Information Technology in Childhood Education (2002) 173-196

Technology and Pedagogy in Early Childhood Education: Guidance from Cultural-Historical-Activity Theory and Developmentally Appropriate Instruction

HÉCTOR RIVERA, SHERI LYN GALARZA, SUSAN ENTZ, AND ROLAND G. THARP
Center for Research on Education, Diversity & Excellence
University of California, Santa Cruz USA
hectorhrivera@yahoo.com

Technology can facilitate a pedagogy-based on neo-Vygotskian sociocultural theory, and on developmentally appropriate instruction. This article reviews the basic principles of such a pedagogy, and then presents a detailed case study of one day's instruction in a preschool classroom, that is richly infused with a system employing digital photography, computer image manipulation, and color printing. This system situates instruction in the socio-cultural nexus of the students and their families and facilitates the effective pedagogy by the rapid and appealing communication and stimulation provided by technology.

Technological innovation, no doubt beginning with the sharpened stick, has created challenges for socialization of young or new members of communities. New technology modifies community practices and understanding. Technology changes the repertoires needed for successful community membership. Socialization requires that human development be contextualized in the tool-environment of the community. Should pedagogy be modified, now that children must learn to use sharpened sticks? Or must now learn to use digitized information processors?

"Yes and no," is the answer given by neo-Vygotskian theorists, and by "developmentally appropriate" instructors. Yes, pedagogy can and must

change, to the extent that technology is a tool to be taught. Yes, pedagogy can and must change to the extent that technology is a tool that assists teaching. But also, "No." Foundational principles of pedagogy, rooted in first principles of human organization and human development, are (for all practical purposes) fixed—either by the hard wiring of phylogenesis, or the social-historical evolution of human society. The purpose of this article is to illustrate how technology can and should influence pedagogy for young children, and how those innovations can serve as powerful tools for increasing the potency of pedagogy based on fundamental principles of human development.

In developing this argument, technology is considered in the light of pedagogical principles derived from neo-Vygotskian theory, now called cultural-historical-activity theory (CHAT), technology is considered both as a tool-to-be-taught and as a tool-for-teaching. The close alignment of CHAT principles to those of the developmentally appropriate instruction endorsed by the National Association for the Education of Young Children (NAEYC) is demonstrated.

Finally, the theoretical position with observations of a morning's instruction in a preschool classroom, a classroom that integrates technology, teaches it, and exploits its potential for teaching, while fully exemplifying the principles of CHAT and NAEYC is illustrated. The technology in this classroom is based on the digital still camera, the computer, and the color printer. Photographs of students manipulated and delivered by computer, are a developmentally appropriate use of technology, because it capitalizes on the fact that young children are "egocentric" learners, that is, they are at the center of their own universe. Digital photographs, delivered immediately, put children right where they want to be, at the center of the action. These digital images of children's physical, social and cultural experience allows the teachers to assist children to draw on these experiences to construct an understanding of their world.

Cultural-Historical-Activity Theory

This CHAT approach continues to emphasize the foundational proposition of its founders, Vygotsky (1978) and Luria (1961), that the shared problem-solving activity of child and adult is the primary framework for cognitive development (Tharp & Gallimore, 1988; Barocas, Seifer, Sameroff, Andrews, Croft, & Ostrow, 1991). In this view, Piaget and contemporary constructivists are not incorrect when they discuss the individual's construction of knowledge through interaction with materials and activities, but

that explanation neglects the fundamentally social origins of human emotional, relational, and cognitive development. Only when social tools are integrated with the tools of physical action (including technological) can the potential for full development of higher mental processes be reached.

The CHAT approach emphasizes that the learner's interaction with materials and activity occurs primarily *in a social context* of relationships. In fact, that social context is the major constituent of the activity itself. As people (adults and children) act and talk together, minds are under constant construction, particularly for the novice and the young. The social process by which minds are created is the work of education. Teaching proceeds best when *assistance is provided that permits a learner to perform at a level higher than would be possible alone.* Vygotsky described this condition as a *Zone of Proximal Development (ZPD),* which is the *"...distance between the actual developmental level as determined by individual problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers*." The ZPD defines those functions that have not yet matured but are in the process of maturation, functions that will mature tomorrow but are currently in an embryonic state. These functions could be termed the "buds" or "flowers" of development rather than the "fruits" of development (Vygotsky 1978:86, italics original).

The ZPD must be distinguished from the "developmental level" where individual, unassisted performance is possible. Focusing on this proximal zone allows us to see where teaching and learning actually occur. From this analysis, Tharp and Gallimore derived this general definition of teaching: "Teaching consists of assisting performance through the ZPD. Teaching can be said to occur when assistance is offered at points in the [zone] at which performance requires assistance" (Tharp & Gallimore, 1988, italics original)." This is consistent with the principles of child development and learning, given by the NAEYC (1996): "development advances when children have opportunities to practice newly acquired skills as well as when they experience a challenge just beyond the level of their present mastery" (pp. 9).

As might be expected, a CHAT approach to technologically infused teaching would not have "teacher-proofing" as its design goal. It would not expect that fully self-instructing software could be expected to provide sufficient socialization into current communities of practice. Experts, and expert learners, can of course learn from such sources, just as fully literate readers can learn from text. But developing expertise solely from self-instruction is an expectation that has little warrant in current knowledge of cognitive development. Only if the computer could sensitively and dialogically interact with the learner, assessing the point in the ZPD at which assistance is

appropriate, and then select the best form of such assistance—and make this stream of judgments and actions continuously and accurately—only then might we do without the teacher's participation. Even then, the computer would also have to simulate the emotional and value context in which cognitive development is also situated.

In the developmentally appropriate literacy-learning activities to be discussed, technology provides the teacher with unusual and valuable forms of assistance. But her dialogically gauged assistance to the young readers situates instruction where literacy itself lies—in the social nexus. Reading instruction for young children through long exercises in individual computer cubicles is, from the CHAT perspective, misguided.

Within the CHAT community, the most fully elaborated practical pedagogy is that developed by Tharp and his associates, now primarily affiliated with the Center for Research on Education, Diversity, and Excellence (CREDE). Building on the definition that teaching is defined as appropriate assistance within the Zone of Proximal Development, they offer an analysis of the means by which assistance is offered. The six means of assisting performance are: (a) modeling, (b) contingency managing, (c) feed-back, (d) instructing, (e) questioning, (f) cognitive structuring, and (g) task structuring (Tharp & Gallimore, 1988; Tharp, 1993). Each of these has a substantial corpus of supporting and clarifying research, in developmental, social, and cognitive psychology. For example, the national guidelines of the NAEYC (1996) on developmentally appropriate activity practices assert,

> ...(during) an individual child's effort or engagement in purposeful activities, teachers select from a range of strategies, including but not limited to modeling, demonstrating specific skills, and providing information, focused attention, physical proximity, verbal encouragement, reinforcement and other behavioral procedures, as well as additional structure and modification of equipment or schedules as needed (p. 12).

From a study of the interactions of assistance, CHAT-based research has moved into considerations of total classroom pedagogy, and the ways that instructional activity is organized. This is a reflection of recent developments in CHAT theory and research. Vygotsky's fundamental concern was to understand how higher-order mental processes developed—a traditional focus for psychologists studying the mind. To understand that process, he and his students were drawn into studying social psychological processes, that is, the interactions between child and adults. The CHAT pedagogy described to this point also focuses on social processes of teacher-child interactions.

More recent CHAT work has treated the ways in which social interactions are embedded in larger units—communities and cultures. Adult interactions with children, in the processes of socialization and fostering development, exist within a context of repertoires and values that are shared and strengthened by the communities in which the activities occur. For example, Rogoff (1995) suggested that human phenomena can be understood as occurring on three planes, (a) individual-psychological, (b) social-interactional, and (c) community-institutional. Or rather, the planes are perspectives that one may take in analyzing the unity of psychological-social-community of which all human events are constituted.

This newer focus on community as a plane of analysis is particularly important for understanding technology and education. Communities are built and continue to build through shared activities involving the use of tools and language. The introduction of new technology into a community alters community practice, which alters social interactions, which alters psychological phenomena such as cognition and values. This is true of "community" at large—towns or nations, and also on smaller scales, including communities-of-practice (such as the community of computer-educators) as well as early childhood classroom communities.

The implications for CHAT-based pedagogy are considerable. While not superceding the central importance of assistance-providing social interactions for fostering development, we are now also concerned with the community-level context—the overall classroom structure of activities, tools, and values. The CREDE work of the last decade elaborates CHAT-based pedagogy by also emphasizing issues of classroom organization of activity, the development of classroom-community values, and the articulation of the classroom community with the larger community in which it is embedded. Of particular interest is the incorporation of emergent information technology into a developmentally appropriate pedagogy. Nowhere are the issues more crucial than in early education.

Standards for Effective Pedagogy

The CREDE group, after an exhaustive analysis of the research on effective education for at-risk students, engaged in a 10-year consensus-building process that resulted in the publication of Five Standards for Effective Pedagogy (Tharp, 1989, 1995; Dalton & Youpa, 1998; Tharp, Estrada, Dalton, & Yamauchi, 2000). Phrased in CHAT language, they are also justified by CHAT theory, but they are empirically derived from the existing corpus

of research across age and grade levels, cultural and linguistic groups, and subject matters. These Standards are therefore consensual generic guidelines for pedagogy. Evidence for their efficacy can be found in Tharp, et al., (2000). Unsurprisingly, they are highly congruent with those standards independently developed by NAEYC, by the National Council of Teachers of Mathematics, by the various Standards publications of the National Board of Professional Teaching Standards, and the National Association for Bilingual Education.

The Five Standards for Effective Pedagogy are:

I. Joint Productive Activity: Teachers and students producing together.
II. Developing Language and Literacy Across the Curriculum
III. Making Meaning: Connecting School to Students' Lives
IV. Teaching Complex Thinking: Cognitive Challenge
V. Teaching Through Instructional Conversation

Indicators for each Standard are available, as is a reliable and valid instrument for assessing the level of their performance (www.crede.ucsc.edu).

Standard I: Joint Productive Activity: Teachers and students producing together. When experts and novices work together for a common product or goal and have opportunities to converse about the activity, learning is likely (Rogoff, 1991; Moll, 1990; Tharp & Gallimore, 1988; Wertsch, 1985). In natural (non-formal) settings even the youngest students, as well as mature adult learners, develop their competencies in the context of joint activity. Whether it is mother and child cooking together, or leader and team producing together on the shop floor, shared ways of understanding the world are created through the development of language systems and word meanings that are used during shared activity. The common motivation provided by a joint goal inclines all participants to offer and receive assistance, since it is in everyone's best interest that the goal is reached. Because providing assistance is the basic act of teaching, joint productive activity creates the conditions in which development will occur. The use of joint productive activity increases exponentially the amount of communication and assisted performance available in the classroom. The teacher becomes only one source among 30 or so peer resources. Research evidence also clearly supports the role of the constructive, productive activity; the critical feature is applying that knowledge in productive action with others (Boaler, 1999; Webb, Troper, & Fall, 1995; Tharp & Gallimore, 1988; Vygotsky, 1978).

In conventional classrooms, joint products with a common goal are relatively rare; most tasks have an individual focus. While the individual computer with its individual keyboard appears to defy opportunities for technologically infused joint productive activity, it need not. In the following example, technological tools facilitate joint activity. With innovative furniture arrangements, students can converse with one another to coordinate their work while working on their individual keyboards.

This is consistent with the guidelines for developmentally appropriate practices of the NAEYC.

> Social relationships are an important context for learning. Each child has strengths or interests that contribute to the overall functioning of the group. When children have opportunities to play together, work on projects in small groups, and talk with other children and adults, their own development and learning are enhanced. Interacting with other children in small groups provides a context for children to operate on the edge of their developing capacities. The learning environment enables children to construct understanding through interactions with adults and other children (NAEYC, 1996, pp. 10).

Standard II: Developing Language and Literacy Across the Curriculum. Proficiency in speaking, reading, and writing is key to academic achievement. Implementing the language development standard means that teachers seize informal opportunities to learn about students while encouraging student participation in the emerging academic community of their classroom. Language, thinking, values, and culture have deep interconnections; dialogue—particularly during joint productive activity—supports students' academic achievement and affective development (Tharp, 1997; Cazden, 1986; Au, 1980; Vygotsky, 1978).

Students need opportunities to speak and write, to practice language use, and to receive the natural feedback of conversation from their teacher and peers. Oral and written language development can be fostered by restating, modeling, offering alternative phrasing, and questioning. Everyday language and academic language need continuous and integrated development. This is because academic language builds on and modifies everyday language and the thinking that it reflects. Academic discussion encourages students to move beyond everyday talk and use subject lexicons to express their understanding of concepts. Teachers implementing this standard provide students with many opportunities to use language in appropriate forms with their teacher and peers. Students participating in joint activities from preschool through high school use academic language and create text on academic topics. The teacher's role is to involve students in activities that stimulate language use.

In the following example, the teacher uses technology to increase the opportunities for both social and academic language use. This is in sharp contrast to uses of technology that isolate children in front of computers, thus draining the day of conversational opportunity. One of the guidelines proposed by NAEYC (1996) is that curriculum should provide "opportunities to support children's home culture and language while also developing all children's abilities to participate in the shared culture of the program and the community" (pp. 13).

Standard III: Making Meaning: Connecting School to Student's Lives. A wide range of social contexts and circumstances beyond classroom and school influence academic accomplishment (August & Hakuta, 1997). The reality of students' lives is anchored in contexts outside school (August & Hakuta, 1997; Moll, Amanti, Neff, & Gonzalez, 1992; Vogt, Jordan, & Tharp, 1992). The Making Meaning Standard encourages teachers to use a variety of direct and indirect approaches to draw on students' familial and local contexts of experience. This is also consistent with NAEYC (1996) guidelines for appropriate developmental activities which stress that teachers need to "incorporate a wide variety of experiences, materials and equipment, and teaching strategies in constructing curriculum to accommodate a broad range of children's individual differences in prior experiences, maturation rates, styles of learning, needs, and interests" (pp. 11).

Developmentally appropriate preschool instruction is notable for its family involvement. Does the use of new (and sometimes costly) technology in the classroom further alienate poor and less well educated families, thus broadening the "digital divide"? It need not. The following classroom example uses technology to provide rich, immediate communication to families, allowing them to make connections between their home-based activities and the classroom.

Standard IV: Teaching Complex Thinking: Cognitive Challenge. Standard IV reflects research evidence that the teaching of complex thinking, by involving students in challenging tasks, is a universal principle for effective instruction. Children learn what they are taught. If they are taught only facts and basic skills, they will learn only facts and basic skills. Cognitive complexity will be learned if it is taught. Of course, neither a challenge too low nor one too high will assist development. Through the activity-and-language-based interaction of the CHAT approach to pedagogy, "challenge" can be appropriately leveled. The appropriate level of cognitive challenge is to be found in the ZPD. For development to occur, challenge must constantly be set at the point where assistance is necessary. According to the recommendations by

NAEYC (1996), teachers need to "pose problems, ask questions, and make comments and suggestions that stimulate children's thinking and extend their learning" (pp. 12).

If the history of education is recapitulated in the new domain of technology, we will see many students, who have not had an early start in technology, assigned routine boring tasks. Only the unusually able or home-stimulated students will be drawn into joint activity with the teacher, or given challenging opportunities. In the following example, all students are involved; all students experience the richness and complexity available in the digital world, and are drawn into it by positive, exciting, emotionally satisfying experiences.

Standard V: Teaching Through Instructional Conversation. Instructional Conversation teaches students to engage in thoughtful and accountable conversation about cultural artifacts, ideally in small groups of three to seven. Teachers urge students to question and challenge, find alternative and deep problem solutions, rationalize and justify, and continually seek information to produce more complex and higher order thinking habits (Resnick & Hall, 1998). Typical classrooms provide infrequent occasions for sustained conversation, and rarely arrange for it to occur on a regular schedule. There are consequences: students' mastery of languages, conversational conventions, and academic content are effectively postponed, if not eliminated (Au, 1980; Erickson & Mohatt, 1982; Rosebery, Warren, & Conant, 1992). By middle school, such restricted opportunities result in language minority students' limited academic success and low self-confidence in their ability to learn (Padron 1992; Dalton & Youpa, 1998). The Instructional conversation allows for in-flight assessment of students learning and development. For example, the according to the NAEYC (1996), it is important to assess young children's progress and achievements during ongoing, strategic, and purposeful activities. The results of such dialogical assessment can be used to benefit children—by adapting curriculum to developmentally appropriate tasks and by meeting the developmental and learning needs of children during and beyond the classroom activity. The following case example illustrates inflight adjustments of the instructional task itself, in the light of teacher-student dialogue.

Instructional conversation provides the opportunity to explore students' experience and knowledge and affirm their value and relevance to learning. Good teaching uses meaningful content presented in life-like situations (Allington, 1990; Chalmot, 1992; Means & Knapp, 1991). The Instructional Conversation builds on and incorporates students' funds of knowledge,

based on their familial and community experiences, to increase connections between students' prior knowledge and the unknown, abstract, and academic content of instruction (Dalton & Sison, 1994). The Instructional Conversation both communicates and creates these new conventions. The Instructional Conversation can only occur in a community of learners, and it is by means of that conversation that the community is created. The Instructional Conversation is the capstone of effective education.

Conversation also carries the community's values and emotional shadings. Talking together, in natural informal learning environments, not only develops higher order thinking, but also socializes children into community values, and teaches them the conventions and pleasures of human relationships. Young children, especially, should not be deprived of these experiences. No use of technology can be endorsed that has the net effect of reducing young children's opportunities for instructional dialogue with the teacher. In the following case example, technology is used to stimulate an occasion rich dialogue between children and their teacher.

Necessary Conditions for Enacting the Five Standards

Certain classroom conditions are necessary for the full enactment of the Five Standards (Tharp et al., 2000). Here two are discussed: (a) multiple simultaneous instructional activities: and (b) value consistency across all classroom activities. This is also consistent with the guidelines by NAEYC (1996) for the enhancement of teaching and learning. They proposed that teachers "use a variety of ways of flexibly grouping children for the purposes of instruction, supporting collaboration among children, and building a sense of community. At various times, children have opportunities to work individually, in small groups, and with the whole group" (pp. 12).

1. *Multiple simultaneous instructional activities.* Joint productive activity with teacher and peers, and opportunities for the Instructional Conversation, require that classrooms employ multiple, simultaneous, and diversified instructional activities. Although it is possible to have some teacher-student dialogue in a single, undifferentiated activity such as whole-group instruction or seatwork, quality instructional dialogue cannot take place with 30 students, or even with 15. When the teacher organizes groups of four to seven students for conversation, the other students must be otherwise employed. Genuine joint productive activity cannot involve 20 or 30 students doing the same thing; even when

there is a joint class-wide project, as for example a school newspaper to be written, it will require smaller diverse and more specialized activities, devoted to parts of the newspaper, to allow true joint participation with others.

In the following classroom case, two computer stations are available for preschool students to choose throughout the instructional morning. Their arrangement allows for assistance from other students, both those at the keyboards and those kibitzing over their shoulders. The computers are one among 6 to 12 working stations, all operating simultaneously.

However, technology is present throughout the entire classroom, providing an enriching saturation of all activity centers.

2. *The values of the classroom culture should be expressed consistently in every activity setting.* Whether or not it is consciously guided, activity produces values. Things, words, and actions take on meaning, negotiated and evolved by participants. Willy-nilly, "rules" develop in activity. Teachers determine this process, sometimes unintentionally, sometimes by exercising creative leadership to develop values conducive to the goals of teaching and learning. "Classroom management," or "deportment," or "good values" in the classroom is an absolute precondition for any effective instruction, especially for classrooms organized into complex, diverse, simultaneous activities, where most students, most of the time, are working under their own self-control, and not dependent on close teacher monitoring.

Overall, the basic value presumption of a productive classroom community is that each member has important contributions to make and serious business to do, and that teachers and students will do it together, making it work for each other. As the class develops that understanding, much else will accompany it—rapport, trust, and mutual respect. Only as such a classroom community is developed can the teacher move into differentiated activity settings. If the classroom is to be productive, cooperative, filled with appropriate talk and activity, with each person having equal access to opportunity and to each other, then certain values are a necessity: helping and not interfering with the work of others, caring and generosity, high standards, mutual respect, and cleaning up. One of the more unlikely and pleasing uses of the technology in the following model case is its use in developing such a set of community values.

Principles In Action: A Day in a Technologically Enriched Preschool Classroom

Technologically enriched instruction can operate in full accord with CHAT-based and developmentally appropriate pedagogy for children from three to eight. Our classroom illustration is based on a systematic approach to teaching/learning interactions facilitated by the use of digital camera, computer and color printer in a preschool classroom; some 80 such activities have been described in Entz and Galarza (2000). The activities described are typical of this classroom, which was observed and recorded on September 11, 2000, in the classroom of the author, "Ms. Sheri" Galarza, at the Kamehameha Preschool, Kona, Hawaii. Her 20 students range in age from three and a half to four and a half. All are of Hawaiian or part-Hawaiian ancestry. Several would be classifiable as "special education-appropriate." The majority speak Hawaiian Creole (Hawaiian "Pidgin") as their first language. Parental backgrounds range from poverty/low parental education to middle-class/professional. The classroom is fully inclusive, and "mainstreamed," in the sense that each child is taught according to individual readiness and developmental appropriateness.

This is the fifth week of school. The daily routine is well established. From the time of arrival until nine a.m., children engage in individual, "free" activities at any of the learning centers or with any of the materials, games or toys. Ms. Sheri and "Ms. Pam" (Pam Punihaole) the teaching aide, circulate and interact with the children, and complete the preparations for the learning center phase.

This is the second week of a thematic instructional unit on the Ipu—a gourd used variously in Hawaii culture, but especially as a musical percussion instrument. In dance and chant, the ipu is struck by hand or on the ground to provide a strong rhythm line. An ipu accompanies the name chant that opens each day's morning circle. Ipus grow on a vine on the back fence of the school. The children have been painting pictures of ipus, learning songs about them, and learning to play them as instruments. The ipu theme continues today.

At 9:00, Morning Circle begins with a Hawaiian name chant, a song, an arm hula, simple exercises, and the typical classroom morning business of assigning roles, and explaining any unusual daily activities and goals. Today's explanation features Planting an Ipu Seed, which groups of four or five children will do in the outdoor Garden Center. (This activity will be the focus of the following discussion.) Ms. Sheri also reminds the students of the ongoing theme of building classroom community values. The complex

classroom activities and routines require self-control and a shared sense of values. This week Ms. Sheri is concentrating on three: (a) helpfulness to others; (b) cleaning up after activities; and (c) doing quality work. As we will see, she uses technology to assist in each of these goals. She asks the children to call her attention to enactments of these values, so that she can record these events with the digital camera.

After the Morning Circle is completed, the children disperse into the classroom's multiple activity centers. Each center will accommodate only four, so children insert their name cards into any empty slot outside a center, and then can enter. As always, there are five to eight simultaneous activity settings, under the general supervision of the teachers, but largely managed by the children themselves. (For special lessons, such as today's planting activity, Ms. Sheri may call out the groups of four in succession.)

This period of concentrated instructional activity lasts about an hour. Recess and outdoors play follow. Next is a period usually devoted to learning music and/or dance, then comes lunch, a nap, and children are usually gathered by their families about one pm.

Mathematics—Sequencing/Time: The Gourd Planting Lesson

Before turning to a detailed examination of the day's main lesson, the template by which the lesson has been designed was examined. Entz and Galarza (2000) suggested two criteria for lesson planning. First, one needs to consider the goals of the lesson in relation to the long-term goals for development of general knowledge of the subject matter. This entails the development of multiple simultaneous differentiated activities to develop multiple skills. Second, an immediate goal for each activity that will guide the teacher to assess and assist the child's development of those skills is needed. Instructional activities also involve personalizing the subject matter for the students, and connecting the learning experience from the classroom to the child's world of family and community.

A meaningful and developmentally appropriate lesson plan includes four steps. The first step in their lesson plan is to define the concept to be taught. In today's case, mathematics is defined as a way of thinking that enables children to organize and understand their world. The second step is to address in the lesson, the general importance of the subject matter. Mathematics is more than numbers, counting, and rules. It arises from an attempt to solve problems with space, shapes, time, size, patterns, quantities, and relations. Mathematics and mathematical thinking are indispensable in the

modern society where one has to make sense of information that is organized and analyzed using mathematical and scientific thinking. The third step is to identify how mathematics is learned. Mathematics learning is a process that begins in infancy and continues to develop through childhood. It evolves through direct experience with real objects in play and daily life. The fourth step is to create the conditions for facilitating mathematical thinking. Because young children learn best through hand-on experiences, mathematical concepts should be embedded in play and daily routines. Simple tasks such as using measuring cups and spoons in sand and water play, matching shoes, and putting one sock on each foot make mathematics meaningful for children. A mathematics-rich environment is filled with opportunities to investigate relationships between materials. Specific activities should be developed for specific areas of mathematical learning, such as matching, sorting, patterning, counting and comparing, exploring shapes, estimating, measuring, one-to-one correspondence, geometry, and time (Entz & Galarza, 2000). Today's lesson is designed to develop the concept of sequencing (of events over time).

Developmentally appropriate activities are embedded in an environment that facilitates the development of social and emotional maturity, as well as the mastering of subject matter. Instructional activities need to include (a) objectives for teaching and learning; (b) discussions with students about the description and sequence of events in the activity, (c) connection of a single activity to the overall objective of the day, and (d) activity extensions that increase the understanding achieved in the designed lesson. Thus a developmentally appropriate lesson also involves their connection or extension to the context of the family and immediate community environment (Entz & Galarza, 2000).

Enacting Today's Lesson

Prior to the student's arrival, the use of the technology that infuses this classroom has already begun (digital still camera, computer, and color printer). The teachers made task cards for each phase of the learning activity, and clipped each to the appropriate station in the center, under a bright yellow number card for each task. The task cards include simple printed instructions, below a printed photo of the hands of Ms. Sheri or Ms. Pam performing the task. Today's activity of planting gourd seeds in tiny pots and watering them is presented in six segments. Six cards depict the six stages, from #1, taking a pot, #2, filling the pot with dirt, to #5, sprinkling the

planted seed, to #6, putting their name-flags in the pot. These depicted instructions are excellent, accessible cues to the children, most of whom have not fully absorbed the Morning Circle verbal instructions. They also prepare the students for the using task cards, a common feature of all K-12 multiple activity setting classrooms.

The transcript begins after all students have finished planting their seeds. Ms. Sheri calls four students back to the garden area, and the mathematics sequencing/time lesson begins. They are all seated on a beach mat in a semicircle, Ms. Sheri shuffles the set of task cards and asks the children to recall and describe the activity depicted. She then asks the children to arrange the cards in sequence. Note that this is organized as a Joint Productive Activity (Standard One), with its first phase being among teacher and students, and phase two being among peers with the teacher observing.

Here is the transcript of the first group's lesson:

Ms. Sheri: Now I want you to decide what was the first thing you did.

Child: Get your cup.

Ms. Sheri: Right! So now I'm going to put it right here (face up on the grass), for the first thing. Now. Who knows what comes next? Mika?

Mika.: Get your stuff.

Ms. Sheri: Is that the one that comes next? Do you agree? Right! That's what comes next. What is the stuff called?

Chelsea: Dirt.

Ms. Sheri: Right. Very good. Get the dirt. Now I'm putting the card for it right here (next to "get your cup."). The first thing you did was get your cup, the second was fill it with dirt. You were right! Very good! Now who knows what comes next? Then what did you do next? Kainalu, do you remember? You got your cup, you got your dirt.

Chelsea: (points to "pour the water.")

Ms. Sheri: Chelsea, is that right? Is something missing? What comes after getting the dirt? You pour the water after you get the dirt? What's missing?

Mika: Seed.

Ms. Sheri: Seed? Is that right?
Children nod.

Ms. Sheri: Show me the picture. OK, does anything come before that? What do you think? No? OK. (She puts the seed picture third in line).

The children perceive an anomaly: the task cards themselves have small numbers printed on them. According to those numbers, the sequence now laid out is 1, 2, 4. One child notices a 3 card, and puts it between 2 and 4. The children then complete the sorting quickly, using the numbers. Ms. Sheri then repeats the description of each.

Ms. Sheri: Do you know what you did with these? You put them all in order, 1, 2, 3, 4, 5, 6.

Bram: Yeah, but we had them, like, (points, points) 1, 2, 4, 3. 5, 6.

Ms. Sheri: That's right, you did, but then you got it right, you solved the problem. You are problem solvers! And you remembered what you did.

Bram: Maybe what you should do is, like, put the numbers on the back or something...

Ms. Sheri: You mean...cover up the numbers! What a great idea! Ms. Pam, do we have those stickers we could cover up these numbers with? What a great idea! You are thinking! That is a good idea, Bram, I love that idea. Now I'm going to try to trick you. (Conspiratorially) Can you do it if I trick you?

Now Ms. Pam has brought a glob of plasticine; Ms. Sheri covers each number with a disc of it.

Ms. Sheri: Now here's the rule. You CAN NOT touch this, right?

Bram: Right.

Ms. Sheri: That's so you can't use the numbers to help. Can you sort them if you don't use the numbers? You have to use your memory.

She takes the yellow number signs and places them on the grass facing the beach mat. She shuffles the task cards again, and hands them to the students.

Ms. Sheri: Now you put the pictures in the right order, under the number signs. And the only rule is, Don't....(pointing to the plasticine)
Bram: Touch this.

Ms. Sheri: Right. Now do it, you look at them and talk about it, and help each other, everybody help, I'm not going to say a word (puts her hand over her mouth), I'm going to move back there, and you tell me when you have them all fixed.

The children all participate, arranging the cards and moving them around. They place each task card under the appropriate number card, place them in correct sequence, and all look up to Ms. Sheri, who has been observing from a short distance.

Ms. Sheri: Now I want you to tell me what you did. What does that say to do?

Children begin to name the sequence, and drift away as though the task is completed. Ms. Sheri calls them back.

Ms. Sheri: Wait, wait, we're going to check if it's right before you go. Now what is the fourth one?

The card "Put water in it" has been placed before the card for "Put in the seed." As the children tell her the actions of the sequence, she challenges them:

Ms. Sheri: Is that right? Is that what you did? Put the water in before the seed? Do you think that's right, Kainalu?

Bram: We mixed something up.

Ms. Sheri: What did you get mixed up?

Bram: The numbers are correct.

Ms. Sheri: Yes, the numbers are in correct order, so what is not in correct order? Jessie, can you tell? The sequence says: get the pot, put the dirt in, dig a hole, pour the water, put the seed... (Jessie: that's wrong.) ...put your name flag in. What's wrong?

Two children quickly exchange number cards 4 and 5.

> *Ms. Sheri:* Now take off the plasticine and see if you are correct.

Starting at the top, one at a time, the children pull off the plasticine, and compare the number on the task card with the number card. All greet each correspondence with increasing enthusiasm, and cheer when 6 matches 6.

> *Ms. Sheri:* That's great! Give yourselves a hand! Wait, wait, just a minute! Let me get your picture! Yea! (She snaps the photo.) What a good team you are...(aside to the observer) great kids, aren't they?

That photograph will be printed in many copies, for multiple uses, as will be described later.

Discussion of Principles Exemplified in the Lesson

Cognitive development (Standard IV). The lesson is cognitively challenging. The students are unable to complete the sequencing task by themselves. However, with assistance, they manage to do so. This is teaching within the ZPD, a task that was very well leveled to provide the stretching toward thinking in more complex ways than usual for the students. In the first iteration, the teacher inadvertently supplied them with the assistance of the numbers printed on the cards. Once the students used those cues, they solved the task quickly. At the suggestion of a student, those cues were removed for a second iteration. In that instance, they were able to complete the task correctly, but only when assisted by the questioning of the teacher. This kind of "relentless" stretching of students' capacities exemplifies Standard IV.

Teaching through dialogue—the instructional conversation (Standard V): This excellent example of an instructional conversation is built on the solid foundation of several crucial elements, especially the presence of appropriate stimulus materials (digitally produced), that are deeply contextualized in the children's immediate sensory experience of the planting. This contextualization is achieved because of the immediacy of the task card photographs, made possible by the high-speed technological capacity. The task cards are photographs of the actual manipulanda, *in situ*, and were produced only the afternoon before, when the materials were all prepared.

Another notable feature of this lesson is the teacher's responsiveness to the student's suggestion of how to improve the problem-solving task. This is a rare event in classrooms, and can occur only in the context of genuine dialogue between teacher and students. This kind of dialogic negotiation

and correction is crucial to teaching in the zone of proximal development. The social element of teaching, even in technologically based activity, is eliminated only at great cost.

Use of Technology in the Other, Simultaneous Activities

Before, after, and during the planting and sequencing activities, children are engaged in a variety of simultaneous activity centers. Technology is infused in the entire instructional period. On the day of observation, technology use follows a clear sequence: the teacher takes a digital still photograph of an event or accomplishment; downloads a full disc into the computer; and color-prints the images onto various sheets for various purposes. She used these images in several ways.

Generic benefits of the technological system. Immediately delivered digital images of themselves in meaningful activities provides developmental benefits that extend beyond the immediate lesson goals.

Increased motivation. The photographs, and the processes of producing them, are so enjoyed by the students that their motivation for engaging in all instructional activities is heightened. In every activity of the day, they strive for a "good" performance, in the hope and expectation that it will be recorded by the teachers' camera. On a day when the camera was being repaired, the children continued the system; they pretended to "photograph" each other's good work.

Increased span of visual attention. The student's appetite for examining the photographs produced unusually long periods of focused visual attention, at a developmental stage when that is a generic goal of the preschool experience. *Community building.* Their shared enjoyment, and the opportunities to review one another's accomplishments as recorded in their library "book," enhances their development as a community of learners.

Assisting the development of targeted competencies. The technology sequence provided two major means of assistance: instructing, and rewarding, as well as creating opportunities for review.

Instructing. As already illustrated, digital photos are used to create task cards and other forms of visual instructions.

Rewarding. By rewarding desirable behavior and accomplishment, Ms. Sheri strengthens that development. Her attention and the printed pictures both serve as strong positive reinforcements, thereby increasing positive classroom behavior and enhancing social interaction by "catching them being good."

Review. The visual image provides an ideal opportunity for the student to revisit the activity for review and consolidation of learning.

Language/literacy development (Standard II). After printing the digital photographs, the teacher uses them as a stimulus for dialogue (oral language development) with the children pictured; and then for a literacy activity, when she writes their dictation below the picture, and has them print their names as "signature." As a third literacy tool, she binds the photographs into a "book," that goes into their library each week, where the books are popular for reviewing and "reading." This morning Ms. Sheri takes about 10 additional photographs. Three are snapshots of good quality work: block building, writing, and a sensory-identification task. Most record instances of good behavior, identified by classmates, noticed by the teachers, or self-nominated.

The conversation over the photographs includes much praise, and questions about the situation depicted: what led up to the event, what is happening at the moment, and the elements that the teacher wants to develop in the child's repertoire. This system of clear social reinforcement and discrimination training plays a large role in the children's rapid development of classroom-community values and expectations.

These photographs of familiar people, places, and things are ideal stimuli for conversation by young children, and thus for opportunities for the teacher to assist language development. These conversations actively engage children in constructing their own understanding of experiences.

After this dialogue, Ms. Sheri asks the child to dictate what should be written on the picture. She prints these remarks in a large hand, and the child signs the picture as well as able. This interaction provides an excellent opportunity for oral language development, as the teacher rephrases, asks for clarification, provides vocabulary enrichment and the like. The writing portion of the lesson is a situation rich with potential for reading and writing development. After the teacher writes the child's dictated text, she asks the child to read the text back to her, a form of the language-experience method of reading instruction. The opportunities for the development of sight vocabulary development are particularly enriched by the presence of the digitized picture—a visual cue for a meaningful event to which the text can be related.

Family contextualization and communication (Standard III). Selections from the day's digital images are reduced in size and printed with descriptive text on a single sheet that is posted on the front door for families' perusal as they collect their children. This documented photographic record

assists the parents to understand what transpires in the classroom, and also to understand the context of Ms. Sheri's daily letter to them, suggesting follow-up activities at home. She also provides to the family a copy of each child's photograph sheet on the day it was taken. Another family involvement strategy includes sending home a copy of activity task cards; for the mathematics—sequencing lesson above, she asked the parents to have the children sequence the cards again, and talk about the task with parents. The teacher also sends home duplicate copies of the digital "library book" but with the text deleted. Parents are asked to have their children describe what is happening in each picture and record their responses. The family receives a copy of each child's photograph sheet on the day it was taken. The technology helps to develop positive home-school relations; the photographic records are highly valued by the families, as well as by the children.

Portfolio Creation. The individual pictures (with their inscriptions) provide feedback on process, product, and behavior, which is invaluable to parents, teachers, and the children themselves. The pictures document and validate the process of development, not only the product. Teachers use them as data for assessment. The portfolio documents cognitive, social, and character development, and can be used for various forms of performance ratings, qualitative and quantitative.

The completed year's portfolio provides a remarkable record of a year's development of a child; and a remarkable record of a year's performance by a teaching team. Both have rich potential for assessment. The emerging portfolio, collected by the parents each week, promotes their awareness of their child's current level of development, and provides a record of their progress. This concrete assessment data can be used at home to guide parents own "curriculum" for their children's activities.

Technology in Early Childhood Education

This approach to technology and early education may strike some readers as conservative. The classrooms are not filled with terminals, the curriculum material is not executed by software. But the teachers ensure that even the computer-reluctant students spend time in this center, learning rudiments. The modest two-station computer learning center is loaded only with engaging games and learning activities, such as color mixing and greeting card construction. Yet before reaching five years old, students can manage desktop folders-and-documents, call up applications, and begin to produce text. Their attitudes toward computer use are uniformly positive, and many

want to appropriate the teacher's actions of downloading the photo files. At this time, we are content with this level of development of tool-use skills and attitudes.

This model does avoid the obvious hazards of computer-reliant classrooms. Ms. Sheri continues to organize rich, first hand, concrete, active sensory-motor experiences on which to construct knowledge. In this classroom, computers do not entail social isolation. Teachers do not tempt themselves to use computers as electronic babysitters, surrogate television sets. However future research illuminates the issue, this conservative system avoids currently feared ill effects on the development of young brains, as well as young minds, of heavy doses of close electronic exposure. But these are negative considerations.

Positive criteria drive the introduction of digital information technology into these early education classrooms. These positive criteria include:

VI. Classroom technology should prepare young children for the competencies in new technology that will be required for the good adult life, as well as we can predict it?
VII. Positive attitudinal development toward new tools should be prioritized over premature specific skill development in young children.
VIII. Technology in the classroom should facilitate teaching by providing tools *for* teaching.
IX. Technology tools should facilitate, not diminish, dependable human pedagogy, pedagogy established by decades of practice (NAEYC), justified by theory (CHAT), and verified by research (CREDE).

References

Allington, R. (1990). Children who find learning to read difficult: School responses to diversity. In E.H. Hiebert (Ed.), *Literacy for a diverse society: Perspectives, programs, and policies* (pp. 237-252). Bristol, PA: Palmer.

Au, K. (1980). Participation structures in a reading lesson with Hawaiian children: Analysis of a culturally appropriate instructional event. *Anthropology and Education Quarterly, 11*(2), 91-115.

August, D., & Hakuta, K. (1997). *Improving schooling for language-minority children: A research agenda*. Washington DC: National Academy Press.

Barocas, R., Seifer, R., Sameroff, A., Andrews, T., Croft, R., & Ostrow, E. (1991). Social and interpersonal determinants of developmental risk. *Developmental Psychology, 27*(3), 479-488.

Boaler, J. (1999). Participation, knowledge, and beliefs: A community perspective on mathematics learning. *Educational Studies in Math, 40,* 259-281.

Cazden, C. (1986). Classroom discourse. In M.S. Wittrock (Ed.), *Handbook of research on teaching* (3rd ed.) pp.432-464. New York: Macmillan.

Chalmot, A.U. (1992). Learning and problem solving strategies of ESL students. *Bilingual Research Journal, 16*(3/4), 3-27.

Dalton, S.S., & Sison, J. (1994). *Enacting instructional conversation in math with Spanish speaking language minority students.* Research Report No. 12, National Research Center on Cultural Diversity and Second Language Learning. Washington, DC: Center for Applied Linguistics.

Dalton, S.S., & Youpa, D.G. (1998). Standards-based teaching reform in Zuni pueblo middle and high schools. *Equity and Excellence in Education, 31*(1), 55-68.

Entz, S., & Galarza, S. (2000). *Picture this: Digital and instant photography activities for early childhood learning*. Thousand Oaks, CA: Corwin Press.

Erickson, F., & Mohatt, G. (1982). The cultural organization of participation structure in two classrooms of Indian students. In G. Spindler (Ed.), *Doing the ethnography of schooling* (pp. 132-174). New York: Holt, Rinehart & Winston.

Luria, A.R. (1961). *The role of speech in the regulation of normal and abnormal behavior.* New York: Liveiryut.

Means, B., & Knapp, M.S. (1991). *Models for teaching advanced skills to educationally disadvantaged children. Teaching advanced skills to educationally disadvantaged children.* Washington, DC: U.S. Department of Education, Office of Planning.

Moll, L.C. (Ed.) (1990). *Vygotsky and education: Instructional implications and applications of sociohistorical psychology*. New York: Cambridge University Press.

Moll, L., Amanti, C., Neff, D., & Gonzalez, N. (1992). Funds of knowledge for teaching: Using a qualitative approach to connect homes and classrooms. *Theory into Practice, 31,* 132-141.

National Association for the Education of Young Children (2001). NAEYC Guidelines Revision: NAEYC Standards for Early Childhood Professional Preparation. [Online]. Available: http://www.naeyc.org/

Padron, Y.N. (1992). The effect of strategy instruction on bilingual students' cognitive strategy use in reading. *Bilingual Research Journal, 16*(3/4), 35-51.

Resnick, R.B., & Hall, M.W. (1998). Learning organizations for sustainable education reform. *Daedalus, 127*, 89-118.

Rogoff, B. (1995). Observing sociocultural activity on three planes: Participatory appropriation, guided participation, and apprenticeship. In J. V. Wertsch, P. del Rio, & A. Alvarez (Eds.), *Sociocultural studies of mind* (pp. 139-164). Cambridge, UK: Cambridge university Press.

Rogoff, B. (1991). Social interaction as apprenticeship in thinking: Guidance and participation in spatial planning. In L.B. Resnick, J.M. Levine, & S. Teasley (Eds.), *Perspectives on socially shared cognition* (pp.273-294). Washington, DC: APA Press.

Rosebery, A.S., Warren, B.W., & Conant, F.R. (1992). Appropriating scientific discourse: Findings from language minority classrooms. *The Journal of the Learning Sciences, 2*(1), 61-94.

Tharp, R.G. (1997). *From at-risk to excellence: Research, theory and principles for practice.* Research Report No. 1. Washington, DC: Center for Applied Linguistics and Center for Research on Education, Diversity & Excellence.

Tharp, R.G. (1995). Instructional conversations in Zuni classrooms. In C.L. Montone (Ed.), *Teaching linguistically and culturally diverse learners: Effective programs and practices* (pp. 12-13). Santa Cruz, CA: National Center for Research on Cultural Diversity and Second Language Learning.

Tharp, R.G. (1993). The institutional and social context of educational practice and reform. In E.A. Forman, N. Minick, & C.A. Stone (Eds.), *Contexts for learning: Sociocultural dynamics in children's development* (pp. 269-282). Cambridge, UK: Cambridge University Press.

Tharp, R.G. (1989). Psychocultural variables and constants: Effects on teaching and learning in schools. *American Psychologist, 44,* 349-359.

Tharp, R.G., Estrada, P., Dalton, S.S., & Yamauchi, L. (2000). *Teaching transformed: Achieving excellence, fairness, inclusion*. Denver, CO: Harmony Westview Press.

Tharp, R.G., & Gallimore, R. (1988). *Rousing minds to life: Teaching, learning, schooling in social context*. New York: Cambridge University Press.

Vogt, L.A., Jordan, C., & Tharp, R.G. (1992). Explaining school failure, producing school success: Two cases. In E. Jacob & C. Jordan (Eds.), *Minority education: Anthropological perspectives* (pp. 53-66). Norwood, NJ: Ablex. (Reprinted from *Anthropology & Education Quarterly, 18,* 276-286.)

Vygotsky, L.S. (1978). *Mind in society: The development of higher psychological processes* (M. Cole, V. John-Steiner, S. Scribner, & E. Souberman, Eds. and Trans). Cambridge, MA: Harvard University.

Webb, N.M., Troper, J.D., & Fall, R. (1995). Constructive activity and learning in collaborative small groups. *Journal of Educational Psychology, 87*(3), 406-423.

Wertsch, J.V. (1985). *Culture, communication, and cognition: Vygotskian perspectives.* New York: Cambridge University Press.