APPLE CLASSROOMS OF TOMORROW

# Research

**The Relationship Between Technological Innovation and Collegial Interaction**


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**ACOT Report #13**

*Apple Classrooms of Tomorrow (ACOT)℠ is a collaboration—initiated in 1985—among public schools, universities, research agencies, and Apple Computer, Inc. In ACOT classrooms, students and teachers have immediate access to a wide range of technologies, including computers, videodisc players, video cameras, scanners, CD-ROM drives, modems, and online communications services. In addition, students can use an assortment of software programs and tools, including word processors, databases, spreadsheets, and graphics packages. In ACOT classrooms, technology is viewed as a tool for learning and a medium for thinking, collaborating, and communicating.*

*ACOT's research has demonstrated that the introduction of technology to classrooms can significantly increase the potential for learning, especially when it is used to support collaboration, information access, and the expression and representation of students' thoughts and ideas.*

*Realizing this opportunity for all students, however, requires a broadly conceived approach to educational change that integrates new technologies and curricula with new ideas about learning and teaching, as well as with authentic forms of assessment.*

*Constant access to technology influences the frequency, form and substance of teachers' collegial interaction.*

*This study examines how teachers already enjoying collegial interaction are able to implement new technology and instructional strategies more quickly.*

*The adoption of innovation and the creation of a collaborative environment are complementary conditions for change.*

# The Study

## Preface

Begun in 1985, Apple Classrooms of Tomorrow (ACOT)℠ is a research and development collaboration among public schools, universities, research agencies and Apple Computer, Inc. ACOT explores, develops and demonstrates the powerful uses of technologies in teaching and learning. In all ACOT endeavors, instruction and assessment are as integral to learning as technology.

Supporting a constructivist approach to learning, technology is used as knowledge-building tools. As students collaborate, create media-rich compositions and use simulations and models, researchers investigate four aspects of learning: tasks, interactions, situations and tools. The research is formative. The findings guide ACOT staff and teachers as they refine their approach to learning, teaching and professional development. ACOT teachers and students often use the most advanced technologies available, including experimental technologies, to help us envision the future and improve the educational process.

ACOT views technology as a necessary and catalytic part of the effort required to fundamental restructure America's education system. We hope that by sharing our results with parents, educators, policy makers, and technology developers the lessons of ACOT will contribute to the advancement of educational reform.

## Abstract

This report examines the process by which an immediate-access-to-technology environment influences the frequency, form and substance of collegial interaction among classroom teachers. The study covered a five year period, utilizing data from 32 elementary and secondary teachers in five schools located in four different states. Over time, teachers' interactions moved from informal, infrequent exchanges to structured technical assistance to formalized team teaching. However, the process of building collaboration was lengthy, involved overcoming numerous obstacles, and varied for elementary and secondary teachers.

## Introduction

> *Technology clearly has the potential to vastly transform relationships between teachers and students and even what schools look like. However, the history of education reform provides scant evidence that such a transformation will occur simply because the technology exists. Schools have demonstrated an unyielding resistance to change over the decades. Reforms that are adopted tend to be those that readily fit existing organizational structures and practices.*
> *(David, 1990, p. 76)*

The effective use of technology in elementary and secondary school classrooms is often a slow process marked by a variety of obstacles, and one of the key obstacles is a condition common in many schools: teacher isolation.

*Previous research indicates teacher interaction in effective schools tends to be frequent, task focused and widespread.*

*For teaming to work, teachers need long-term assistance.*

*Teacher change evolves over time only after technology proves to help them in their teaching.*

*Thirty-two ACOT elementary and secondary teachers were studied for five years. Computers were used as tools and didn't replace other materials or technologies.*

This report examines how technology-rich environments, like the Apple Classrooms of Tomorrow, influence and encourage collegial interaction among teachers, and how teachers who already enjoy a high level of interaction are able to implement new technology and instructional strategies more quickly. The adoption of innovation and the creation of a collaborative environment are complementary conditions for change, and constructive change occurs most quickly in environments where these two conditions are operating simultaneously.

The nationwide movement toward restructuring schools acknowledges that innovations introduced at only one level of a system are not likely to succeed, and that lasting change will not occur simply by giving teachers the latest technological tools. Teachers must be provided with on-going support which is available only if the larger system in which they are working changes as well. The reduction of teacher isolation is an important part of that change.

## Research on Collegial Interaction and Innovation

Researchers have identified regular opportunities for interaction with colleagues as an important feature of a successful work environment (Purkey & Smith, 1983). Teacher inter-action in effective schools tends to be frequent, task focused, and widespread (Little 1982; Rutter, Maughanm Mortimore & Ouston, 1979). However, in many schools, opportunities for interaction are limited and communication tends to be informal and infrequent, even though teachers believe their teaching could be improved by working with colleagues (Corcoran, 1988).

Attempts to increase teacher interaction typically involve creating formalized team teaching arrangements, sometimes across grade levels and disciplines. These changes in school structures increase the incidence of collaborative teaching and the overall amount of task-related communication (Charters, 1980). However, teachers are reluctant to sustain team allegiance over time (Charters, 1980) and need long-term assistance in order to make teaming work effectively and efficiently (Rutherford, 1981).

Innovation can be extremely difficult to institutionalize because homeostatic forces in schools are more powerful than innovative forces (Joyce, 1982). Teachers may also resist change because the innovation comes from policy makers or non-teaching experts (Butt, 1984; Common, 1983). Serious commitment to innovation occurs only after teachers see that it really does assist them in teaching their students (Gersten & Guskey, 1985). However, this type of change does not occur quickly, but evolves over a period of time (Dwyer, Ringstaff & Sandholtz, 1990; Gersten & Guskey, 1985). In addition to identifying time as a critical resource, researchers point to the importance of a supportive organizational environment and collegial sharing in moving teachers toward the adoption of innovations (Educational Technology Center, 1985; Joyce, 1982; Henson, 1987).

This paper links these two areas of research by examining the relationship between collegial interaction and technological innovation. During the five years this of study, the symbiotic relationship between innovation and teacher collaboration became increasingly apparent. As innovation was introduced and adopted, teachers interactions moved from informal infrequent exchanges to structured technical assistance and finally to team teaching.

*Teachers used the media that best supported the learning goal.*

*Annually at each site, new technology was available and project goals changed somewhat.*

*Because not all teachers were involved all five years of the study, we viewed data collectively, documenting overall shifts.*

*The relationship between teacher interaction and instructional activities are investigated.*

## The Study

This qualitative study utilizes data from 32 elementary and secondary teachers in five schools located in four different states. The ACOT classrooms represent the diverse populations and conditions found in contemporary public schooling. Each of these sites began with one classroom in the fall of 1986, adding classrooms, staff, and students in subsequent years.

| Site | Grades | Teachers | Students | Community/Socio-Economic Status |
|---|---|---|---|---|
| 1 | 1–4 | 8 | 180 | Suburban/High Income |
| 2 | 5–6 | 7 | 180 | Rural/Middle Income |
| 3 | 4–6 | 4 | 90 | Inner-City/Low Income |
| 4 | 4 & Sp. Ed. | 4 | 80 | Suburban-Urban/Low-Middle Income |
| 5 | 9–12 | 9 | 120 | Urban/Low-Middle Income |

**Table 1: The status of each ACOT study site in the spring of 1990.**

The elementary classes are equipped with Apple IIe, IIGS, and Macintosh® computers. The high school is an all Macintosh installation. In addition to the computers, classrooms are equipped with printers, scanners, laser disks and videotape players, modems, CD ROM drives, and hundreds of software titles.

The technology is used as a tool to support learning across the curriculum. No attempt is made to replace existing instructional technologies with computers. 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, as well as computers. The operating principle is to use the media that best supports the learning goal.

The ACOT project provides a variety of supports for teachers with the goals of increasing teachers' knowledge of theories on teaching and learning, expanding their technical expertise, and encouraging them to share acquired knowledge and skills. This support ranges from holding conferences and training workshops to providing technical equipment and professional release time. In addition, all sites are linked by a telecommunications network, called AppleLink,® that permits teachers to communicate with teachers at other sites as well as the Apple ACOT staff.

## Data Collection

The sources of data for this study, covering from October 1985 through June 1990, include weekly reports sent via electronic mail; correspondence between sites, and bimonthly audio tapes on which teachers reflected about their experiences. Although this study does not include observational data, systematic observations by independent researchers support the self-report data reported in this investigation (Gearhart, Herman, Baker, Novak, & Whittaker, 1990; Tierney, 1988).

*Five stages of instructional evolution are identified as Entry; Adoption, Adaptation, Appropriation, and Invention.*

*In the entry stage, teachers had little or no computer experience and didn't want to change instruction.*

*At first, teachers used technology to replicate traditional learning activities.*

*Early teacher interaction was informal for emotional support.*

The data have been divided into two databases, which together have nearly 20,000 entries. A relational database, *Double Helix,* allows the data to be organized in a number of ways (e.g., by teacher, by school site, by dates, by thematic categories). Because the project spans five years, some of the teachers represented in the database were not involved for this entire time. Thus, simply examining individual teachers' data in terms of chronological dates could be misleading. At some sites, teachers worked with the same group of teachers and students over several years, while at other schools the key players changed more frequently. Each year of the project brought about additional changes in site organization, in the types of available equipment, and in project goals. Rather than examining change within individual teachers over time, we viewed the data collectively, documenting general trends related to collegial interaction during the evolution of the project. (For a thorough discussion of the data collection strategies and methodology used in this study, please see Dwyer, Ringstaff, Sandholtz, Keirns, & Grant, 1990).

## Results

This report deals primarily with the collegial interaction among teachers rather than instructional changes. However, the two areas are closely related. Figure 1 displays the new patterns of teaching and learning that emerged over time. This progression can be viewed as an evolutionary process similar to other models of educational change (e.g., Berman & McLaughlin, 1976; Giacquinta, 1973; Gross & Herriott, 1979). The five stages of instructional evolution in the ACOT classrooms include: Entry, Adoption, Adaptation, Appropriation, and Invention. In this model, text-based curriculum delivered in a lecture-recitation-seat work mode is first strengthened through the use of technology and then gradually replaced by far more dynamic learning experiences for the students. (For a more thorough treatment of the changes in instructional practices, see Dwyer, Ringstaff, & Sandholtz, 1990).

*Using technology increased interactions as teachers sought technical help from each other.*

*Sharing experiences through electronic mail provided other opportunities for teacher interaction.*

*Teacher interactions started shifting from offering technical help to sharing instruction strategies.*

*Collaboration on instruction emerged when teachers ventured beyond using the computer for drill-and-practice.*

| Phase | Instructional Technology | Pedagogy | Outcome |
|---|---|---|---|
| **Entry** | Text | Lecture<br>Recitation<br>Seatwork | Social & Cognitive |
| **Adoption** | Text | Lecture<br>Recitation<br>Seatwork | Social & Cognitive |
| | High Computer Access | | |
| **Adaptation** | Text | Lecture<br>Recitation<br>Seatwork | Social & Cognitive |
| | High Computer Access | Play & Experiment | Social & Cognitive |
| **Appropriation** | Text | Lecture<br>Recitation<br>Seatwork | Social & Cognitive |
| | High Computer Access | Individualized<br>Cooperative<br>Project-based<br>Simulation<br>Interdiscipline<br>Distance<br>Multimodal<br>Self-paced | Social & Cognitive |
| **Invention** | Immediate Computer Access | Interact<br>Do<br>Create | Social & Cognitive |

**Figure 1: Instructional Evolution in Technology-Intensive Classrooms**

| Instructional Phase | Collegial Interaction |
|---|---|
| **Entry** | ■ Emotional Support |
| **Adoption** | ■ Emotional Support<br>■ Technical Assistance |
| **Adaptation** | ■ Emotional Support<br>■ Technical Assistance<br>■ Instructional Sharing |
| **Appropriation** | ■ Emotional Support<br>■ Technical Assistance<br>■ Instructional Sharing<br>■ Collaboration |

**Figure 2: The relationship between Instructional Evolution and Collegial Interaction of Teachers**

*Feeling comfortable with increased interaction, teachers started to observe each other's teaching methods.*

*When teachers began using technology effortlessly as a tool, their roles shifted noticeably.*

*New instructional patterns emerged.*

*Teachers began to reflect and question old patterns.*

Figure 2 depicts the relationship between the instructional evolution and the collegial interaction of teachers. Corresponding to the gradual instructional shifts are changes in the frequency and form of collegial interaction. At the beginning of the project, interaction was infrequent and focused on emotional support. Over time, teachers' interactions shifted to include technical assistance, instructional sharing, and, eventually, formalized collaboration.

| Categories of Collegial Interaction | |
|---|---|
| Emotional Support | Sharing frustrations and successes, providing encouragement |
| Technical Assistance | Managing equipment, using equipment, locating software, using software, dealing with technical problems |
| Instructional Sharing | Discussing instructional strategies, sharing ideas, observing instruction |
| Collaboration | Joint planning, team teaching, developing new methods, interdisciplinary teaching |

**Table 2: Summarizes the main differences among the categories of collegial interaction.**

The following sections briefly summarize the changes in instructional practices during each stage, and describe the accompanying changes in collegial interaction among the teachers.

## Entry/Emotional Support

### Instructional Activities

In the entry stage of the project, ACOT teachers had little or no experience with computer technology and demonstrated little inclination to significantly change their instruction. The first weeks of the project involved transforming the physical environment of the classroom—unpacking boxes, running extension cords, untangling cables, inserting cards, formatting disks, checking out home systems. Once instruction began, experienced teachers faced typical first-year-teacher problems such as discipline, resource management, and personal frustration. (See Sandholtz, Ringstaff, & Dwyer, 1990, for a full discussion of classroom management issues.) Teachers began using their technological resources, but simply to replicate traditional instructional and learning activities.

### Teacher Interaction

During these first few weeks, teachers had little time for collegial interaction even though the supports for such interaction, such as professional release time, training workshops, and a telecommunications network between sites, were available. As the year progressed, the frequency of interaction among teachers increased, but exchanges remained informal, and focused on emotional support, as teachers shared their frustrations and successes.

*The most interaction occurred at schools where team teaching was formalized.*

*Team teaching created friction because of differences in personalities, technology know-how and teaching styles, including grading and discipline.*

*While teachers agreed in principle during planning their differences became obvious when they taught together.*

## Adoption/Technical Assistance

### Instructional Activities

As teachers moved into the adoption stage, their concerns began to shift from connecting the computers to using them. Teachers adopted the new electronic technology to support established text-based drill-and-practice instruction. Students continued to receive steady diets of whole-group lectures, recitation, and individualized seat work. Although the physical environment had changed, the instructional strategies remained the same, just using different tools.

### Teacher Interaction

As teachers began to utilize the new technology in their instruction, their interactions increased but revolved around providing technical assistance. Teachers in project classrooms, both within and across sites, shared strategies in areas such as managing the equipment and locating relevant software.

Formal meetings among the project teachers at each site provided opportunities for sharing experiences and ideas. Teachers also began using the AppleLink telecommunications network to submit weekly reports and to communicate with teachers at other sites. Those with less computer expertise approached their colleagues for assistance and capitalized on opportunities to learn from each other.

> *You've cleared up a lot of questions for me. I didn't know I could send anything but Microsoft Word over AppleLink...I'm still pretty new at this.* (SL, 11259, 10/19/88)[1]

> *I found out that the kids had put their database information together, and I saw the same entries in my combined database. Unfortunately, I didn't know which student did what entries because I just dumped all of the files into my database. [Another teacher] told me how I can put the student's name in a column and then know what data belongs to what student.* (AT, 2746, 10/30/87)

Technical assistance among the teachers helped them to adopt the new technology and to begin to utilize it in their instruction, even if simply as a support for their previous instructional style. Conversely, because the teachers began to accept the innovation, they had questions and concerns which compelled them to seek assistance from their colleagues.

## Adaptation/Instructional Sharing

### Instructional Activities

The adaptation phase brought changes in the efficiency of the instructional process. Students' productivity increased in a variety of areas. For example, students completed a self-paced math curriculum in significantly less time than usual, allowing teachers to engage students in higher-order learning objectives and problem solving. Many students also completed written assignments more quickly, with greater fluency, and willingly reworked their papers. According to one study, students not only produced more written work but the quality improved as a result of computer accessibility (Hiebert, 1987).

*Some enjoyed collaboration, while others were reluctant to lose autonomy.*

*Secondary teachers had a harder time making the transition to team teaching than elementary teachers because of a stronger sense of ownership of subject matter.*

### Teacher Interaction

During this phase, teacher interactions began to shift from offering technical assistance to sharing instructional strategies. Collaboration on instructional topics emerged when teachers ventured beyond text-based drill-and-practice, and experimentation with new applications motivated them to share their endeavors with other teachers and sites.

> *The kids are transposing their music into Logowriter language using sub and super procedures. We then got into doing shapes which resulted in animation. We're using Turtle Graphics for graphics and animation, also including sound effects. The kids love it; they worked solidly at it. It was amazing what they all came up with; they work in cooperative groups so no one gets left out. I'd like to share this with [another] site that has a sixth grade. I'd like to get more communication between the two.* (AT, 3432, 2/15/88)

Teachers continued to communicate directly to other ACOT colleagues through the network, and offered unsolicited assistance in response to weekly reports published on the network. At several sites, teachers decided that the benefits of cross-site communication should be extended to the students as well, and they arranged for specific days when the students in their classes could "chat" using telecommunications. Others set up formalized "AppleLink pals" arrangements that lasted throughout the school year. Students not only sent electronic mail, but also videotapes so the AppleLink pals could see each other in the classroom setting. One teacher arranged for students to correspond with students in Sweden, leading teachers at other sites to request similar opportunities for their classes.

As teachers began to feel comfortable with increased interaction among both students and teachers, they started to observe each other's teaching methods, as opposed to simply discussing their instructional ideas. Previously, very few teachers had observed other classrooms, and when they did, the primary purpose was to learn more about the technology rather than to garner instructional ideas.

> *I realized after this conference that I need to share with the other math teachers what we are doing with the graphic calculator and to extend the program to more than the ACOT classes.* (AT, 5863, 12/11/88)

## Appropriation/Collaboration

Instructional Activities As teachers eventually reached the Appropriation phase—the point at which an individual comes to understand technology and use it effortlessly as a tool to accomplish real work—their roles began to shift noticeably and new instructional patterns emerged. Team teaching, interdisciplinary project-based instruction, and individually-paced instruction became more common at all of the sites. To accommodate more ambitious class projects, some teachers even altered the master schedule. Perhaps most important in this phase was an increasing tendency among ACOT teachers to reflect on teaching, to question old patterns, and to speculate about the causes behind changes they were seeing in their students.

*Obstacles were overcome by arranging time to do cooperative planning and locating offices near classrooms so teachers had more contact with each other.*

Teacher Interaction Along with the new instructional patterns came increased collaboration on instructional topics. The greatest degree of interaction occurred at sites that decided to formalize team teaching arrangements, a decision which was made by the teachers themselves rather than being imposed by district or school administrators. Given the differences at each site, team teaching configurations varied in the number of team members, student groupings, interdisciplinary approaches, and grade level assignments. As the benefits of team teaching became more apparent, ACOT staff encouraged this arrangement at all of the sites.

## Team Teaching: Obstacles and Solutions

*Teachers learned how to effectively prioritize, set goals and create lessons so colleagues understood what needed to be done.*

In the beginning, teachers frequently viewed team teaching as a great deal of additional work for relatively little gain. Some of the primary obstacles included differences in personalities, technical knowledge, teaching styles, grading policies, and approaches to discipline. For some teams, personality differences created only minor problems as the teachers came to know each other better. However, other teams found that personality problems carried over from year to year and became extremely divisive.

> *[One teacher] is not an easy person to talk with—he is always sure what he is doing is right. I'm not really sure what my role is sometimes. . . so we need to work this out. I wonder if the other sites have these personality problems?* (AT, 7127, 9/27/88)

*Successful teams resolved personality and teaching style differences.*

> *I must say that the team teaching approach seems to create some friction; jealousies seem to arise when one teacher thinks another teacher is doing something that makes him or her look good and the other teacher look bad. I think it is unfortunate. We should dismiss our personalities and subjective feelings about things and get on with teaching. If we let students and their learning come first, everything else would fall into place.* (AT, 7539, 12/13/88)

Differences in technical knowledge among teachers also led to conflicts and feelings of competition.

> *As things become more competitive in terms of the use of equipment and software, and as some of us have become more competent, some of those who have been the "kings" have been challenged and are reacting in unfortunate ways which is creating some tensions.* (AT, 610, 11/17/89)

Teachers found it easy to agree in principle as they planned collaborations. However, when they began teaching together, differences became more obvious. One such difference was teaching style. One team teacher believed in allowing students enough time to finish an assignment, while the other stuck to a pre-determined time schedule. Another team discovered they held divergent views about the structure of mathematics and their approaches to answering students' questions.

> *I'm also trying to impress on him that math is not just the calculating in the problems he gives. The thinking process of setting it up is math, too.* (AT, 412, 4/27/90)

> *He answered a lot of questions for the students. The only problem is he'll sit down and do it, not tell them how to do it.* (AT, 458, 5/16/90)

*Varying teaching approaches could be complementary and beneficial to student learning.*

Like many teachers, ACOT teachers felt strongly about their teaching philosophies and styles. Consequently, they were resistant to changing their own style and were hesitant to impose their technique on other teachers. While some teachers enjoyed working closely with colleagues, others were reluctant to relinquish their autonomy.

> *Moving from an independent teacher to a team teacher without much preparation contributed a great deal to my feelings of aimlessness and lack of control. It worked but I was uncomfortable with it. I feel better about being in charge of teaching and the curriculum.* (AT, 6052, 12/11/86)

*Team teaching gave more flexibility in grouping students and made it easier to spot students' misunderstandings.*

Some found they were defining their team teaching roles differently. One teacher felt it was okay to work on individual projects or to leave the room when the other person was "teaching." The other teacher felt a team approach involved more than a simple division of responsibilities.

> *Those opportunities to fit things together don't come up unless you're right there in the classroom paying attention. He feels if I'm teaching there's no need for him to be there.* (AT, 220, 10/27/89)

*The team approach allowed one teacher to be absent without throwing instruction off schedule.*

Inevitable differences in discipline and grading policies created initial obstacles to team teaching. Some teachers believed in making computerized summaries of scores and grades available to students while others felt such a policy created competition and emphasized grades over substantive learning. Teachers also expressed frustration over varying approaches to classroom management and discipline.

> *I don't believe that her standards of discipline were the same as mine. She was very patient with the children and didn't use discipline techniques. Their behavior tended to get out of hand before she brought them back, which frustrated me.* (AT, 1392, 6/13/90)

Elementary teachers tended to exhibit less ownership over subject matter and frequently had prior experience working together. At the secondary school level, teams had to break through the boundaries of established subject matter, and overcome the independent orientation of the teachers. Team teaching also requires planning time during the school day, but elementary school teachers typically do not have a daily preparation period, making it difficult to set up a common planning time. In addition, a school's physical layout sometimes hinders the opportunity for spontaneous interaction and cooperative planning. While some teams were able to overcome the obstacles inherent in team teaching, others eventually reduced the amount of team teaching or dropped the arrangement altogether.

> *I really feel better about being solely in charge of my own classes. Now when I come in at off hours to work I know that I'm working for myself. You just don't feel the same when it's a team. I need to feel that student performance results directly from my teaching.* (AT, 6057, 12/11/86)

*Cross disciplinary teaching helped students understand how subjects are integrated in the real world.*

*Students taught by teams could handle more advanced material than students in traditional classes.*

*The ACOT team teaching and interdisciplinary approach became a model for both schools and districts.*

The sites that continued with team teaching found various ways to overcome the obstacles. Proximity between classrooms and offices facilitated greater contact among teachers. Cooperative planning was facilitated by allowing teachers regularly scheduled time during the school day for meetings.

> *The fact that we can sit down, coordinate lessons, and get a chance to talk is a very important thing to what it is we are trying to do out here. I need to campaign that all teachers should have that time to coordinate with a team teacher and how important that is to the learning process.* (AT, 1143, 11/9/89)

Teachers also became more proficient at using available time for planning. They learned how to prioritize, set goals and block out lessons so both team members understood what needed to be done. Having the time to plan eased tensions.

Successful teams also resolved personality differences and reached consensus about individual teaching styles, discipline policies, and the definition of team teaching. Although problems reappeared periodically, these teams managed to reduce competition, and draw upon one another's areas of expertise and specialized knowledge. Those teachers who continued with team teaching began to reap the rewards of collaboration. They developed a strong camaraderie and gleaned support from one another.

> *It is so nice, when you are having a stressful day, to have someone thinking about your needs. In a normal teaching situation, no one would even know what your needs are.* (AT, 100, 8/29/89)

Teachers discovered ways to connect and improve upon activities and strategies they had tried individually, and found that their varying approaches could be complementary, and benefit rather than hinder student learning.

> *[The other team member] was telling me that she was really impressed with the different way I covered the use of the trig functions today and how well that complemented what she had done. She thought the kids would come away with a better understanding.* (AT, 1139, 11/7/89)

The team approach also allowed more flexibility in grouping students. For example, one teacher could take small groups to the biology lab while the other remained in the classroom, decreasing the amount of lab equipment needed and making it easier to monitor students and answer questions. Other teachers tried a similar strategy with the chemistry class. Within the classroom, teachers could work with smaller groups requiring help in particular areas, and vary their teaching assignments for different groups.

> *I am pleased with the way Algebra 1 has turned out. We have the students working in two groups, and we switched groups this week. She was getting frustrated with the group she had that just didn't follow through. So it was a good idea just to shift to keep from getting burned out on one group. This wouldn't have happened in a regular classroom.* (AT, 7771, 2/28/89)

*Using technology drove teachers to be more collegial and share instruction.*

The teachers also reported that teaming increased what teachers were able to accomplish during a class period and made it easier to spot patterns of student misunderstanding.

> *We had two pages of requests for individual attention on our sign-up list. That's 60 questions out of a class of 30 kids. There is no way you could do that in a period with one teacher.* (AT, 3659, 11/4/88)

When a team member was absent, the instructional program continued on schedule—unlike what occurred previously with substitute teachers. Teachers felt more comfortable about attending professional conferences scheduled during the school year.

*Teachers who already enjoyed a high level of collegiality embraced innovation in technology and instruction more quickly.*

### Collaboration and Interdisciplinary Teaching

The team teaching arrangement allowed teachers at all grade levels to develop and implement interdisciplinary curriculum across a variety of subject areas such as math/science, life skills/English, history/literature. Teachers also combined a number of subject areas into one class; for example, a class called "Strategies" included math computation, problem-solving, science, and health. Through cross-disciplinary teaching, students started to understand the integration among subject areas, instead of viewing them as separate, unrelated subjects.

*The view that team teaching is more demanding than beneficial changed.*

> *The students don't differentiate between math and science now. It is exciting to have an opportunity to work in an interdisciplinary way.* (AT, 240, 11/14/89)
>
> *In the course we are teaching—American literature and history together—the students are really putting the two together . . . It will help them learn two areas which in the past students thought were boring. Now they are thinking and asking questions about it.* (AT, 1, 10/7/88)

*Team teaching led to cross-disciplinary instruction benefitting students and teachers.*

Teachers discovered that their team-taught classes could handle more advanced material than students in traditional classes.

> *[One teacher] sees a great difference in the amount of understanding the ACOT students have as compared with the students in his two regular classes that do not have the luxury of the teaming approach with the mathematics teacher.* (WL, 10190, 12/12/86)

A math/science team found they were teaching concepts that other science teachers avoided because they believed the students couldn't do the math involved. The integration also helped the math/science teams in their goal of helping students to develop problem solving skills in mathematics rather than simply seeking solutions.

> *In the past, students have had a hard time determining which trig function to use to solve the triangle, no matter how much we go over it. Now they see it in math and physics classes.* (AT, 236, 11/8/89)

The teachers noted an increase in their own enthusiasm and knowledge as they became involved in interdisciplinary teaching. At the secondary level, the boundaries between subjects started to diminish, and teachers began to seek out instructional resources and opportunities in other subject areas.

> *Team teaching is interesting because I concentrate on math, but I try to think of the science applications of it. I look for more ideas and materials than I would as a solitary teacher.* (AT, 238, 11/10/89)

*Change happens fastest when innovation and collegial interaction happen simultaneously.*

*Significant change won't occur simply by giving teachers computers.*

*Innovations introduced at one level are likely to fail. Innovations must be systemwide and simultaneous.*

At one site, the team teaching and interdisciplinary approach developed by the project teachers became a model for classes throughout the school and district. A principal at another high school in the district, highly impressed with the approach, located funding to modify the model and develop curriculum that could be replicated in other urban schools—even those without access to technology.

## Summary and Implications

This study points out the symbiotic relationship between innovation and collegial interaction. The innovative, high-access-to-technology classrooms drove teachers to more collegial interaction and instructional sharing. But teachers who already enjoyed a high level of collegial interaction embraced technological innovation and implemented new instructional strategies more quickly.

The instructional changes among the teachers corresponded closely with changes in collegial interaction. In the entry stage of the project, the teachers demonstrated little penchant for significant instructional change, and their collegial interaction was infrequent and focused on emotional support. In the adoption stage, teachers used the technology to support traditional instructional and learning activities; collegial interaction increased but included primarily technical assistance. The adaptation phase brought changes in the efficiency of the instructional process, and the substance of their interactions included the sharing of instructional strategies. As teachers eventually reached the appropriation phase, their roles shifted and new instructional patterns emerged. Similarly, teachers engaged in greater collaboration about instructional topics. At many sites, the increased collaboration led to team teaching and interdisciplinary instruction.

At first, teachers viewed team teaching as more demanding than beneficial. But as sites continued with team teaching and found ways to overcome the inherent obstacles, the benefits began to emerge. Eventually, team teaching led to cross-disciplinary teaching which held additional advantages for both teachers and students.

**Advantages of team teaching**

- Shared responsibilities
- Increased camaraderie, enthusiasm and support
- Development of activities based on teacher strengths
- Development of new ideas and teaching methods
- Utilization of approaches that promote student understanding
- Increased individual help for students
- Increased flexibility in grouping students
- Increased amount accomplished during class period
- Greater ease in identifying student misunderstanding
- Continuity of instructional program when one teacher is absent
- Development of an interdisciplinary curriculum
- Greater student ability to handle more advanced material

**Table 3**

*The introduction of technology can be a catalyst for change.*

*Change is slow, so schools must take a long-term perspective.*

*Teachers won't commit to innovation until it makes a positive impact on their practice.*

This paper highlights four main issues relevant to practice and research. First, the adoption of innovation and the creation of a collaborative environment are complementary conditions for change. Individuals interested in school change need not focus only on one condition. Change occurs most quickly in environments where innovation and collegial interaction are operating simultaneously, each enhancing the other.

Second, in line with the beliefs of those attempting to restructure schools (David, 1990; David, Cohen, Honetschlager, & Traiman, 1990), our reflections on the ACOT experience support the idea that structural and programmatic shifts in the working environments of teachers who are adopting innovative technology are critical. The nationwide movement toward restructuring the entire school system—including the curriculum, the way students are taught, and the way schools are governed—seeks to attack the problem of change from multiple levels simultaneously. Unlike previous reform efforts, the reconstruction movement acknowledges that innovations introduced at only one level of the system are not likely to succeed.

Lasting, significant change will not occur simply by giving teachers the latest technological tools. Rather, teachers must be provided with on-going support which is available only if the larger system in which they are working changes as well. Organizational supports for ACOT teachers included training workshops, technical support, release time for conferences, extra time for joint planning and team teaching, a telecommunications network that allowed interaction across sites and with the ACOT project staff, and the opportunity for routine peer observations and group discussions. One site was even allowed by the school and district to alter the master schedule.

Third, not only can restructuring enhance the adoption and integration of technology—or any innovation, for that matter—but the introduction of technology to schools can act as a catalyst for change, thereby enhancing restructuring efforts.

In the case of ACOT, the introduction of technology had a direct impact on the way teachers worked with one another: there was more emotional support, more sharing of instructional ideas, and more collegial interaction because teachers sought each other out in their attempts to adapt to their innovative classrooms. Perhaps, in the scheme of things, this is a relatively small change, but the reduction of teacher isolation is an important part of restructuring.

Finally, the experience of the ACOT project demonstrates the value of taking a long-term perspective on change. Data from this five-year study illustrate that, even when classroom environments are drastically altered and teachers are willingly immersed in innovation, change is slow, and sometimes includes temporary regression. Unfortunately, agencies or organizations funding innovative programs often expect to see measurable progress or change within a short time. In line with other research on teacher change, the data suggest that teacher commitment to an innovation will not occur until they see a positive impact on their teaching. Moreover, those searching for a way to assess the impact of innovation should not expect to see a clear progression through stages. Problems of implementation and adoption may arise, disappear, and then reoccur as teachers and students adjust to the innovation.

## References


**Berman, P., & McLaughlin, M. W.** (1976) Implementation of educational innovation. *Educational Forum, 40(3),* 345–370.

**Butt, R.L.** (1984) Curriculum implementation, classroom change and professional development: The challenge for supervision. (Paper presented at the annual meeting of the Canadian Society for the Study of Education, Ontario, Canada, 1984.)

**Charters, W.** (1980) Formal organization and faculty communication: A study of the multi-unit elementary school. Center for Educational Policy and Management, Eugene, OR.

**Common, D.** (1983) Who should have the power to change schools: Teachers or policy makers? Education-Canada, 23(2), 40–45.

**Costello, R.** (1987) Improving student achievement by overcoming teacher isolation. *The Clearing House, 61(2),* 91–93.

**Cotton, K.** (1982) Effects of interdisciplinary team teaching. Research synthesis. Northwest Regional Educational Lab, Portland, OR.

**Corcoran, T.B.** (1988) Schoolwork: Perspectives on workplace reform in the public schools. (CRC 88-600) Center for Research on the Context of Secondary School Teaching, Stanford, CA.

**David, J. L.** (1990) Restructuring and Technology: Partners in Change. In K. Sheingold and M. Tucker (Eds.). *Restructuring for learning with technology.* Center for Technology in Education and the National Center on Education and the Economy, Rochester, NY.

**David, J.L., Cohen, M., Honetschlager, D., & Traiman, S.** (1990) State Actions to Restructure Schools: First Steps. National Governor's Association, Washington, D.C.

**Dwyer, D., Ringstaff, C., & Sandholtz, J.H.** (1990) The Evolution of Teachers' Instructional Beliefs and Practices in High-Access-to-Technology Classrooms. (Paper presented at the annual meeting of the American Educational Research Association, Boston, 1990.)

**Dwyer, D., Ringstaff, C., Sandholtz, J.H., Keirns, J., & Grant, W.** (unpublished) Desktop Social Science: Coming of Age. (Paper presented at the annual meeting of the American Educational Research Association, Boston, 1990.)

**Educational Technology Center** (1986) Teacher as learner: The impact of technology. Cambridge, MA.

**Gearhart, M., Herman, J., Baker, E., Novak, J., & Whittaker, A.** (unpublished) A new mirror for the classroom: Using technology to assess the effects of technology on instruction. (Paper presented at Apple Classrooms of Tomorrow Symposium, Cupertino, CA, 1990.)

**Gersten, R. & Guskey, T.** (1985) Transforming teacher reluctance to teacher commitment. (Paper presented at the annual meeting of the American Educational Research Association, Chicago, 1985.)

**Giacquinta, J. B.** (1973) The process of organizational change in schools. In F. N. Kerlinger (Ed.), *Review of Research in Education, 3* 178–208. Peacock, Itasca, IL.

**Glaser, B., & Strauss, A.** (1967) *The discovery of grounded theory,* Aldine Publishing Co., Chicago.

**Gross, N., & Herriott, R. E. (Eds.).** (1979) *The dynamics of planned educational change,* McCutchan, Berkeley.

**Hamilton, D., MacDonald, B., King, C., Jenkins, D., & Parlett, M.** (1977) *Beyond the numbers game.* MacMillan Education Ltd., London.

**Henson, K.** (1987) *Strategies for overcoming barriers to educational change,* NASSP Bulletin, 71(497). 125–27.

**Hiebert, E.** (unpublished) Report on the writing program at ACOT's Cupertino site. (Cupertino, CA 1987).

**Joyce, B.** (1982) Organizational homeostasis and innovation: Tightening the loose couplings, *Education and Urban Society,* 15(1), 42–69.

**Little, J.** (1982) Norms of collegiality and experimentation: Workplace conditions of school success. *American Educational Research Journal, 84(4),* 493–511.

**Purkey, S. C. & Smith, M. S.** (1983) Effective schools—a review. *Elementary School Journal, 83,* 427–452.

**Rutherford, W.** (1981) Team teaching—How do teachers use it? Research and Development Center for Teacher Education, Austin, TX.

**Rutter, M., Maughan, B., Mortimore, P., & Ouston, J.** (1979) *Fifteen thousand hours: Secondary schools and their effects on children.* Harvard University Press, Cambridge, MA.

**Sandholtz, J. H., Ringstaff, C., & Dwyer, D.** (1990) Teaching in high-tech environments: Classroom Management Revisited. (Paper presented at the annual meeting of the American Educational Research Association, Boston, 1990.)

**Schmidt, D. & Kane, J.** (1984) Solving an identity crisis. *Principal, 63(3),* 32–35.

**Sigurdson, S.** (1982) Two years on the block plan: Meeting the needs of junior high school students. Alberta Department of Education, Edmonton, CA.

**Smith, L.** (1978) An evolving logic of participant observation, educational ethnography and other case studies. In L. Shulman (Ed.), *Review of Research in Education.* Peacock, Itaska, IL.

**Swanson-Owens, D.** (1985) Identifying natural sources of resistance: A case study analysis of curriculum implementation. (Paper presented at the annual meeting of the American Education Research Association, Chicago, 1985.)

**Tierney, R.** (1988) The engagement of thinking processes: A two-year study of selected Apple Classrooms of Tomorrow students.

## Endnote

1 The data notation system used throughout this paper indicates the source of the data (AT = audio tape data; WL = weekly reports sent via electronic mail; SL = links sent between sites), the episode's entry number in the database, and when the data were generated.

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