the US Department of Education Title I funds and was in charge of a "Higher

Order Thinking Skills-HOTS" (Pogrow, 1990) laboratory with 20 Macintosh computers. Her responsibilities also included modeling math lessons in classrooms and supporting teachers with mathematics instruction based on their individual needs. Approximately 80 staff members, including administrative, certified, classified, and support staff were at the school during the period of the study. Two reading/ELL specialists, four ELL teachers, and four ELL aides formed a part of the school staff.

The Classroom

In Year 1 of the study, Mrs. Kaminski's classroom was a multi-grade/multi-year 2nd–3rd grade classroom in Park Elementary (see Table 1 for student enrollment by selected student characteristics). This classroom was selected for the study, because Mrs. Turner, the mathematics specialist, worked with Mrs. Kaminski on a regular basis to coordinate mathematics education with learning technologies in the classroom and computer lab sessions. Mrs. Turner described her efforts with Mrs. Kaminski as an attempt to create a model for math education with learning technologies at their school that could be expanded to other classrooms.

Mrs. Kaminski started the school Year 1 with 21 students. Gabriel arrived from Mexico in late November and Jesus, also from Mexico, arrived in late January. However, over the course of the school year, three students left the school and some new students were placed in this classroom. At the end of school Year 1, the class had 25 students; eleven 2nd graders, and fourteen 3rd graders with 13 boys and 12 girls. In Year 2, Mrs. Kaminski taught 3rd grade and her prior year 2nd grade students remained in her classroom. She started the year with 22 students in her 3rd grade class and ended with 26 students, 14 boys and 12 girls.

TABLE 1.
Student Enrollment in Mrs. Kaminski's Classroom

	Year 1	Year 2
Enrollment by race/ethnicity		
Native American	1	1
African American	1	2
Asian American	1	1
European American	8	7
Hispanic American/Latino	14	15
Number enrolled in free or reduced price breakfast/lunch	20	22
ELLs	12	16

Mrs. Kaminski's room had small rectangular tables where students sat in groups of 3 or 4. At the front and the back of the classroom there were "U" shaped tables used primarily for small group reading/language arts instruction. This class had one new Macintosh computer and one older computer in a corner. An overhead projector was in the front of the room.

The Teacher Participants

Mrs. Kaminski

Mrs. Kaminski began her teaching career at Park Elementary and has 6 years teaching experience. She lives in the same city as that of Park Elementary, but not within the school's attendance boundary. Mrs. Kaminski, in her late thirties, is married and the mother of two teenage girls. Always professional in her attire, she mostly wore long dresses and occasionally wore trousers or jeans on Fridays. Her cheerful demeanor and kind attitude towards children made her very approachable to her students. Her classroom walls were adorned with student generated work and print material such as posters, art work, and inspirational messages. These displays were frequently changed based on the thematic instructional focus for the class. She sought the collaborative assistance of Mrs. Turner, Park Elementary's math specialist to enhance her class mathematics and technology integrated instruction. Mrs. Turner was in Mrs. Kaminski's room 4 days of the week, for one class period each day, to assist with mathematics instruction. Each week, Mrs. Kaminski's students went to Mrs. Turner's HOTS computer lab for one class period. These teachers worked well with each other and each picked up with math lessons where the other had stopped.

Mrs. Turner

Mrs. Turner has 8 years of teaching experience. She did not have a classroom of her own in her role as the school's mathematics specialist and HOTS lab manager. Her 7ft×7ft office, located next to that of school psychologist, is lined with bookshelves filled with books, journals, notebooks, binders of software manuals, conference proceedings, and two floor-to-ceiling height stacks of boxes full of math manipulatives. She has her desk against one wall and near the door had a round table with two chairs that she uses when she meets with teachers.

In her late twenties, Mrs. Turner is a wife and mother of two boys, one in kindergarten, and the other 2 years old. She is always gentle with students and characterized by her soft voice and ever smiling face, she comes across as cool, calm, and collected. Mrs. Turner's hearty laugh and helpful attitude endears her to her colleagues. Professional in her attire and interactions with colleagues, she offers lessons to various classes in the HOTS computer lab and works with individual teachers to provide and support math instruction. She also conducts technology workshops for teachers at Park Elementary and other schools in the district. Mrs. Turner lives in a neighboring city to that where Park Elementary is located and her neighborhood is zoned to a different school district. Mrs. Turner has a Masters degree in Mathematics Education. Mrs. Turner received "The Math Teacher of the Year Award" from the Arizona Board of Education. She has participated in developing the state's math standards, actively reviewed early drafts of the National Council of Teachers of Mathematics (2000) standards and provided feedback to the individuals who developed the standards.

Mrs. Miller

Mrs. Miller, the ELL specialist, with 15-years of teaching experience, is the only Spanish speaking, bilingual specialist in the entire district. She too lives in a city that adjoins that of Park Elementary. In her early forties, a mother of two college-age girls, Mrs. Miller comes across as confident and quiet, always helpful to her colleagues. She visits various classrooms to provide language arts education to ELLs by pulling them out during language arts lessons. In addition she provides support to Park Elementary school teachers in providing reading instruction to all students. This bespectacled lady with her steel cart packed with books and neatly arranged white boxes filled with small sized, thin books and toy-like visual aids, colorful letter and word cards, visits Mrs. Kaminski's room during the class language arts period all five days of the week.

WHAT WE LEARNED

From the collected data corpus we make the following assertions (Erickson, 1986, pp. 145–156) about the use of technology for mathematics instruction, and its impact on ELLs.

> Assertion 1. It's not just instructional practices; teachers have a broad local definition of technology that includes concrete materials (in the form of math manipulatives) as well as computer programs under the umbrella term, "Teaching Tools."

For the purposes of this research study, at the outset we defined technology as computer software, Internet, graphing calculators, electronic devices, and other similar devices used as tools in the mathematics education process.

However, we took care not to take this definition for granted. Our initial definition changed over the course of the study, as evidenced from this assertion. Local meanings of technology went beyond the researchers' initial definition to include math manipulatives such as pattern blocks, geo-boards, fraction tiles, etc. Use of these manipulatives was observed consistently during the time spent in the classroom (see Table 2).

TABLE 2.
Summary of Observed Math Lessons and Use of Concrete Objects

	Number of lessons/year	
Concrete objects (math manipulatives)	Year 1	Year 2
Animal counters—six different animals, in 2 sizes and 6 colors	4	2
Solid counting discs—four colors, all the same size	2	0
Buttons—assorted colors and sizes	2	0
Bottle caps—assorted colors and sizes	1	0
Popsicle sticks	2	2
Attribute shapes—four shapes in two sizes and four colors: circles, squares, rectangles, and triangles	4	4
Relational attribute blocks—60 plastic blocks in five shapes, three colors, two sizes, and two thicknesses per shape	4	4
Pattern blocks—six shapes and colors: squares, triangles, parallelograms, hexagons, trapezoids, and rhombi	2	4
Power blocks—four shapes of different colors and sizes: 10 sizes of triangles, five squares, five rectangles, and four parallelograms	4	4
Fraction squares—24 pieces in six colors: six squares divided into halves, thirds, fourths, sixths, eighths, and a whole	3	3
Fraction circles—24 pieces in six colors: pieces show halves, thirds, fourths, sixths, eighths, and a whole	3	3
Fraction bars—51 pieces in nine colors: set of halves, thirds, fourths, fifths, sixths, eighths, tenths, twelfths, and a whole	4	4
Dice	2	4
Geoboards	2	4
Paper clips	1	1

Mrs. Turner, the math specialist, vocalized and demonstrated her definition of technology. During an initial interview, when asked how she perceived technology in mathematics education, Mrs. Turner said:

> I see technology as any tool that I use to help get across the concept. Whatever concept, standards, performance objective I'm teaching, technology is the math manipulative, the computer, the overhead. Technology includes all the tools I use to help students, either in delivery (of instruction), practice, or assessments. I see technology as manipulatives—things that students can use to explore concepts; it helps build the concepts.

Field observations corroborated the local meanings expressed by the teachers. A pattern emerged in the regular use of power blocks, math-fraction tiles, pattern blocks, geo-boards, and paper and pencil. Mrs. Turner always began her lessons by providing 5 min time for her students to explore the concrete objects. This was followed by a short 10–12 min lesson where she modeled the use of the concrete objects on the overhead to develop a mathematical representation along with notations she would typically make on the chalk board. She engaged students in eliciting responses related to the mathematical problem on hand and then provided two or three problems for them to solve on their own with the use of the objects. Mrs. Turner and Mrs. Kaminski typically walked around the room, monitored what students were doing, and worked with small groups of students at their tables. Reflecting on the role of concrete objects in teaching mathematics for understanding and advocating thoughtful use of these manipulatives, Thompson (1994) said:

> Our primary question should always be "What, in principle, do I want my students to *understand*?" Too often it is, "What shall I have my students learn to *do*?" If we can answer only the second question, then we have not given sufficient thought to what we hope to achieve by a particular segment of instruction or use of concrete materials. (p. 556).

Mrs. Turner, like Thompson (1994), wanted her students to not only "do mathematics" with concrete objects, but also "understand mathematical ideas" by using the concrete objects to demonstrate or represent their understanding of the ideas. She hoped to have conversations with her students, engaging her students in ways to think and converse about mathematical ideas using the concrete objects. Mrs. Turner felt that the concrete objects could be used to bridge the mathematical language and notations with physical "tangible" representations. Her approach could be characterized as "constructivist learning and teaching" (Clements & Bautista, 1990). It is important to note that so much of this form of learning is social in nature and involves clarification, negotiation, sharing, and evaluation. In this particular classroom, with a significant number of ELLs, these classroom negotiations of mathematical meaning occurred in an English immersion setting.

Mrs. Turner's beliefs and mathematics instructional practices in the elementary grades were socially astute. These beliefs could be largely categorized as:

1. Learning mathematics is a social process—She believed and demonstrated with her actions, particularly with the use of concrete objects in the classroom, that learning is a social process (Bruner, 1986).
2. Learning mathematics is enhanced by the use of concrete objects—She believed that it was important to allow children, even very young children, to explore complex and advanced mathematical topics and represent their thinking in varied forms (NCTM, 2000).

We have developed a vignette of a typical mathematics lesson with concrete objects, taught by Mrs. Turner, the mathematics specialist, in Mrs. Kaminski's classroom to illustrate these two specific aspects of participants' beliefs and practice.

Vignette of Observed Typical Approach to Mathematics Education with Technology

It was a cool Arizona spring morning. Mrs. Turner, wearing a high collared shirt, rolling an erasable marker in her hand, stood at the front near the overhead projector. She spent a minute observing the students. She cast her eyes over the classroom, looking around to see who was in the room and what her students were doing.

> Mrs. Turner (to class): Today, we are going to do a lesson on relative area. It is going to look like what we have already done in geometry and what we have started in fractions. We are going to use a manipulative called power blocks.[7] And power blocks have different kinds of triangles, squares, rectangles, and parallelograms.

Students were given 5 min to explore the power blocks independently.

> Mrs. Turner (to the researcher): When they are exploring, they are going back to whatever they have mastered, like making patterns or sorting by shapes,

something that they feel very comfortable with. This is the best five minutes spent!

Mrs. Turner and the researcher walk around the classroom to discover that some of the students sorted the blocks by shape and size. After allowing students to explore and noting what students were doing, Mrs. Turner continued with the lesson. During this lesson with pattern blocks, Mrs. Turner first reviewed the different shapes by holding up different shapes and asking students to identify and name them, thereby exploring students' prior conceptions about shape. Then, she led the class through an exercise comparing shapes and sizes, and exploring the relationship among the different shapes.

Mrs. Turner (to class): I want you to get the smallest square and put it in front of you. Square... Square...(gesturing with her hands the shape of a square).

Mrs. Kaminski walked around to where Jesus and Pedro were sitting. These students had arrived from Mexico in the middle of the school year and were classified as monolingual Spanish speakers. She said to them, ''poquito'' and gestured with her fingers to indicate small. Jesus and Pedro looked around to their neighbors, and shyly held up the smallest square. Mrs. Kaminski nodded her head and smiled encouragingly.

Mrs. Kaminski (to the researcher): Jesus is a new student. He was placed in my classroom last week. Straight from Mexico.
Mrs. Turner (to class): I'm going to tell you a couple of secrets. (In a conspirator's tone, lowering her voice). Do you see this square? (holding up the smallest square).
Class: Yeah (with enthusiasm).
Mrs. Turner: I want you to build on top of this square a square of the same size with little triangles. Find the smallest triangles and try to ***build*** (emphasis on build) that square. Build the square on top. (Pauses, walks around.). How many does it take?

Students are building the square. Some of the bilingual students are helping their friends who are primarily Spanish speakers. Jesus and Pedro look around for help to understand the directions. Pedro was fingering the various shapes and touching them around the edges, as if he were memorizing their shapes by touch.

Mrs. Turner (to Pedro): Oh! Oh! Pedro, get two of the triangles. Two of the little triangles, OK?''

> Mrs. Turner (walking around): Oh! May I see yours Martha? (Pauses. Looks. Pauses).

The researcher noted that students felt comfortable in this classroom to talk among themselves and share their representations and speak about them with their peers at their table. In some cases, the bilingual students had attempted to engage their ELL peers in conversation as well, by speaking in Spanish.

> Mrs. Turner (to class, excitedly): Take a look at what Martha and Juanita have done. (Pauses) Oh, several of you did! (Pauses) Did you take the small triangle? Did you lay them down flat?

Displaying enthusiasm at students' responses to her request to build a square with triangles, Mrs. Turner walked up to the chalk board and drew the depiction in Figure 1 as she described the process. She also placed the square (from the set that is to be used with the overhead projector) and demonstrated the process with the square and triangle blocks on the overhead projector.

> Mrs. Turner (to class): Lay the square flat and put the triangles on top of it. (Pauses). How many triangles will it take to cover that square if you are laying them down flat?
> Mrs. Turner (to Mario): Oh! Mario, Muy bien.
> Mrs. Turner (to class): Look at Mario and Brittney. They are showing me with their number fingers. How many did it take to cover the square? (Some of the students are holding up two fingers. This includes a few ELL students, Angel, Tran, and Pearl.)
> Mrs. Turner: Who can give the fraction that this triangle is of this square? (holding up one of the small triangles and the square)
> John: One half.
> Mrs. Turner: Ok great. This is a fraction. If the two triangles are part of a whole square, what fraction would one of the triangles be?
> Brittney: One half.
> Mrs. Turner: Why? (Pauses)

By now, Jesus, Pedro, Gabriel, Angel, Maria, and Tran (all of whom are primarily monolingual Spanish speakers, except for Tran whose primary language is Vietnamese) are playing with the blocks or staring blankly. Mrs. Turner looks around the class to see who is raising their hands and is willing to share an explanation. She notices that she seems to have lost a number of the ELL students' attention, but continues anyway. She picks John to respond.

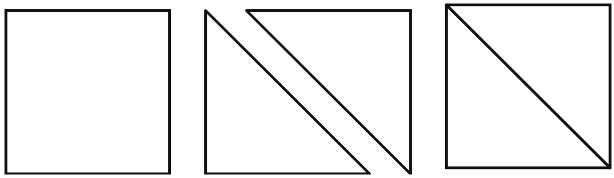

FIG. 1. Construction of square using two small triangles.

> John: One out of two pieces. (John holds up one small triangle in his left hand and the larger square in his right hand.)
> Mrs. Turner: One half of a square or one piece out of two pieces. Oh! My goodness. We have figured something out! I am going to tell you a secret. (pauses). This square is worth one (holding up the square) and this triangle (holding up the small triangle) is worth one half. (pauses). We are covering area today. Area means how much space is in the middle of the square (pointing to the square on the board and then walking her finger around the perimeter of the square.)

Mrs. Turner continued the lesson, asking students to build a parallelogram with triangles, a large square with smaller squares, a large square with eight small triangles, and so on. She provided students time to build the shapes and share solutions with their peers at their tables and asked students to explain the relationship between the shapes in their own words.

Interpretive Commentary. Here we link the particular description of Mrs. Turner's enacted beliefs about technology to the observed meanings in action of the teacher's use of concrete objects as a form of learning technology. The purpose of this interpretive analysis (Erickson, 1986, pp. 150–151) is to connect the particular descriptions in the vignette to the notion of such technologies as cognitive and representational tools in learning.

During this lesson and other such lessons with concrete objects, it was clear that Mrs. Turner and Mrs. Kaminski made an active attempt to include all children, native English speakers and the ELLs in the academic objectives. In the pattern blocks lesson example we shared here, the teacher's stated objectives were to determine the characteristics (attributes) of objects, communicate orally the names of shapes and explore the relationship among the shapes to concrete representations of the idea of a fraction. As the lesson progressed, a number of primarily Spanish-speaking students showed difficulty in following the directions provided by the teacher, all of which were in the English language. Some students began to play with the pattern blocks building intricate designs. Jesus, who wore a clean crisp shirt with a pocket that had a Velcro flap, kept playing with the Velcro flap! Pedro was yawning. Pearl, Tran, Pedro, Angel, Jesus, Jasmyn, seemed to be slower at catching up with the lesson in relation to others in class like, John, Daniel, and Brittney. The following excerpt from Mrs. Turner's conversation with the researcher confirms the observer's notes. Mrs. Turner said:

> This is one of those activities used to get them ready for problem solving. It is way above some of them as they have difficulty following directions in the English language. So, I provide support by giving answers on the board, by drawing, but letting them guess. It starts them thinking. (Pauses. Smiles). I am using the technology of manipulatives—to give them the hands-on concrete objects to construct their knowledge, but I am applying concepts of geometry, fractions, multiplication.

The hands-on manipulatives in this classroom were used consistently by the teachers who hoped to provide all students—ELL, bilingual, and native English speakers—the opportunity to explore mathematics concepts. They anticipated that the use of the concrete objects would support the formation and communication of mental conceptions among all learners. We propose that this local definition of technology embodies, in theory, the notion of cognitive technologies as promoted by Pea (1987). Additionally, it supports the representational perspective on technology (e.g., Kaput, 1995) in that such materially realizable notation systems contribute to the formation of mathematical conceptions. Schoenfeld (1988, pp. 67–69, 73) said that a view of mathematics as a verb—something you do—as opposed to a noun—something you master—causes a radical reconceptualization of mathematics instruction. In this particular classroom, we began to question whether the teachers' beliefs and actions embodied these theoretical notions for *all* students, especially the linguistically diverse students.

The teachers had hoped that for the ELL students, activities with manipulatives would provide openings in classroom discourse to not only express their knowledge about mathematics concepts using the representational tools (power blocks, attribute blocks, fraction tiles, fraction bars, geoboards, etc.) but also to a multiplicity of simple language vocabulary. But, this was true only for those students who could understand the classroom negotiation that occurred predominantly in the English language. For instance, with the attribute blocks, students had access to a directly concrete experience in which vocabulary could be learned. The following excerpt from another observation illustrates how the use of concrete objects[8] facilitated connections between mathematics concepts and English language vocabulary. The class had returned from a session in the HOTS computer lab where Mrs. Turner had first demonstrated the *Logical Journey of the Zoombinis*™ (Broderbund Software, Inc.) program and each student had explored the software individually on independent computers.

Mrs. Kaminski: Do you know what we have been talking about in Mrs. Turner's class in the HOTS lab?
Brittney: Attributes.
Mrs. Kaminski: What is an attribute? What kind of attributes did the Zoombinis have?
Mario (ELL): Color, shape.
Juanita (ELL): Hair styles, eyes, feets.
Mrs. Kaminski: "Feets"—one is a *foot*, two or more are *feet*.
Juanita: Feet.
Mrs. Kaminski: When Mrs. Turner was in here with the power blocks, what kind of attributes did we look at?
Pearl (ELL): Red, green.
Mrs. Kaminski: Yes, color!
Daniel: Thickness, big, and small.
Mrs. Kaminski: Right, we looked at shapes, colors, sizes. We made patterns!

We first wondered if Pearl's response to Mrs. Kaminski's question was merely a rote reply. We speculated if we could state that the use of the concrete objects and the computer technology in this setting were facilitative of an interactive approach to pedagogy that directly challenged the transmission model of learning? However, over long-term observation, we noted that for only some ELL students the concrete objects made it possible to communicate their mathematical ideas and representations with their bilingual peers, native English speakers, and teachers, that too with a lot of hesitancy. We categorized Mrs. Kaminski's 2nd/3rd grade students by the number of years they had continuously attended Park Elementary to confirm whether these students were the ones who attempted to use the representational modes afforded by the available learning technologies—the analog concrete objects or the digital objects on the computer screen. We looked for all instances in the data corpus where Mrs. Kaminski's ELL students had responded to their teacher's questions during math instruction. Then we coded the responses of all ELL students by those who had been continuously enrolled in Park Elementary since their kindergarten year and those who weren't. We found that Mrs. Turner's enthusiastic exhortations were more or less responded to only by the ELL students who had been in Park Elementary's English immersion settings since their kindergarten year. What about the newly arrived students who did not understand any English language instructions? Thus the approach adopted by Mrs. Turner and Mrs. Kaminski provided openings for largely native English learners to share their understandings of mathematical knowledge in the academic language of school. But the same was not true for all ELL students; these teachers' beliefs and practices had merely begun to provide opportunities for the ELL students to develop English language vocabulary.

It is important to note that the observed use of concrete manipulatives (e.g., pattern blocks) and software (e.g., *Zoombinis*) directly related to the articulated academic outcomes as found in the school's curricular documents. The school's second and third grade teachers had collaborated with the mathematics and language arts specialists to develop learner outcomes for mathematics by grade level. An examination of the school's curricular documents entitled *Curriculum Components* and *Learner Outcomes* showed an emphasis on concrete materials and technology along with the use of reasoning and communication skills for specific mathematics standards.[9] For instance, a review of grade 2 standards and learner outcomes included the following that related directly to the lesson presented in our vignette: (a) Identify two dimensional shapes by name and attribute, (b) Compare attributes of two-dimensional shapes, (c) Relate geometric concepts to number and measurement ideas.

Students from Mrs. Kaminski's classroom spent at least two class periods a week in the HOTS lab where software such as the *Logical Journey of the Zoombinis*™ (Broderbund Software, Inc.) and *Turbo Math Facts 3.0* (Nordic Software Inc.) were used. (See Table 3 for a list of math instructional software used by Mrs. Kaminski's students.) In particular, these two pieces of software served distinctly different purposes. The *Zoombinis* software was used to provide learners with opportunities to put to use what they knew about reasoning, logic, and patterns, and had learned from their experiences with the hands-on manipulatives ideas such as attributes or characteristics of objects. Conversely, the *Math Facts* software was used mainly as a drill and practice scaffold.

While in the computer lab setting, students worked alone on the stand-alone programs, did not interact with each other or the teacher significantly, and did not discuss strategies or underlying mathematical ideas. Any discussions about the lab software programs occurred in the classroom, and not while students were using the software technologies. Instructions on what to do in the computer lab were provided to the entire group, students were assigned to a computer each. Each student sat at a computer with headphones. Only one pair of headphones could be attached to a computer. Teachers were concerned about classroom management issues related to noise level if students did not use headphones. Clements and Sarama (2002) noted that computers can "serve as catalysts of social interaction" (p. 341). On the contrary, in the computer lab setting, Mrs. Kaminski's students largely used the *Math Facts* drill and practice software in a one student per computer setting. Rather than use software programs that encourage children to engage in open-ended interactive activity with the technology and with their peers, they used the software programs largely in isolation from their peers. Notably, the frequency (see Table 3) with which students used the *Math Facts* program dramatically differed from that of the other math software.

Further, this contrast is marked, in that while using hands-on manipulative tools, the classroom resembled the kinds of classrooms that emphasize the development of mathematical understanding (Hiebert et al., 1997). While using digital computational tools, however, the setup in the computer lab resembled a didactic environment that emphasizes fact production. Students listened to the English language directions provided by the software programs where available, and interacted with the technology in isolation. These inconsistencies are not uncommon as teachers struggle to implement reformed practices (Koellner & Middleton, 1999). The computational technologies were isolated geographically in the HOTS lab instead of integrated into the classroom.

In the *Zoombinis* program children engaged with the characters and the narrative story of the game and as a result engaged with the mathematics of sorting, organizing and analyzing data, formation of hypothesis, set theory, logical reasoning, pattern finding, attribute comparison, and algebraic thinking. But, the *Math Facts* software largely emphasized drill and practice. The *Math Facts* software program utilized a contradictory model (to that of the *Zoombinis*) of what is important mathematically and pedagogically. Mrs. Kaminski said:

> We've taken advantage of one program in particular, the *Math Facts* software as it focuses on mathematics facts. Students have to master addition to go on to subtraction and master subtraction to go on to multiplication. And what's really nice about this particular program is that students have to master the fact three times before they can move on. So that you know the child actually knows the facts. Then there's a game attached to it.

TABLE 3.
Software Programs used by Mrs. Kaminski's Students in the HOTS Computer Lab

	Number of Lessons/Year	
Software	Year 1	Year 2
Turbo Math Facts, Nordic Software Inc.	26	28
The Logical Journey of the Zoombinis, Broderbund Software, Inc.	4	2
The Lost Mind of Dr. Brain, Sierra On-Line, Inc.	2	0
Mighty Math: Carnival Countdown, EdMark Corp.	1	2
Mighty Math: Number Heroes, EdMark Corp.	1	2

In the *Math Facts* program, as students answer problems in a drill format, they earn points or money for each correct answer to buy race cars for an interactive race. Certificates were awarded for student completion of specific levels and advancement to the next level in the *Math Facts* program. "Stars" corresponding to the specific levels of advancement with the student name prominently shown on it were displayed on the walls of the HOTS lab by classroom. Students took pride in having their name on the *Math Facts* wall as teachers made a big deal of their success. ELL students were encouraged to use the HOTS lab during lunch and recess to practice math facts and received rewards such as M&Ms.

The grouping practices and discursive structures of the classroom and the computer lab were completely different. This exchange between students and the classroom teacher, Mrs. Kaminski, illustrates some students' unenthusiastic views of their computer lab experiences.

> John: Why don't we go to HOTS lab everyday?
> Daniel: We don't learn anything there!
> Mrs. Kaminski: Who thinks we don't learn at the HOTS lab? (Almost three-fourths of the students or 18 students raised their hands.)
> Mrs. Kaminski: Sometimes you think it is not learning when we are in the computer lab. Learning can be fun.
> John: We learned patterns and shapes. I had to pass the bridge. I had to sort. (A reference to the *Zoombinis* software program.)
> Brittney: We learned attributes.

What was notable about this exchange was that the native English speakers actively participated in this dialogue, whereas, the ELL and the bilingual students were silent. The researcher noticed that a number of the ELL students were bored in the computer lab, whereas some of these same students eagerly participated in the classroom activities with hands-on manipulatives such as pattern blocks, fraction bars, etc.

In summary, although there were inconsistencies in how teachers structured the use of digital computational technologies (software use in the HOTS lab) in relation to the concrete objects, it was clear that these teachers (Mrs. Turner and Mrs. Kaminski) believed in and enacted their beliefs about technology as inclusive of representational tools such as fraction bars, pattern blocks, graphs, equations, charts, verbal rules, geo boards, paper and pencil, blackboard and chalk, and the computer software. We propose that this is an advanced definition of technology, and is consistent with viewing technology in terms of its use. It is a pragmatic application of technology for an enterprise like education. Mrs. Turner demonstrated her understanding of the role of technology in society—she attempted to use the tools of technology (in her words) "to reveal children's thinking." Learning technologies such as those described here have a purpose, in this case to reveal students' thinking, to communicate it, and to structure it. The regular use of the concrete manipulative tools and software like the *Zoombinis* permitted children to understand the tools, and use them reasonably well to express their knowledge, considering the constraints of the school's context—that of the English immersion policy. In the words of the ELL specialist, "our goal is to speak, read, write, and think in English." This statement sets the context for our next assertion.

> Assertion 2. Notwithstanding the use of "powerful" learning technologies in mathematics education, both the software and the hands-on learning opportunities remained inaccessible to immersion students because they could not understand and speak English.

We use the notion of "powerful" learning technologies to convey the potential offered by the use of technologies to enhance learning. With the publication of the National Educational Technology Standards for Students (ISTE, 2000), and the revision of the National Council of Teachers of Mathematics' (2000) *Principles and Standards for School Mathematics* coinciding in time, new emphasis has been placed on the importance of implementing learning technologies into the mathematics classroom. The technology—both physically concrete and digital materials—exists to allow children, even very young children, to explore complex and advanced mathematical topics and represent their thinking in varied forms (NCTM, 2000). Multiple mathematical representations that are visual and symbolic allowing students to make the move from simple to more complex and abstract notions are recommended for understanding (Nickerson, 1995; Roschelle, 1996). These affordances of technology are what we contend makes it powerful. Implementation of such powerful tools depends on the teacher. The teacher needs to facilitate and channel students' activities so that they develop in a mathematically sound and sophisticated manner. In our study, the teachers were also faced with learners who included large number of ELLs.

The students in Mrs. Kaminski's class were at a wide variety of reading levels (in the English language). In her first interview, Mrs. Kaminski mentioned that she had students who hardly knew the letters of the alphabet.

> We have children in here who are considered immersion children. This means that they speak another language [other than English] and relatively no other

language. Our school's policy is to immerse these students in English. Some are still learning the English alphabet.

From reviewing the long-term field notes it was clear that some of the students in Mrs. Kaminski's room had limited English language skills. Mrs. Miller worked with the immersion students, some of whom were recent immigrants and monolingual Spanish speakers. She worked with them 5 days a week for one class period each day. Mrs. Miller engaged them in small groups of four or five students for 12–15 min each at the reading center. The students were formed into three groups, with one group at each of the three centers: (a) listening center—a tape recorder was connected to a device which allowed multiple headphones to be plugged in and an audio taped book was played for the students, (b) a reading activity center which had hands-on visual aids and reading manipulatives, (c) the reading center where Mrs. Miller sat at a U-shaped table with the students facing her and she read to the students, asking them to follow along with her. These centers were adjacent to each other at the back of the classroom. While Mrs. Miller worked with the immersion children, Mrs. Kaminski worked with the other half of the class on various reading related activities. The following vignette illustrates a typical approach to literacy.

Vignette of the Observed Typical Approach to Literacy

It is a bright Arizona spring morning, cool and pleasant, in Mrs. Kaminski's multi-graded classroom. Mrs. Kaminski goes over the day's schedule with her students who are sitting at their desks and is settling herself at her U-shaped reading table at the front of the classroom. She looks at the clock and the bell rings. This is the first class period of the day. She reaches out to the bookshelf next to her and pulls out a sheaf of papers, copies of a lesson on choosing the right word. Mrs. Miller walks in from the back door pushing a cart filled with books and reading manipulatives. Children walk in from the back door, the side door connecting to the adjoining classroom, and from the main door. These are some of the students from other grades 2 and 3 classrooms who are classified as immersion students.

Mrs. Miller places five plastic bags with some reading manipulatives on the round table next to the U-shaped table. She settles herself down at the U-shaped reading table. Speaking in a low voice so as not to disturb Mrs. Kaminski, Mrs. Miller, giving instructions in Spanish and English, forms three groups of four students each. Jesus, Pedro, Maria, and Juanita, the four monolingual Spanish speakers (i.e., ELLs classified as immersion students) all, from Mrs. Kaminski's room, are at Mrs. Miller's table. The others are at the listening center and the reading activity center.

Mrs. Miller holds up a chart, which has the letters of the alphabet in upper and lower case, and related color pictures. For example: A, a, and a picture of an ant. She holds the chart facing the children and says with a smile: "Let us go over the letters of the alphabet. A a ant." The children point to the drawing of the ant and repeat after her "A a ant." Mrs. Miller goes through the letters of the alphabet B b bear, C c car, D d dog, E e elephant, F f fish and so on.

Pedro puts his head down on the table.

Mrs. Miller touches his arm gently, directs him in Spanish to sit up and pay attention: "Pedro, escucha." Jesus, Maria, and Juanita are looking at Mrs. Miller and following along. Pedro yawns. Done with the alphabet chart, she puts the chart back on the wall behind her.

Mrs. Miller pulls out a little book. She leans forward with her elbows on the table and holds up the book "Building with Blocks" with the cover facing the students, points to a red colored block pictured on the cover page and says, "What color is this?"

Juanita: Red.
Maria stares with a blank look.
Pedro is yawning again.
Mrs. Miller: R-r-red.
Mrs. Miller (to the researcher): Mariela who is at the listening center over there, could not speak English when she arrived early this year. Now, she understands what she's reading. She can read a lot more than she understands. She knows all her letter sounds, and is just rolling along, everyday. The boys have just arrived from Mexico, it will take a while. (Sighs heavily).

Each child at the table has a copy of the book. Mrs. Miller reads the book twice, asking the students to repeat after her each time, while pointing to the colored block on the page. She provides instructions in Spanish first and then in English, saying, "Lean conmigo." "Read with me." She starts the reading.

Mrs. Miller: A green block. A red block. A yellow block. A blue block. A black block. A white block. A spaceship.

Pedro and Maria yawn. Pedro seems very tired; he looks as if he has not had enough sleep the previous night. He puts his head down on the table again. This time Mrs. Miller doesn't say anything.

In the meanwhile, Mrs. Kaminski has Joshua, Jewel, Cathy, and Daniel at her reading table, who each have a set of worksheets in front of them. Others are reading on their own at their tables, reading a chapter book, Chapter 6 of *It's like This, Cat* (Neville, 1963). She says to the group at her reading table:

> Look at what you need to do this morning. (Pauses.) Everybody read with your eyes while I read out aloud, please. This is part two. Remember, normally this is a test. We are reviewing it. So when you take your test later this spring you are ready. You need to do Questions 5 through 16. Question 5—choose the word that finishes each sentence correctly. Fill in the space on the answer sheet with the best answer. (Pauses.) Now look at the sample. It says Jason enjoys all outdoor_______. Is it: a.) sport b.) sported c.) sporting d.) sports.

Looking at Joshua, Mrs. Kaminski asks ''What do you think it is?''

> Joshua replies, ''d. sports.''

Mrs. Miller's group is singing a song, and Mrs. Miller's gentle voice with the children in chorus wafts over to where Mrs. Kaminski is sitting: ''B b Did you ever see a brown bear, a brown bear, a brown bear, eat blue berries and bugs.''

> Pointing to the letter A on an alphabet letter chart, Mrs. Miller asks, ''What letter is this?''
> Jesus (says in a low voice): ''I.''
> Juanita and Maria say: ''A.''
> Pedro just stares at Mrs. Miller.
> Mrs. Miller (smiles and says): A a The ant ate the apple, A a The ant ate the apple, High-ho the demy-o, The ants ate the apple.

At the reading activity center, students are playing a word game. The object was to match concrete objects like a toy bear, car, etc, with visual aids on cards that displayed a letter of the alphabet, the word for that letter, and a picture of the concrete object. The students said B b bear... while physically lifting the bear and placing it on the ''B b'' card. A plastic bag filled with the English alphabet cards and a few more filled with little toys, one each for the letters of the alphabet was at the table. Students actively played the game, interacting with each other. At the listening center, two students were paired to a tape recorder. Through a device connected to a tape-recorder that could plug in two headphones, the students listened to a story and followed along the reading in a book that they held in their hands.

Interpretive Commentary. In this section we link the particular description of the students' varied reading levels presented in the vignette with the notion of access to learning within the context of Park Elementary as evident in the data corpus. It is evident that the monolingual Spanish-speaking students, referred to as immersion students, are at beginning kindergarten reading level in English, while others are able to read chapter books. The high mobility rates at the school also affected learning in a significant manner. Over the course of one school year, Mrs. Kaminski had five new students, all "immersion students"—according to Mrs. Kaminski, recent immigrants—who were placed in her classroom. Three of the 26 students left the school over winter break to move to another state. One of these students returned to the school in early February and was placed in Mrs. Kaminski's room; this student had missed 4 weeks of school. Only 10 of the 25 students had been at Park Elementary since kindergarten. Such student mobility was common in Park Elementary. Park Elementary has the unique challenge of orchestrating a classroom with students who are native English speakers, students who speak no English at all but speak fluently in their primary language, and a large number of students according to the teachers, mostly recent arrivals, who speak no English at all and have a poor background in their primary language as well. The policy is that instruction is provided exclusively in English. Teachers are unable to provide immersion students the explanation of an important concept in the student's primary language. Krashen (1996) suggested that first language use in class occasionally is useful rather than teachers resorting to the frustrating use of pantomime and gestures; however, cautioned about situations where the input is hard to understand, that concurrent translation is necessary.

As the observation occasions progressed it was noticed that the immersion children seemed disinterested during instruction, which was primarily in English. Mrs. Kaminski, the classroom teacher, and Mrs. Turner, the math specialist did not speak Spanish, even though they made attempts at communicating with their very limited knowledge of the language. During mathematics instruction, teachers typically used a concrete manipulative, allowed students to explore on their own with the manipulative, and gave instructions on how to use them. Instructions were all in English, and students with little or no knowledge of English were easily distracted and engaged in activities of their own that are not related to learning.

An analysis of the district's learner outcomes for mathematics revealed that Mrs. Kaminski's students were required to "solve word problems using the appropriate operations." Each day, the class was asked to solve mathematics word problems as outlined in the "problem of the day." Here is an example of the problem of the day, written on the board that allowed for practicing "Computation in Context."

Problem of the day: My daughter Bridget borrowed $275 from me. She paid me back $127. Now she gave me a check for $411. How much do I keep? How much will she get?

Most of the non-ELL students were attempting to solve this problem. However, the immersion children were unable to follow the instructions provided in English. Most of them were just scribbling on the paper, while a few attempted to copy down the numbers that their neighbors were putting down. *Language* began to emerge as the key to access mathematics learning. A curriculum that attempts to integrate mathematics into the daily lives of students by providing context to problems is really creditable (Trentacosta & Kenney, 1997). However, readability is an essential issue in developing word problems and analyzing student performance in solving them. It is important to provide ELL students word problems in terms that they can actually understand. Secada (1990) recommended that teachers invite bilingual children to speak with one another in any language that they are comfortable and not insist that everything be explained in English. But in an English immersion program, such as in Park Elementary, this was not a possibility.

In the HOTS lab, each student sat independently at a computer and worked on software that allowed them to practice basic mathematics facts (*Turbo Math Facts 3.0*) or topics in discrete mathematics—sorting, organizing and analyzing data, hypothesis formation, set theory, logical reasoning, pattern finding, attribute comparison, and algebraic thinking (*Logical Journey of the Zoombinis*). The verbal instructions heard by students with headphones from the software (where available) are in English, and the prompts on the screen are in English. The immersion students usually just sat at the computer clicking the mouse at random. They seemed equally lost when Mrs. Turner worked with them in Mrs. Kaminski's classroom, especially when the academic language became increasingly difficult to follow. The following vignette can illustrate the importance of the academic language of English in students' access to powerful learning technologies such as concrete manipulatives in exploring their understanding and revealing their thinking of mathematics knowledge.

Vignette of Language as Access to Mathematics Education with Learning Technologies

This lesson during the month of March, in Mrs. Kaminski's room illustrates the challenges faced by ELLs—especially the immersion students.

Mrs. Turner (to the researcher, explaining the objective for the lesson): My objective today is writing fractions. Read, write, and speak the fraction, and also to know the different values, which one is smaller and which one is bigger. We are going to use fraction bars that are of different sizes, each size in a different color in relation to the one whole, which is in black.
Mrs. Turner (to the class): I have brought in my fraction bars and we are going to do some fraction bar building. And I'm going to see if you can write a fraction, read a fraction, and build a fraction. (Pauses).
Mrs. Turner (in a low voice as if she is sharing a secret): We're actually going to add mixed fractions, which you are not supposed to know how to do just yet, not until 4th or 5th grade. So don't tell anybody. Okay? (In a conspirator's tone.)
Class: (Enthusiastically responded.) Yeah!

Mrs. Turner gave students five minutes to explore the fraction bars/tiles. The tiles were rectangular in shape, with 1 black tile representing one ''whole,'' 2 orange tiles representing a 1/2 each, 3 green 1/3rds, 4 purple 1/4ths, 5 blue 1/5ths, six red 1/6ths, 8 brown 1/8ths, 10 yellow 1/10ths, and 12 white 1/12ths. We walked around the classroom and were observing what the students were doing during exploration. We saw that Maria had her head down on the desk.

Mrs Turner (to the researcher, referring to Maria): You can see that she is not ready.
Mrs. Turner (to Maria): Are you not feeling too well today, Maria?
Maria did not respond verbally. She just lifted her head up a little.
Mrs. Turner (to Maria): Just need to explore right now ...
We walked over to Jesus. Maria had put her head down again.
Mrs. Turner (to Jesus): You are ready for the lesson? Huh? What are you doing? (Pauses.)

Jesus smiled shyly. He had the large fraction bar considered to be one whole and on it he was building a pyramid with the other fraction bars. He attempted to cover up his creation with his arms.

Mrs. Turner (to Jesus): Just exploring, very interesting, Okay. Seeing how they fit together.

Mrs. Turner (to the class): Okay. What we're going to do today is, now, we're going to use these (referring to the fraction tiles) as tools for learning, now that you've used them to explore. I saw some pretty cool exploring going on! (Pauses.) Okay, I want you to hold up the black piece. What does the black piece have on it? What numbers?

Most students hold up the black piece in the air. Pedro and Jesus (the two monolingual Spanish-peaking children) seemed to follow what the other children were doing and catch up by holding up the black piece. Mario and Carla are attempting to build some elaborate structure with their fractions bars.

> Class: One.
> Mrs. Turner: One. Guess what? This is your "one whole." This is the whole, this is the one. (Holding up the black piece, which is a rectangle shaped plastic piece. Pauses.) Okay, I want you to see if you can make the ONE with the oranges (still holding up the black piece, which was designated as "one whole.")

The students lowered their hands. Mario was yawning. He made eye contact with the researcher and smiled warily.

> Mrs. Turner: Lay the black (referring to the tile) on your table and build it with the oranges. Not on top, but right next to it. Okay. One whole and you are going to build it with the oranges, exactly. (Pauses.)

Some of the students like Tony, Joshua, and Brittney had their fingers up in the air showing "two" by holding up two fingers.

> Mrs. Turner: How many oranges did it take? Show me with your number fingers, some of you already did. (Pauses.)
> Students respond by holding up two fingers. These are mostly the native English speakers.
> Mrs. Turner: Okay, two. Who can raise their hand and tell me the fraction that is on the orange tile?
> Sara: One out of two.
> Mrs. Turner: One out of two or one half.

Brittney held up one hand and the other hand below it, on the wrist of the first hand with two fingers, indicating one half. Maria had her head down on the table. Mario was busy playing with the tiles.

> Mrs. Turner: And Brittney remembered from before how we said we could do fractions by holding up our one hand with our numerator and holding up the other below for our denominator. She remembered one half. (Pauses.) Okay. Let me show you what you are not supposed to know until about 4th or 5th grade. Are you ready?
> Class: Yeah.
> Mrs. Turner: Today, you're going to write some algorithms. That means mathematics sentences. What does one half plus one half equal? (Pauses a few

> seconds.) Does anyone know? (Walking towards the other end of the room.) What do you think it equals?
> Brittney: Two halves.
> Mrs. Turner: Two halves. And what does two halves equal? What do you think it equals (looking at Tony)?
> Tony: One whole.
> Mrs. Turner: Oh! Let's write that. (Writing on the board: 1/2 + ½ =) An algorithm just means an adding sentence with numbers. (Pauses.) Look at this (pointing to what she just wrote on the board.) One out of two plus one out of two equals...
> Brittney: Two out of two (2/2)
> Mrs. Turner: Or... Pauses.
> Joshua: One whole.

Maria and Juanita were playing with their tiles, looking around at others. Jesus was wearing his (favorite it seemed) shirt with the Velcro flap on the shirt pocket flap and was playing with it, opening and shutting the flap! Pedro was chewing on his pencil end.

> Mrs. Turner: It equals one. (Completes writing on the blackboard 1/2 + 1/2 = 2/2 = 1) One! (Pauses.) Okay now I want you to build the black whole... Isn't that kinda cool "black whole?" ...using orange and purple. Just one or two oranges and some purples.

These colors that Mrs. Turner referred to were that of the fraction tiles. Mrs. Turner continued with the lesson, leading the students through the building of the one whole with many different smaller fractions. She allowed time for the students to build the one whole on their own. While Mrs. Turner was leading the lesson, Mrs. Kaminski walked around the classroom assisting students, or worked with one or two of the immersion students and their bilingual neighbor, if any, attempting to get the point across. However, almost none of the immersion students responded to the prompts from Mrs. Turner or to Mrs. Kaminski's attempts to involve them in the lesson.

Interpretive Commentary. Common language is used along with mathematical notational systems during the process of mathematics instruction. The manipulatives (fraction bars) were useful in visualizing the mathematics, and served as a technological ramp for students to move from the concrete to the abstract symbolism (Kaput, 1995) of the written mathematical notations of fractions. However, as the academic language of the classroom was English, the mathematical discourse became difficult for the ELL students to access. Mrs. Turner, the mathematics specialist, said to the researcher, "Mathematics is a language of its own." When probed further with the question, "How so?" Mrs. Turner said:

> Mathematics has a technical vocabulary. With fractions, students need to know what a one half, one fourths, or three fourths represents. For example: more than, equal to, polygon, congruent, triangle ... It is very important to teach young children the correct mathematics vocabulary.

Further, teachers believed that parents were illiterate and largely unable to help children with academic work at home. Mrs. Kaminski related a poignant story about the school librarian taking one of her ELL students, the student's two older siblings and parents to the local library. While at the library, they found that the mother is missing all of a sudden, only to find her in the Spanish language section of the library. To her chagrin, Mrs. Kaminski for the first time was confronted with the idea that not all of her immersion students' parents were illiterate in any language—in fact some of her students' parents could read and write in the Spanish language. This points out how in English immersion settings, the institution of school is often unable to anticipate well enough what parents need and want for their children, particularly as it relates to academics and often parents are unable to utilize available resources that do exist in their community. This excerpt from an interview with Mrs. Kaminski, illustrates the teacher's perception of parents' ability to help students' in their learning at home:

> For many of them, the parents don't speak English, so they can't help the child in English. Many of the parents I've come across are illiterate [in any language] or they speak another language. But, they may be able to help in mathematics, it crosses all lines.

This statement about the nature of mathematics, reflected the expressed belief of Mrs. Kaminski and also Mrs. Turner (supported throughout this study) that "Mathematics is a language of its own" and is less impacted by the use of language than other subject areas. Still, Mrs. Miller, the designated ELL specialist for this classroom said, "Our goal is to *speak*, *read*, *write*, and *think* in English" with special emphasis on the words in italics.

These beliefs held by teachers about mathematics, particularly about the nature of mathematics as a language of its own, and the academic language of instruction existed in direct contradiction to that of what the students were doing, particularly the "immersion" students. Kaput (1995) and other researchers contend that the concrete objects (e.g., fraction bars) are useful in visualizing mathematical ideas (e.g. fractions), and can serve as a technological ramp for students to move from the concrete to the abstract symbolism of the written mathematical notations (in this example the notations of fractions). We agree with this notion. However, as the academic language of the classroom was English, the mathematical discourse became difficult for the ELL students to access. In fact, the ELL students were demonstrating boredom, despite teachers' good intentions.

The teachers' beliefs about mathematics vocabulary highlights the need to verbalize mathematical notations and also to demonstrate the meaning offered by these notations—hence the importance of providing concrete experiences with manipulatives. Rubenstein and Thompson (2001) noted that the use of mathematical notations is one of the hallmarks of mathematics, a feature that is distinctive and apparent. The symbols (e.g., $+$, -, $\div$, $\leq$, $\geq$, , $\neq$, $\frac{1}{3}$, ∞, $\sqrt{}$, $\sum$) of mathematics help us make mathematical operations routine. Lemke (1990, p. 159) stated that "You can, quite literally, talk mathematics, either by reading the symbols, or by converting them into conventional words and phrases of the language (register) of mathematical English." Time and again, the words, phrases, and symbols of mathematics that adults take for granted as meaningful may not be common to the ELL student and non-ELL students as well. As the language of mathematics is used to verbalize, read, understand, write, and otherwise express mathematical knowledge, the development of all students' facility in the use of the language of mathematics becomes a critical issue.

Bruner (1960) directed that learning should proceed from the concrete to the abstract. In learning mathematics, meaning must by and large precede the use of abstract mathematical notations. Students who are not proficient in the English language are at a serious disadvantage in immersion settings, since learning is expressed in common oral English with mathematical vocabulary and in written English with mathematical notations. Moreover, in this study, as observed consistently, classroom negotiation occurred in English. Instructions on how to use the concrete objects and the computer software also involved the exclusive use of the English language. Immersion students did not have any means of understanding the complex "problem of the day," which was presented in written English. Again, the English reading level of the 2nd–3rd grade immersion students was at a pre-kindergarten or kindergarten level. A few of them were unable to identify letters of the English alphabet. For the immersion students, sessions involving the use of learning technologies—the analog and the digital—often degenerated into playing with them. Sessions involving the computers became random key punching and/or off-task behaviors. Thus notwithstanding the use of powerful learning technologies in mathematics education, both the software and the hands-on learning opportunities remained inaccessible to immersion students because they could not understand and speak English.

We arrived at the assertion presented above, after a series of searches for confirming and disconfirming evidence to warrant our preliminary assertion, which was stated as: *For the immersion students, language and use of learning technologies is critical in providing access to mathematics learning and technology, and thus to academic success*. It is obvious that for immersion students, lack of the English language in an English immersion setting is a barrier to accessing academic instruction. The English immersion policy largely functions under a deficient model—it is the individual student's fault that the student does not know English. Further, after reviewing the Stanford-9 assessment results for Park Elementary (used annually in all Arizona public schools, grades 2 and above) we were unable to warrant the assertion that the particular learning technologies used in this setting lead to academic success for the native English speakers and would lead to academic success for ELL students. This initial assertion reflected our hope that what we call, powerful learning technologies, when used thoughtfully would enhance learning for all—both native English speakers and ELL students. The reality was that despite, the teachers' good intentions; they lacked the ability to communicate effectively to immersion students, especially those in the 2nd and 3rd grade who were at beginning pre-kindergarten ability with regard to their English language ability. We refined our initial assertion based on the evidence collected from the data corpus.

We contend that the practices of English-immersion and the ensuing instructional practices of Mrs. Kaminski and Mrs. Turner are exclusionary in terms of students whose first language was not English, as per the school's English immersion policy. These practices, when coupled with digital computational technologies that require the use of English to interpret, added insult to injury. Also, the context of one-person-one-computer isolated children from each other and from the teachers, who might have provided some translation support.

CONCLUSION

Findings show two incommensurate sides to technology implementation. On the one side, teachers utilize powerful learning technologies (manipulatives and other modeling tools) as a natural part of their everyday practice. These tools are used to reveal thinking, and for communication of foundational mathematics. On the other side, computational technologies served none of these functions. Why?

We suggest four hypothetical reasons for this *disconnect*, all of which will need to be studied further. The first deals with software availability. The software available to Mrs. Turner and Mrs. Kaminski did not do the kinds of things that the manipulative tools do. Despite the commercial availability of exemplary software packages (e.g., *Geo Logo*, *To Market To Market*, *Zoombinis, Graphers, The Oregon Trail*), Park Elementary school has yet to purchase many of these packages (with the exception of *Zoombinis*); see Table 3 for software used by Mrs. Kaminski's students. Kerrigan (2002) presented a review of software programs for integration into the elementary school mathematics curriculum.

Second, disconnect exists in the teachers' knowledge of exemplary software. Manipulative tools have received the lion's share of coverage (in teacher journals such as *Teaching Children Mathematics*, or in staff development packages), but reviews of software, and research on its design and use, have not been as widely available.

Third, Park Elementary school utilizes an impoverished model of technology integration as it pertains to computers. Infusions of computers into classrooms (Middleton, Flores, & Knaupp, 1997) are recommeneded over the separate computer laboratory model. However, Park Elementary's district opted for continuation of the separate laboratory. To be appropriately integrated into the mathematics curriculum, technological tools need to be available when and where they are needed (NCTM, 2000).

Fourth, and perhaps most importantly, school and district policies of English immersion for ELL students constrain teachers' abilities to deal effectively with the issues of language. While the teachers believed that mathematics is its own language, their behavior suggests that mathematics teaching, regardless of this belief, is not predicated on effective communication. Teachers actions suggests that they are oblivious to how much ordinary English is a part of their math teaching and that their use of common English language is largely inaccessible to immersion students. In Park Elementary, most instructional communication involved the use of the English language. Spanish-speaking students could not participate in mathematical discourse, so they exhibited behaviors of learned helplessness such as daydreaming, or acting out (e.g., Dweck, 1986). This challenge is seemingly insurmountable within the English immersion policy context. In Park Elementary school, effective communication was heavily weighted towards the use of English language instructions for teaching, and verbal English representations of understanding for learning and classroom discourse. Because the computational tools made available to teachers did not facilitate the more robust kinds of communication strategies and representations suggested in the standards documents, Spanish-speaking students were excluded from legitimate mathematical discourse.

Teachers in this study held an inclusive definition of technology that exceeds the traditional view that technology is primarily computer-based programs. While the local definitions of technology include manipulatives and other tools that could function to bridge the language gap, seldom were the immersion students able to access these technologies due to their lack of access to the language in which important concepts and classroom management decisions were negotiated. Manipulatives, graphs and charts enable learners to explore and form initial understandings of complex, abstract notions in mathematics; yet, due to the fact that subject matter instruction is in English, the use of the tools by the dominant culture is incomprehensible to students without facility in the dominant language.

Findings of this study have implications for school policy and practice regarding the role of English in the use of technology for the education of recently arrived non-English speaking children. The most important implication is that the classroom teacher/instructional technologist must take into account the role of language when designing and delivering mathematics instruction and technology to such students by ensuring that students understand the academic instructions that are used in combination with the notational systems, and that the emphasis in discourse be that of *communication* (e.g., NCTM, 1989), instead of *verbal English*. This may suggest the use of "comprehensible input" in sheltered subject matter (mathematics instruction) learning (Krashen, 1996) as a way to facilitate technology integration for all. Providing equitable access to learning, academic success, and fully developing the intellectual potential of all learners is an enormous challenge (Valdés, 1998). The complexity of layering computational technologies into instructional practices compounds these issues.

Khisty (2001) observed the characteristics of effective elementary mathematics teachers working with ELLs. In her study, she revealed that the use of meaningful questions and explanations with multiple opportunities for students to hear and produce important mathematical vocabulary to be facilitative of students' mathematical understanding. In addition, these pedagogical strategies were overlaid on a base of high expectations for ELLs, writing mathematics and a classroom organization that facilitated students' helping each other. All of these features of effective instruction necessitate an integration of knowledge bases—English Language Learning, classroom management, mathematical pedagogical content knowledge, and knowledge of tool use. In our study which focused specifically on the use of learning technologies in relation to the other aspects of teachers' knowledge and behaviors, we did not see evidence of such integration.

In particular, teachers' knowledge of computational technology appeared to be "knowledge of" technology as opposed to "knowledge for" teaching particular concepts and skills. Moreover, even this shallow base was not tied to knowledge of the language and cultural frames with which students entered the classroom. Clearly, there are a host of other issues that set the context at Park Elementary; social issues of poverty, race, home culture, immigration or citizenship status; policy issues of ELL vs. Bilingual Education; funding issues with regard to the hire of bilingual educators, district policy and teacher/administrator perceptions of ELLs/immersion students and so on. Recognition of the complexity of Park Elementary's context, as a reasonable case of technology implementation, helps shed light on the historical difficulty schools have had in providing equitable access to their ELLs. Mathematics provides a higher status to experts who have mastered the subject (Popkewitz, 1988). Mathematics education is also a source of social stratification (Secada, Fennema, & Adajian, 1995) and therefore understanding ELL students' access to mathematics education with learning technologies at the foundation levels is of great importance. Students' language ability and mathematics proficiency are connected; lower language ability tends to translate into poorer mathematics performance (Cocking & Mestre, 1988; MacGregor & Price, 1999). The importance of the role of literacy skills in learning content areas or the disciplines is not only significant, but it also has implications for constructing and selecting learning experiences for ELL students. However, as states (California, 1998; Arizona, 2000; Massachusetts, 2002) mandate English only policies, it is crucial to understand how learning experiences are structured in English-only settings given that cultural and language diversity is increasing in the United States (Garcia, 2005; Wise & Garcia, 2001).

NOTES

1. A learner who speaks language(s) other than English at home and who learns English as the dominant language of the media and education in the host culture.
2. It should be noted that teachers have the responsibility to teach all students even if there is a language disconnect between student and instructor. We could just as easily have used the term, "Spanish Language Learners" to classify the second language capabilities of the teachers in this case.
3. Title I, under the Improving America's Schools Act (IASA), provides financial assistance to local educational agencies to meet the needs of educationally disadvantaged children at the preschool, elementary, and secondary school levels. The purpose of Title I is to help all children achieve the state's Academic Standards.
4. At the time of this study, the ELL specialist in this school was defined as a person who worked with small groups of ELLs in their regular classroom setting as pull-outs and whose sole purpose was to teach and support ELL students by instructing them only in the English language.
5. With regard to the education of ELLs, in 2000, Arizona voters adopted Proposition 203, which requires that all public school instruction be conducted in English. Proposition 203 specified that "Children not fluent in English shall normally be placed in an intensive 1 year English immersion program to teach them the language as quickly as possible while also learning academic subjects." The proposition also required that "All children in Arizona public schools shall be taught English by being taught in English and all children shall be placed in English language classrooms." (see http://www.ade.state.az.us/asd/lep/PROPOSITION203.pdf).
6. Lincoln and Guba (1985, p. 308) defined peer debriefing as "a process of exposing oneself to a disinterested peer in a manner paralleling an analytic session and for the purpose of

exploring aspects of the inquiry that might otherwise remain only implicit within the inquirer's mind."

7. The "power blocks" consist of 10 different sized triangles T1 to T10, 5 squares, S1 through S5, 5 rectangles, R1 to R5 and 4 parallelograms, P1 to P4, all in different colors and increasing size.
8. Clements and McMillen (1996) have argued that computer manipulatives although physically not concrete, are useful objects in mathematical representations.
9. The (Arizona) state and district level math standards were categorized as (a) number sense and operations; (b) data analysis, probability, and discrete mathematics; (c) patterns, algebra, and functions; (d) geometry and measurement; (e) structure and logic. (See http://www.ade.state.az.us/standards/math/articulated.asp).

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