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Changes in Teachers' Beliefs and Practices in Technology-Rich Classrooms

Teachers who had regular access to computer technology in their classrooms over several years' time experienced significant changes in their instruction, but not until they had confronted deeply held beliefs about schooling.

Photograph by Armand Wright

An increase in collaborative learning in ACOT classrooms is evident not only among older students but among much younger ones as well. Here, two students at Stevens Creek Elementary School are working together to create a Hypercard® based report about California whales using a Macintosh® computer.

Sam (a primary-grade student): I don't know if we'll have computers [next year]. If we don't, it will be weird. Cause the teacher talks pretty long, and you have to listen.

Sam's mother: He's really into it—I think computers are just part of our lives now. And it hasn't made Sam any less determined in terms of wanting to read or paint or draw. And he's really proud.

Sam's teacher: I think computers are going to help me. It's not going to hurt students—I think that they are going to get as much out of working on the computers as they will out of working out of workbooks. I think. But see, I'm not even 100 percent sure of that.

Researcher: It appeared that children interacted with each other more frequently while working at computers. And the interactions were different—the students spontaneously helped each other. They were curious about what others were doing. They were excited about their own activities, and they were intently engaged.

These behaviors were juxtaposed against a backdrop in which the adults in the environment variously encouraged and discouraged alternative patterns of operating. It was as if they were not really sure whether to promote or inhibit new behaviors (Phelan 1989).

A primary grade teacher has taken the first step in integrating interactive technologies into her classroom. Her student reports his ready acceptance of computers and, with the guilelessness of the very young, contrasts his year with an imagined return to a computerless room, where "the teacher talks pretty long, and you have to listen." The child's mother, too, expresses her satisfaction with the computer intensive program. But the teacher is ambivalent: will her students do as well with the technology as with her traditional use of workbooks? Phelan, an independent researcher in the setting, notes how the potential of the innovation might be cancelled out by predispositions to the norms of traditional schooling.

The teacher, like all others in the Apple Classrooms of Tomorrow™ project (ACOT™), is a volunteer, a participant in an ambitious program whose espoused goal is change in instruction and learning. ACOT is a flexible consortium of researchers, educators, students, and parents who have worked collaboratively to create and study innovative learning environments and implement educational change since 1985. The project is funded by Apple Computer Inc. and directed by the ACOT staff, within the Advanced Technology Group at Apple. ACOT's mission is formative: to explore, develop, and demonstrate powerful uses of technology in teaching and learning.

Thirty-two teachers and 650 students work in ACOT classrooms. Together they represent the diverse populations and conditions found in contemporary public schooling with a notable exception—participants have immediate access to interactive technologies. Elementary and secondary classes are equipped with computers, printers, scanners, laserdisk and videotape players, modems, CD-Rom drives, and hundreds of software titles. By design, the classrooms are true multimedia environments, where students and teachers use textbooks, workbooks, manipulative math materials, white boards, crayons, paper, glue, overhead projectors, televisions, pianos, and so on, as well as the technology. The operating principle is to use the media that best support learning goals across the curriculum.

Photograph by Armand Wright

Over time, teachers in ACOT classrooms have observed an increase in collaborative learning among their students. Two West High School students are working cooperatively on a project using a Macintosh® portable.

This article describes the course of instructional change over several years in these classrooms and illustrates the process as one of inner conflict for teachers. Although the project's classrooms are radically altered by the physical presence of technology, each member of ACOT's teaching staff brings to those classrooms deeply held beliefs about schooling. These beliefs were ingrained in the traditional classrooms where they spent years, first as students and later as teachers. What we found is that the more things change, the more teachers must confront their beliefs about learning and the efficacy of their instructional activities. To tell this story, we draw on a rich longitudinal, multiperspective body of data, composed of personal reports from teachers; site reports submitted weekly by project coordinators at each school; and classroom observations and student, parent, and teacher interviews conducted by a team of university-based researchers.[1]

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Instructional Change in ACOT Classrooms

In the early days of the introduction of computers to classrooms, everyone seemed to focus on the innovation: computers and software. Little thought was given to the elements that would most likely remain the same: instruction, student tasks, and assessment. In many ways the early progress of ACOT repeated the error. Although the sheer number of computers in ACOT class-

At both elementary and secondary schools, teachers saw their students move away from competitive work patterns toward collaborative ones.

rooms radically transformed the physical environment, for the most part student learning tasks remained unchanged. Gradually, however, new patterns of teaching and learning emerged at all sites. We view the change as an evolutionary process with stages that we label: Entry, Adoption, Adaptation, Appropriation, and Invention. In our model, text-based curriculum delivered in a lecture-recitation-seatwork mode is first strengthened through the use of technology and then gradually replaced by far more dynamic learning experiences for students.

Entry

ACOT's first cadre of teachers, with little or no experience in computer technology, were in various stages of trepidation and excitement in the fall of 1986. In this initial stage, their familiar tools were blackboards, textbooks, workbooks, and ditto sheets, and they used them to support lecture, recitation, and seatwork. That familiar world began to change as classrooms were rewired and rearranged and the first of hundreds of boxes of computers, drives, and magnetic disks began to arrive. School days were given over to unpacking those boxes, running extension cords, untangling cables, inserting memory expansion kits, and formatting disks—in other words, teachers struggled valiantly to establish order in radically transformed physical environments.

Once instruction began, teachers found themselves facing first-year-teacher problems: discipline, resource management, and personal frustration.[2] At this point, they clearly had second thoughts:

> If I had my druthers, I don't think I would ever look at a computer again. One of my students got into the network and lost lots of information because he doesn't know what he is doing. . . . There are so many variables like this that we deal with on a day-to-day basis that I didn't anticipate being part of this program. I'm anxious for the weekend so I don't have to do anything with computers. (AT, 2226, 11/16/88)[3]

Adoption

Teachers' struggles to accommodate the new technology seemed to abate during their first year with the project. Computer-based issues were far from over, but the balance of their concerns began to tilt toward using computers rather than connecting them. What we witnessed during this period was the adoption of the new electronic technology to support traditional text-based drill-and-practice instruction. Students continued to receive steady diets of whole-group lectures and recitation and individualized seatwork. Although much had changed physically in the classrooms, more remained the same.

With so few changes in instruction and the disruptions inevitable with the installation of, and inexperience with, the new technologies, we anticipated short-term declines in student performance. Surprisingly, traditional measures of achievement showed no significant decline or improvement in student performance aggregated at the classroom level (Baker et al. 1989), and teachers reported individual students performing better. Self-esteem and motivation were measured and reported to be strong at all sites. Student attendance was up, and instances of discipline problems in ACOT classrooms ranged from zero to few (Beaty et al. 1988, Kitabachi 1987, Walker 1987).

Adaptation

In this next phase, the new technology became thoroughly integrated into traditional classroom practice. Lecture, recitation, and seatwork remained the dominant forms of student tasks; but they were supported 30–40 percent of the time with the use of word proces-

Photograph by Armand Wright

Here, West High School students are working on math problems using Macintosh® computers. Self-paced programs enable students to complete work faster—and learn more.

Photograph by Armand Wright

Having computer technology in their classrooms has had a striking effect on the way ACOT teachers have come to view teaching and learning. Here, two teachers at Stevens Creek Elementary School discuss a lesson that uses an Apple computer as a tool.

sors, databases, some graphic programs, and many computer-assisted instruction (CAI) packages.

The shift from Adoption to Adaptation was signaled by the emergence of productivity as the common theme in teachers' reports. Staff reported that their students produced more, faster. In a self-paced, computational math program, for example, 6th grade students completed the year's curriculum in 60 percent of the time normally required, and test scores remained as strong as in previous years. Comments from teachers at all levels emphasized speed and efficiency:

> The students have access to the total assignment on the network and are working through it much more quickly and with more understanding. Many of them never use paper and pencil on the assignment at all. They download handouts to their computers, work on the tasks assigned, and send the final copy of their work to the printer to be picked up by the teacher—No more pages and pages of handouts that are lost, replaced, and lost again. (WL, 303, 5/4/88)

> I was amazed at the speed at which some of the students could move through various AppleWorks screens. . . . Many of the students can now type faster than they can write. (WL, 916, 10/25/87)

> Students are writing with a great deal more fluency now, thanks to keyboarding skills. Following a prewriting exercise, they now type their stories directly into the computer, rather than writing out the whole story and then copying it. (WL, 1068, 3, 3/2/88)

Teachers' beliefs may be best modified while they are in the thick of change, taking risks and facing uncertainty.

ACOT's teachers also noted changes in the quality of student engagement in classroom tasks during the Adaptation phase. The following reports are representative of those observations.

> We are finding that the students are coming in to use the computers during lunch and staying late to complete their HyperCard assignments for social studies on the countries they are researching. This degree of commitment and engagement is really unusual in a group of quite ordinary kids. (AT, 69, 10/25/87)

> On Monday, when I announced that it was time for recess, the students wanted to continue to work in the classroom. One said, "You know, I can't believe it's really recess. When you're having a good time, time goes by so fast." They are really involved. . . . They work really quietly without a lot of running around. They seem to be setting up standards for themselves to judge their own work. (AT, 1817, 9/19/88)

Appropriation

Movement to this next phase occurred for the first cadre of ACOT teachers in the second year of the project across all sites. The change hinged on each teacher's personal mastery—or appropriation—of the technology. Because most teachers and their students have limited access to technology (Becker 1987, U.S. Congress Office of Technology Assessment 1989), there have been few opportunities in education to observe this stage and the instructional and learning changes that follow.

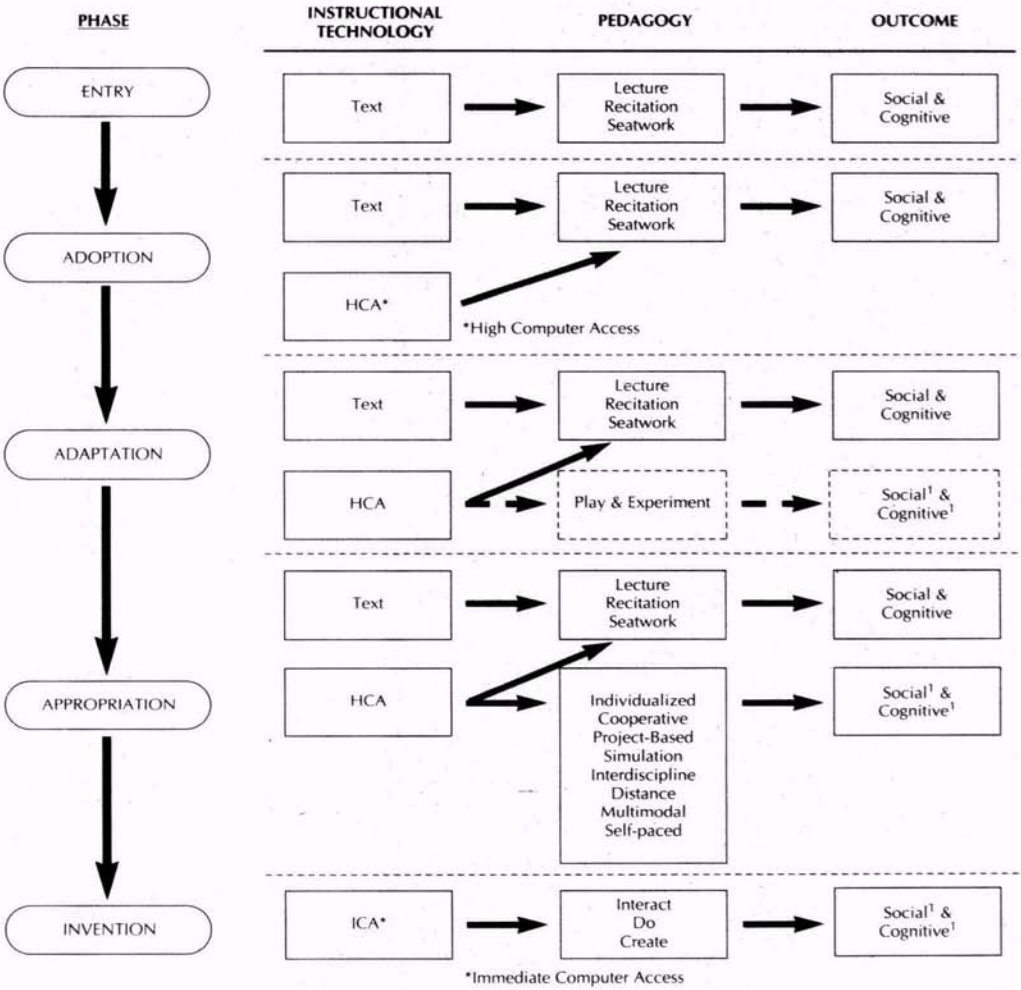
The importance of appropriation for the evolution of instruction can be seen in an instance where a teacher overcame a technical issue that prevented his software from running efficiently over a network. Buoyed by his vision of an exciting instructional unit, he overcame the problem even after a representative of the software company discouraged the idea:

> I was so excited after the first day, I thought it was too good to be true. The students were using the software to make a publication in a 40-minute class period using the network. . . . Now we can simulate a newspaper company. Eventually, students will work in groups, each with their own task, some for art, business graphs, articles, and the editing group. (SL, 263, 3/28/88)

The point is that this teacher's technical intervention opened a path to a new instructional strategy that would engage his students in a highly collaborative and creative activity. As teachers reached this stage independently of each other, their roles began to shift noticeably, and new instructional patterns emerged. Team teaching, interdisciplinary project-based instruction, and individually paced instruction became more and more common at all of the sites. To accommodate more ambitious class projects, teachers even altered the foundation of the traditional school day: the master schedule.

At both elementary and secondary schools, this type of teamed, project-

Fig. 1. Instructional Evolution in Technology-Intensive Classrooms



[1] = These outcomes are of a different order than the other outcomes.
- - - = These behaviors are emerging and less dominant than those contained in solid boxes.

based learning activity opened up opportunities for teachers to step back and observe the results of their own pedagogic shifts. What they saw was their students' highly evolved skill with technology, ability to learn on their own, and movement away from competitive work patterns toward collaborative ones. One teacher reflected:

> It's amazing to me how much these kids are learning. . . . Kids are doing things that are not assigned. The excitement is that they are motivated, seeing the power of the things which they are learning how to use, creating for themselves solutions to problems for other things. (AT, 39, 10/3/88)

Others noted changes, too. Phelan (1989), an independent observer studying one of the elementary sites, commented on changes in communication patterns and the extent of collaborative work among even the very young students.

> The interactions of children at computers were different. Specifically, the students talked to each other more, they frequently asked for assistance from their neighbors, they were quick to interrupt their own

work to help someone else, and they displayed tremendous curiosity about what others were doing (p. 6).

And a district technology supervisor at one of the schools, observing the extent of peer interaction in the ACOT classroom, noted that by allowing students to teach each other, teachers' roles were changing as well.

The students really enjoy these group activities and, as we all know, learn more since they are actively rather than passively participating in the learning experience. Our teachers are learning to be facilitators rather than the total dispensers of knowledge. Everyone benefits. (WL, 186, 1/29/88)

Again, the critical event that triggered this most dramatic change at the sites is the personal appropriation of the technology tools by individual students and teachers. As noted, the first cadre of ACOT teachers and students acquired this level of competence after more than a year with the project. Importantly, many in the second cadre of teachers accelerated through the evolution during their first year with the project. We think the explanation lies in their ready access to teachers and students—local experts—who had already appropriated the technology.

The most important change in this phase was an increasing tendency of ACOT's teachers to reflect on teaching, to question old patterns, and to speculate about the causes behind changes they were seeing in their students. At the beginning of her third year with the project, one of the project's high school teachers recorded the following:

Being on hall duty this year, I have a chance to hear how, in class after class, the teachers' voices drone on and on and on. There is very little chance for the student to become an active participant. In today's schools there is little chance for the individual teacher to actually change the curriculum, but we can make the way we deliver the curriculum very different. And that's where the technology comes into play: to make it more interactive, to encourage collaborative learning, to encourage exploration. (AT, 1378, 10/11/88)

Invention

The final stage in this model of instructional evolution is really a placeholder for further development by ACOT's teachers and for the new learning environments that they will create. Entry, Adoption, Adaptation, and Appropriation can be viewed as stages that build a readiness for purposeful change. In the earliest stages, ACOT teachers demonstrated little penchant for significant change and, in fact, were using their technological resources to replicate traditional instructional and learning activities. During Appropriation, however, they seemed to gain a great deal of perspective on just how profoundly they could alter the experience of learning for their students. Individuals' movement to Invention seemed coupled with their newfound interest in, and ability to question, the very foundations of their craft. One teacher illustrated this point when she said:

As you work into using the computer in the classroom, you start questioning everything you have done in the past and wonder how you can adapt it to the computer. Then, you start questioning the whole concept of what you originally did. (AT, 5857, 12/8/88)

Today, the staff of ACOT's classrooms are more disposed to view learning as an active, creative, and socially interactive process than they were when they entered the program. Knowledge is now held more as something children must construct and less like something that can be transferred intact. The nature of these teachers' classrooms, the permissions they grant their students, and their own instructional behaviors demonstrate this shift in action. Figure 1 summarizes the process.

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Creating the Conditions for Change

I guess I have to realize that what I am doing is learning how to undo my thinking. (AT, 163–2, 9/28/89)

This reflection by one of ACOT's teachers aptly introduces the realization that movement from Adoption to Invention is not an easy passage. Most teachers entering the program believed that technology would make their jobs easier and more efficient. Most never dreamed they would alter their instructional approaches or broaden their perspectives about what children should and should not, could and could not, accomplish in their classrooms. The direction of their change was toward child-centered rather than curriculum-centered instruction; toward collaborative tasks rather than individual tasks; toward active rather than passive learning. Each of these dimensions brought deeply held beliefs about *real schools*[4] into conflict with emergent awarenesses about instruction and learning.

In many instances staff members' inner struggles were compounded by the inflexibility of the contexts in which they worked. Damarin and Bohren's (1988) study of the project's first year at one of the sites puzzled over the persistence of traditional instructional forms and documented how district and state mandates and expectations actually discouraged teachers' progress.

The teachers had long experience and finely tuned methods of working within constraints and maximizing their effectiveness in that context; they had little incentive or direction for making changes which might jeopardize . . . performance on existing criteria. . . . They did not seek to create new approaches to instructional excellence.

Both personal beliefs and contextual constraints, then, can combine to inhibit progress even when change goals are clearly articulated. The point gains bold relief in a program where teachers are personally dedicated to

the investigation of the potential of modern technology but are held in check by personal and institutional habits that characterize 19th century instruction.

From our experience, two conditions seem essential in educational programs set on reform.

- Teachers must be given an opportunity to reflect on their own beliefs about learning and instruction and to develop a sense of the consequences of alternative belief systems.
- Administrators must be willing to implement structural or programmatic shifts in the environment, for teachers who are instructionally evolving.

Further, arguing that change is evolutionary, we suggest an incremental approach to implementation and a progressive shift in the type of support for teachers passing through Adoption, Adaptation, and Appropriation. In the instance of integrating computer-based technology into K-12 classrooms when fundamental instructional change is the goal, we believe that the recommendations listed in Figure 2 seem prudent to speed and ease the transformation.

Note that the nature of the recommended support for teachers in this process changes as they move from phase to phase. In the early stages of implementation, teachers' needs center around their concerns over the technology itself—computers, disk drives, software, and so on—and technical training is a key ingredient to successful adoption. But as evolution proceeds, teachers increasingly need opportunities to think about instruction and learning; to confront their actions and examine their motives; to bring their beliefs to the surface; and to critically reflect on the consequences of their choices, decisions, and actions. They need opportunities for ongoing dialogue about their experiences and for continuous development of their abilities to imagine and

Fig. 2. Support for Instructional Evolution in Technology-Intensive Environments

PHASE	EXPECTATION	SUPPORT
Entry	• Identification of volunteer team • Installation of critical mass of technology to make it a constant feature of the classroom	• Provide advance planning time to develop shared vision • Provide daily team planning time as permanent feature of schedule • Excuse staff from as many district requirements as possible • Create opportunities for staff to share experiences with nonparticipant colleagues
Adoption	• Maintenance of established instructional patterns and course of study • Use of word processors for writing • Use of CAI software for drill and practice of basic skills	• Provide nuts-and-bolts technical support to develop teachers' confidence and ability to maintain hardware and facilitate children's use • Provide CAI and word-processor software training
Adaptation	• Smooth integration of word processing and CAI software into existing instructional program, resulting in increased teacher and student productivity • Modifications in course of study to take advantage of time opened by increase in productivity	• Develop flexible schedule to permit peer observation and team teaching • Introduce and discuss alternative pedagogies • Train staff in use of tool software: spreadsheets, databases, graphics, HyperCard, communications • Introduce videodisk and scanner technology
Appropriation	• Experimentation with interdisciplinary project-based instruction • Experimentation with team teaching • Experimentation with student grouping • Experimentation with scheduling	• Routinize peer observations and group discussions of events and consequences • Re-examine project mission and goals • Build awareness of alternative student assessment strategies, that is, performance-based assessment and portfolio assessment strategies • Encourage and support conference attendance and teacher presentations
Invention	• Implementation of integrated curriculum • Balanced and strategic use of direct teaching and project-based teaching • Integration of alternative modes of student assessment	• Encourage collaboration between teachers and researchers • Encourage teachers to write about and publish their experiences • Explore telecommunications as way to keep teachers in contact with innovators outside of district • Create opportunities for teachers to mentor other teachers

discover more powerful learning experiences for their students.

In sum, instructional change can only proceed with a corresponding change in beliefs about instruction and learning. Teachers' beliefs may be best modified while they are in the thick of change, taking risks and facing uncertainty. Teachers bold enough to participate in these efforts require and deserve modifications in their organizations' structure: alterations that permit and encourage peer observation, dialogue, and reflection. Most important, they must have a way to gain continued assurance that their struggles are worthwhile.

Bringing significant change to the way we do schooling is a complex proposition fraught with setbacks. The experience of the ACOT project demonstrates the value of taking a long-term perspective on change and making the necessary personal and organizational commitments to bring about that change. To the observer, hoping for quick evidence of the efficacy of innovations, computers or otherwise, the process can only be frustrating and inconclusive. To those dedicated enough to make the commitment, the process can be deeply rewarding. □

[1]For more information about data, research procedures, or the ACOT project, write to Apple Classrooms of Tomorrow, 20525 Mariani Ave., MS: 76–2A, Cupertino, CA 95014.

[2]See *Teaching in High-Tech Environments: Classroom Management Revisited* by Sandholtz et al. 1990.

[3]Project data is referenced by type: AT = audiotape teacher journal; WL = weekly report from sites; and SL= electronic memo sent from site to Apple. The data type is followed by the item's unique identifying number and then the date the item was written or tape recorded.

[4]A term aptly applied by Metz (1988) to the traditional concept of schooling predominantly held by society.

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