Environments That Support New Modes of Learning: The Results of Two Interactive Design Workshops

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**Overview: Physical Environment and Educational Settings**

The overarching principle of this research is that change in educational methods occurs at many levels, including the physical setting, and that the physical setting can be an obstruction to educational change. Teacher belief systems relating to the organization of technology and to the physical setting are a major concern of this research. “The introduction of computers into the classroom changes the teachers’ role, as well, leading to decreases in teacher-directed activities and a shift from didactic approaches to a constructivist approach” (Schofield & Verban, 1988). Teacher beliefs are based on previous experience and reluctance to change due to failure of other innovations (Fullan, 1982).

To address the restrictions of teacher belief systems, the research team supported change by offering information, tools, and reflection, as discussed by Beaton. Collaboration, team teaching, and authentic learning were considered activities that the physical setting and organization of technology should support.

**Historical School Design**

From a physical perspective, the traditional school building design is a double-loaded corridor that compartmentalizes classrooms, as well as students and teachers, into what has commonly been called an “eggcrate” arrangement. This historical model for school organization has been associated with an emphasis on control of students and on teacher-centered, lecture-format learning. Today, we look beyond this traditional template of learning to a more interactive, collaborative, and inquisitive student-centered approach to learning. However, while pedagogical changes are taking place within the classroom, the design of new school buildings often perpetuates the “eggcrate” school model.

Research on alternative modes of learning and teaching with technology suggests that change must take place systemically (Sheingold & Tucker, 1990). These changes have been shown to result in improved educational achievement (Gearhart, Herman, Baker, Novak & Whittaker, 1990; Dwyer, Ringstaff & Sandholtz, 1991). We believe that the physical environment contributes to the system of change and can reinforce these educational goals.

**Site-Based Research in Technology-Rich Schools**

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The study of the physical organization of the ACOT classrooms suggests that changes can be made to enhance collaboration and access to technology within the classroom, the school, and the extended learning environment. Physical change could include such simple modifications as choosing more appropriate furniture types, arranging furniture according to activity needs, or acquiring and organizing learning technologies. A larger-scale change might involve redesigning the entire school building in order to cluster activities, offer a diversity of spaces, incorporate community services and resources, or create long-distance learning environments.

This research was based on the belief that the participating teachers were the experts in terms of what they needed in the physical environment. We believed that, given an opportunity and appropriate tools, they would explore alternatives and modifications to their existing classrooms, and that these explorations would suggest interesting changes for the technology-rich educational setting.

Research Sites and Participants

The sites for this study were classrooms within an elementary school and a high school—both long-term ACOT research sites. The physical changes that were made responded to organizational patterns of use based on student and teacher activities. Because none of the changes required funding for construction, they could be made in any school.

The elementary school site is a one-story building built in the 1950s with additions made in 1960 and 1991. The ACOT classrooms (one at each grade) are housed in two classroom types. Grades 1, 2, and 3 are in clustered classrooms separate from the main school building. Grades 4, 5, and 6 are in individual classrooms accessed from an interior corridor. Both classroom types are considered standard size (29 ft. by 32 ft. and 30 ft. by 33 ft., respectively). The average class has 28 to 32 students.

The high school is housed in a multistory building built in the 1940s. Four classrooms are used by the ACOT project for grades 9 through 12. Two of these classrooms are standard-size classrooms (33 ft. by 45 ft.) and two are oversize classrooms (40 ft. by 43 ft.). The average class has 28 students.

All of the ACOT classrooms have been equipped with a wide range of technologies, including computers, videodisc players, video cameras, scanners, CD-ROM drives, and modems.

The participants for this study were ACOT teachers who had been working in these technology-rich classroom environments for an average of five years.

Research Process

From 1989 through 1992, meetings, discussions, and workshops were held to explore the relationship between teaching with technology and the role of the physical setting. The ACOT teachers explored their ideas about the physical learning environment from a number of approaches. The research was conducted in three phases: observation and documentation, workshops, and follow-up.

Observation and Documentation

The research team made initial observations at the two school sites. Each classroom
Observation and Documentation
The research team made initial observations at the two school sites. Each classroom was documented through drawings and photographs. Teachers and students were interviewed regarding their use of the classroom, their concerns about the physical environment, and their preferred teaching mode. (Teaching modes included lecture, team teaching, small group, and individualized.) Meetings were held to discuss the physical environment as well as different approaches to teaching with technology, such as collaboration between students, learning through inquiry, project-based learning, and lecture-based instruction.

Data for this study, collected by the research team between 1990 and 1992, include interviews, observations, meeting notes, photographs, diagrams, architectural drawings, and records of lighting levels. The analysis for this study includes hundreds of hours of observational data by independent researchers, both initially and during the research period (Gearhart et al., 1990).

Variables in Observation. The existing furniture, as well as such building elements as the building envelope, services, furniture and partitioning, were considered constant elements. The variables include the following:

- Number of students in a classroom
- Quantity and type of learning technology
- Teaching modes
- Special projects
- Shared space for two classes
- Length of time allocated to learning activities

Workshops
Design workshops were developed to enable teachers to explore their own ideas about the organization of their classrooms—based on their ongoing experience of teaching with technology. They were also used to stimulate collaboration between teachers. The researchers posed the following questions:

- Given an opportunity to explore alternative settings, would teachers suggest a different environment from their existing one?
- How would teachers organize information technology to support their teaching approach?
- What considerations did the teachers give for the relationship between the physical setting and the educational approach?

Workshop One. The first set of workshops gave the teachers at each site the opportunity to examine a scale model of their respective classroom settings and to
Workshop One. The first set of workshops gave the teachers at each site the opportunity to examine a scale model of their respective classroom settings and to discuss how they might rethink the organization of people, furniture, and technology to facilitate changing modes of teaching and learning. (A scale model is made in true proportion to the full-size example using a “scale” such as one-quarter inch equals one foot. In this way the model is an accurate representation of the subject, only smaller.) At the high school site, four adjacent rooms were used for the ACOT program. This made it possible for the classrooms to work as a system of learning spaces, and the workshop examined them as a single design problem. At the elementary site, both the existing classrooms and a newly constructed cluster of two classrooms were studied.

Workshop Two. The second workshop asked teachers, working in teams, to design a school for 360 students and a multidisciplinary classroom for 75 students. For each assignment, the teams were given a “kit of parts” scale model to help them develop and communicate ideas and to organize team decisions. Having the scale model of the building enabled one team to investigate the overall organization, its physical relationships relative to educational goals, and its need to accommodate community activities.

Having the scale model of the classroom enabled another team to do a more detailed investigation of student groupings, teaching modes, use of technology, and furniture arrangements.

The participants included eight teachers from the high school, a middle school, and the elementary school. The research team provided background material based on the results of the first workshop, tools, and support for the teachers’ design process. Programs for the prototype school and classroom were provided. The participants modified these programs based on their own classroom experiences, modes of teaching, and patterns of technology use.

Follow-up Survey: Teacher Impressions
After the two workshops, a follow-up survey was conducted—via questionnaire—to elicit the teachers’ impression of the effect of the physical setting on their teaching. The teachers were asked to indicate the following:

• Current organization of the classroom

• Number of hours spent teaching in particular classrooms

• Classroom organization for teaching (individual work, small group, or full class)

• Organization of furniture

• Frequency with which the furniture and/or the technology is rearranged

• Location of technology

In addition, the teachers were asked to reflect on the usefulness of the workshop and to assess the effect of the physical design changes on teaching, student organization, and student interaction.
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Findings
Observational Findings
Specific physical needs were identified for technology-rich classrooms that support collaborative, multidisciplinary, and project-based teaching and learning. These needs included adequate space, flexibility, appropriate furniture, climate control, networking and electrical service, and adequate storage.

**Space.** More space may be required for the technology-rich classroom than for the traditional lecture-format classroom. Student desks are occupied by computers and peripheral equipment, as well as by equipment for special projects. Furniture, computers, and student work areas compete for space. Students need space to bring books, papers, and other materials to the workstation, and students often work together in groups at workstations intended for only one student.

Teachers frequently mentioned the impact of the overcrowding on their ability to teach, and they expressed a need for greater ease of contact with students. For example, one teacher reported, “I’m finding the arrangement of the room to be somewhat of a problem. It’s getting very full of equipment and we’re kind of crowded. I like to move around the room as I teach and this makes movement difficult” (Teachers Log, ACOT-LRC, October 1988). Another teacher said the classroom was so crowded that she found herself standing in one place—answering students’ questions regardless of the distance between her and them. By the end of the day she was exhausted by this process (Stuebing teacher interview).

**Organization and Teaching/Learning Methods.** When the study began, many classrooms were organized in a traditional manner. Although student collaboration was a goal, there was little effort to define areas in which students could work together. In the two smaller high school classrooms, the student desks—each with a computer—faced the front of the room. In these rooms, the teachers generally gave full-group instruction, made desk assignments, and circulated through the room to answer questions. In the two larger rooms, the technology stations were organized around the perimeter of the classroom (in part, for access to electricity), and some of the desks were in a major circulation path. A full-group instruction area included rows of two-student tables facing the front of the room. Student work was frequently interrupted by other students circulating through the room.

**Flexibility.** Interactive technologies do not necessarily increase physical or organizational flexibility, but may actually do the reverse. The lack of physical flexibility within the classroom may be a disincentive to change pedagogy.

“One of the biggest gripes we have is that we’re constantly moving technology around. Instead of moving people to the technology, we keep taking technology apart and shifting this cartridge drive to there, this scanner to there, this to that, and that’s a major problem.”

—ACOT teacher
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Although technology offers a variety of learning opportunities, the physical flexibility necessary to support this learning is often difficult to obtain. The networked, computer-integrated classroom was observed to be a static setting that did not readily adapt to changing teaching modes or student projects. The time required to make changes in the classroom was found to be excessive, and in some cases it became an obstruction to new activities. Teachers took personal time after school or during weekends to rearrange their classrooms to support special work.

One teacher, commenting on flexibility, said, “We rearranged furniture last Friday. We moved all the computers from the center to around the walls to make room for the robotics project in the center of the room. We hooked up the network. It took an afternoon to get it done. Just to give you an idea of flexibility” (Teachers Log, Columbus ACOT-LRC, October 1987). The problem caused by lack of flexibility was even more apparent in daily multimedia presentations. Setting up mobile presentation carts often took 15 to 20 minutes of a 60-minute period. Although the teachers eventually designed a stationary presentation center, these units were also sometimes found to interrupt classroom activities.

**Furniture.** The design and arrangements of classroom furniture needs to adapt to support interactive technology.

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**Furniture.** The design and arrangements of classroom furniture needs to adapt to support interactive technology.

“Two by four feet is not enough area if something is sitting on it ... it’s not a good area even without a computer sitting on it.”
—ACOT teacher

Both design and arrangement of furniture appeared to be critical factors in classroom design. For example, furniture designers don’t seem to take into account the variation in student sizes, nor do they accommodate for students’ growth during the year. As computers and other technology-based learning tools occupy more and more territory within the room, the individual student desk was very difficult to preserve. In addition, many teachers indicated a preference for large tables—rather than individual desks—for group activities. Asked if they thought the widespread use of smaller, portable computers would solve the furniture problems, teachers said that the size and design of the standard classroom furniture would still be inadequate.

**Climate Requirements.** The needs for comfort and climate control (heating, ventilation and lighting) are heightened with the introduction of technology. The use of computers, printers, and other peripherals increases the heat load in the classroom and affects teachers’ ability to teach. Typical comments included the following:

“I find that the noise from the applications class is very distracting.”

“ROOM TEMPERATURE TOO HOT! We noticed after the class today the room we are using this year gets very hot if we close the curtains and the windows so we can use the projector.”

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Contrast, uneven light, and glare appeared to be the most significant lighting problems. The teachers’ solutions—turning the lights off altogether or closing the window shades—created a dark or gloomy working environment.

**Networking and Electrical Service.** Electrical service and networking capacity can restrict the use and location of information technology.

“The other problem we’re having with cabling is that if it’s not enclosed it gets disconnected, but if we enclose it and somehow it gets disconnected, it’s harder to get to.”

—ACOT teacher

Classroom organization is restricted by the placement of electrical outlets as well as by networking configurations. For example, the high school classrooms were originally organized for perimeter cabling and access to power. This began to predict that the technology would be located at the perimeter, thus limiting the variety of possible classroom arrangements.

**Storage.** Storage needs are greatly increased in the technology-rich classroom. Teachers criticized the lack of storage within the room. They asked for three kinds of storage space: space that was easier to secure; easily accessible space to store reference material, equipment, and supplies; and easily accessible space for the temporary storage of personal belongings.

**Findings of the First Workshop**
The first workshop was conducted separately at the two school sites. At the high school, workshop participants reorganized the smaller classrooms so that students could more easily work together in groups. The design involved putting desks in clusters of four to six and creating a circulation path.

In the large room, one goal was to make the space more flexible by reducing the lecture area and creating a place for group work. To achieve this, participants removed all the tables and used small cluster areas to define group work space. They also removed the technology workstations from the circulation paths. “Hutches” (desks with tall bookcases attached, as seen in the photo to the right) served to divide the space, to house equipment, and provide work areas. The small work areas for groups also appeared to give greater definition to the group tasks and kept away the distractions of the larger classrooms.

Before attending the workshop, several elementary school teachers had reorganized their classrooms to support group learning. As a result, many of the desks were clustered. In many cases, however, group activities were still conducted on the floor. Teachers in grades one through three had organized the computers in a single row. Although this arrangement allowed teachers to see all the computer screens at one glance, it restricted the number of neighbors with whom students could collaborate.

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**Implementation.** Following the design workshop, teachers reorganized their classrooms. These reorganizations resulted in greater teacher satisfaction with the room. In general, they promoted group activities, moved the technology from a linear arrangement to clusters, and devoted less space for lecturing. The workshops also stimulated teachers’ inventiveness. (Teachers developed concepts for student workstations as well as for presentation stations. They also identified needs for items such as portable storage units.) Overall, the classroom in which there was the greatest diversity in type of work areas was the one with which teachers and students were most satisfied.

![Existing high school classroom](image1.png) ![Redesigned high school classroom](image2.png)

**Findings of the Second Workshop**
In this workshop, participants had two different assignments. One team designed a concept for an entire school and the other designed a concept for a multipurpose room. The following assumptions, based on current research and projections for the direction of future technologies, were agreed upon by the participants:

- Collaborative learning and team teaching are increasingly important to education.

- Multimedia and electronic resources are significant tools that will be accessible from the classroom.

- Teaching and learning will become multidisciplinary, i.e. learning will become more “authentic.”

- Teacher support and training is essential to the integration of technology into the learning environment.
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• School will offer more community services.

• Home-school networks will become more prevalent in the near future.

• Both formal and informal presentation spaces are necessary.

While working on their designs, the workshop participants were free to suggest any alternative for construction or technological innovation without regard to cost. The resulting designs generally offered a greater opportunity for collaboration and interaction, ready access to multiple forms of traditional and technology-based tools, and a diversity of activity-appropriate spaces and room types.

**School-Design Team.** The school-design team supported the concept of a “community of learners” by developing four centers. An academic center included areas for instruction and project-based work, and a community center housed medical, dental, child care, and other social services. A performing arts center and an information resource center completed the design. Each center was intended to be shared, to accommodate use by multiple ages, and to facilitate interaction. In terms of design, the most interesting features included the following:

• Connecting and overlapping instructional areas that would allow for multidisciplinary connections and access for flexible-age groupings

• Visual connections between classrooms—both vertical and horizontal

• Small meeting spaces—located throughout the school and accessible to both teachers and students

• An emphasis on access to information technology in a nonhierarchical organization. As one teacher said, “No one has a priority or control over information. Everyone shares it and is responsible for it.”

The school-design team emphasized access to technology-based learning resources via a schoolwide distribution of networked technology. This idea was extended to include electronic connections to homes and to resources within the community, thereby providing a broad range of local and global communications.

**Classroom-Design Team.** The second team, designing a multipurpose classroom environment for 75 students and three teachers, divided a rectangular space into areas for the following learning activities: large-group instruction, experimentation and simulation, small-group work, and informal presentations or performances. The activity-based learning areas were organized around a large, centrally located storage room containing a telephone, facsimile machine, copy machine, supplies, and portable liquid crystal display (LCD) panels. To provide space for groups that require quiet, or groups whose activities would disturb others, the design also included three
room containing a telephone, facsimile machine, copy machine, supplies, and portable liquid crystal display (LCD) panels. To provide space for groups that require quiet, or groups whose activities would disturb others, the design also included three sound-attenuated rooms separated by folding partitions. Each of these rooms had comfortable furnishings, a meeting table, and a workstation.

The classroom designers envisioned that students would use—and be responsible for—portable computers. Built into each portable computer would be a desktop LCD that could be used both for group viewing and as a work surface. These computers could be connected to six-student networked workstations that would be located throughout the school. There would also be mobile multimedia stations with large-screen monitors and wall-size LCD panels. These mobile stations would house a printer, scanner, VCR, CD-ROM drive, and videodisc player.

The room designers also recommended that teams of teachers share a mobile multimedia presentation cart. Some of the teachers who had used such carts pointed out the need to connect the equipment to power outlets, which are often available only along perimeter walls.

“The problem is we want the presentation station in the center of the room and we want to hook to all these peripherals that are laying out here on the edges. So you’ve got to get the power to the center....”

—ACOT teacher

The teachers also envisioned an ideal presentation cart that would double as an additional workstation or “all-in-one” cart for both students and teachers.

“Often teachers use the same exact identical workstation as the student does.... If you get used to using the exact same tools as the students are using ... and make sure they (students) have access to the same tools as you do ... now, you’re working on common ground.”

—ACOT teacher

**Technology as Environment.** The teachers suggested that, in some cases, architectural elements and technology tools can be interchangeable. The classroom design incorporated display-ready walls with built-in large-screen LCD panels that could be used for demonstrations, to display student work, or to create electronic murals as a form of virtual reality. These panels, which could also be used as backdrops for performances or presentations, could be easily designed by the students and could be changed over time.

**Findings from the Survey**

Responses to our survey suggested that organizational changes enhanced individual instruction and full-class presentations, as well as individual and small-group work. At the high school level, the multipurpose classroom is used most often (60 hours per week of scheduled teacher instruction time). Its design best illustrates the accommodation of student work habits. (The room is used for small-group work 50 percent of the time. The remaining time is divided evenly between individual work and full-class work.) Teachers also observed improved interaction between students in the multipurpose classroom, based on changes made to the physical environment.

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full-class work.) Teachers also observed improved interaction between students in the multipurpose classroom, based on changes made to the physical environment.

Asked where they placed the technology, and if it was moved often, the teachers said they arranged it to support classroom activities. In general, the two multipurpose rooms require some flexibility, because technology and furnishings may be moved weekly. The other two classrooms have more permanent arrangements. Also, students use technology for presentations as often as once a week. This frequency of use supports the idea that the physical design of classrooms needs to accommodate technology-based teaching and learning.

Our survey also asked teachers to think about the classroom of the future and to identify emerging technologies that would have the greatest impact on the physical design. Teachers still desired air-conditioning, more storage space, a raised floor for cable management, and wireless capabilities. One teacher suggested an alternative seating arrangement that incorporated a collapsible work surface that could be used with portable computers. In terms of emerging technologies, teachers indicated that multimedia and mobile computers would most affect the physical design. With mobile systems, they would be able to conduct work outside the classroom; with multimedia and the associated peripheral equipment, they would require more space in the classroom.

Discussion: Research Questions

Question: What are the key issues that indicate that change in the physical environment is needed to support learning with information technology?

Conclusion 1: Change in the physical environment fosters change in teaching and learning. Appropriate settings can encourage collaborative work.

“The freedom to move around the classroom encourages collaborative learning ... allows them to work closely together, and also allows them to draw on each other for their strengths.” —High school teacher

All workshop participants redesigned their classrooms to support their teaching goals. In the high school, both students and teachers reported a greater degree of interaction in classrooms that were organized to enhance group learning. They said the new arrangement created more space in the room, a “warmer and more homelike” feeling, and specific areas for group work. It also provided the flexibility to accommodate a variety of activities.

Conclusion 2: The technology-rich classroom requires greater architectural consideration and sophistication, whether for retrofit or for new construction.

The use of learning technologies in the classroom introduces new issues for the design of the classroom and for the curriculum. An informed decision-making process is critical to resolving the problems inherent in classroom design without having a negative impact on educational goals or on the ability to optimize the use of technology.

Question: What observations do teachers have with regard to facility design and the use of technology?
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Conclusion: Teachers had opinions about the physical setting and acted on them when given the opportunity.

Interviews, discussions, the participatory design process (the two workshops) and the survey collected many observations from teachers regarding the physical setting. These observations were tested, in part, through the redesign and reorganization of their classrooms. The following list summarizes the key design indicators for a technology-rich classroom or school.

• **Access.** Technology should be thought of as a tool for learning. Therefore, the physical environment should be designed in such a way as to allow for ease of use for multiple activities.

• **Territory.** Technology should not be used as an activity in itself, but rather should be one of many tools used in completing a project. Furniture should be selected to allow these diverse activities to take place.

• **Furniture and comfort.** The educational setting should be comfortable and aesthetically pleasing. Comfort includes lighting, cooling, heating, and acoustics.

• **Social condition and acoustics.** The technology-rich environment for learning is an active and social one. Students work together and assist one another with technical problems. Teachers and students often share “coaching” responsibilities. To accommodate these activities, the classroom should be designed for sound attenuation; it may also need to include separate meeting rooms.

• **Flexibility.** The educational setting accommodates many different kinds of activities. Some are of short duration; others are long-term and may require special “set aside” space. Some are planned; others are spontaneous. The physical setting needs to be flexible enough to support all of these. However, “flexibility” does not mean that everything (furniture and technology) must be able to move within the classroom, but rather that some things be able to move occasionally. More important, flexibility means that the classroom provides a diversity of settings for learning.

• **Collaboration.** Student and teacher collaboration can be supported by providing small clusters of desks, shared meeting tables and work spaces, and small student marker boards.

• **Presentation space.** Although the emphasis on teacher presentation may decline in the future, the workshop participants felt that it would not disappear completely. In addition, they felt that student presentations may increase as “portfolio assessment” or project-based assessment is adopted. To meet this need, the teachers proposed mini-theater presentation areas.

• **Portability.** Mobile computers may offer solutions to many of the problems related to computer access and overcrowding in the classroom. However, large-screen
• **Portability.** Mobile computers may offer solutions to many of the problems related to computer access and overcrowding in the classroom. However, large-screen monitors and workstations that allow for peripheral connections will still be required.

• **Communication.** Because they felt that communication encourages learning, the teachers wanted to facilitate visual access—between classes as well as within the classroom setting. They also proposed creating a territory between classrooms that would allow for an exchange of ideas between students and teachers. The concept was to create a multidisciplinary setting.

• **Networking and classroom organization.** The arrangement of network cables and electrical power around the periphery of the room restricts the potential organization of the educational setting. Teachers pointed out the importance of finding a way to bring the technology into the center of the room.

• **Expanding definition of school.** The advent of distance learning, the increased use of portable computers, and the ability of technology to provide information access for the entire community all suggest that the educational setting will become far more diverse during the next few years. As a result, the teachers suggested that the school be considered a center for community-based learning.

**Question:** From a teacher’s perspective, what are the opportunities for change in the design of the physical setting to better support learning with technology?

**Conclusion 1:** Teachers altered classrooms to meet their needs and, with support, developed inventive solutions to better understand and address their classroom settings.

Through an interactive and collaborative problem-solving approach, teachers reflected on and designed potential classroom organizations. Then, they began to alter the arrangement of furniture and technology in their classrooms to match their needs. Some teachers changed their classroom organizations more rapidly than others or explored alternative organizations more frequently. Although minimal in terms of the range of possible alterations, these changes were easily within the control of the teachers.

Teachers also made changes in the relationship of space to time, particularly at the high school where the team of teachers shared four classrooms. After they studied the attributes of each room and identified the needs of different activities, the teachers took this information into consideration when scheduling classes.

**Conclusion 2:** With support for change, teachers were inventive and explored new ideas.

The process for this study is interactive in that the teachers became part of the research team and the architect and educator served as change agents. “With this change there has been a corresponding shift in change agent roles from disseminator of curriculum ideas and materials to process consultant or trainer” (Beaton, 1985). Parallel work on teachers’ beliefs and practices reviews the role of the teacher in the technology-rich educational environment (Dwyer, Ringstaff & Sandholtz, 1991).

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Parallel work on teachers’ beliefs and practices reviews the role of the teacher in the technology-rich educational environment (Dwyer, Ringstaff & Sandholtz, 1991).

The participatory design process met two goals. First, by viewing the classroom organization from an alternative vantage point, the teachers were able to reflect on aspects of the physical environment and to identify connections to teaching issues (for example, overcrowding in the classroom as it relates to the ability to serve as a “coach”). Each school kept a study model so teachers could continue to explore ways to organize the physical environment. Second, teachers were able to envision ways in which they could alter their teaching environment to meet their needs. Workshop Two was an important follow-through to the process of reflecting on the physical environment. In this workshop, the teachers were free to explore their ideas about potential educational settings without the restriction of existing architecture.

Given an opportunity to explore possibilities, teachers recommended new educational components, such as wall-size LCD panels and shared group workstations, which had both technological and organizational aspects. The teachers demonstrated a desire for organizational change by suggesting the need for greater connection between classes. They also suggested that there be a wider variety of spaces, and they suggested specific types of spaces, such as small rooms for working. Larger changes in the system were also developed; for example, they proposed using the school facility as a setting for general community-based learning and support.

Teachers also demonstrated innovation as they began to design supports for their environment. To address the problem of setup time for overhead displays, for example, one teacher designed a presentation station using LCD panels. To address the need for individualized and personalized storage, while eliminating assigned desks, the elementary teachers designed storage cabinets.

Conclusion 3: Embedded beliefs can limit both the possibilities for change in the physical learning environment and the opportunities for teaching with technology.

The teacher’s role in the classroom is critical when making a change from a curriculum-centered education system to a child-centered one, and from individual tasks to collaborative tasks (Dwyer, Ringstaff & Sandholtz, 1991). Our ongoing research indicates that the process of change in the classroom environment is controlled, in part, by teacher belief systems that limit the number of possible options for change.

Several prominent teacher beliefs appeared to be contrary to the goals of authentic, cooperative learning and to a highly interactive and creative learning environment. For example, in the elementary school we found two predominant teacher beliefs: (1) all students need an assigned desk; and (2) primary grade teachers need to be able to see all the computer screens at the same time. Through our observations, we found that the assigned desks were used infrequently and that work was conducted on the floor, in between the assigned desks, and at the computer stations.

Conclusions

The difficulty of exploring change in the physical setting for education is due to embedded beliefs. These beliefs are cultural, experiential, and historical. Nevertheless, the use of information technology and the move toward more collaboration suggest that a new model for educational settings may emerge.

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Nevertheless, the use of information technology and the move toward more collaboration suggest that a new model for educational settings may emerge.

The design workshops described in this paper are one solution to the issues teachers raise about their teaching environment. In this respect, they are really a demonstration of a possible change and a contribution to a growing exploration. One follow-up to this work might be to take the second workshop toward the development of a “built” setting, though that would require a series of explorations.

However, the limitations of change in the existing “rectangular box” classroom must be reckoned with. As demonstrated in the first workshop, the ability to make change with existing furniture and settings will be critical for most schools and teachers. The search for ways to support educational change by creating supportive environments within existing conditions should be a companion to other forms of educational change, in particular to the introduction of technology.

The increased use of mobile computers, multimedia, and long-distance communications must be considered when studying the relationship between technology and the physical setting. For example, future research on the physical environment should explore the role of the mobile computer and other emerging technologies. In our study, teachers indicated that mobile computers should be used in conjunction with other learning technologies.

The need to connect to electric power and to networking cables will continue to keep the electronic environment grounded to the physical environment. Although wireless networks may answer many design issues raised in this report, they may also introduce new problems. Appropriately designed cable management systems can facilitate the flow of information as well as the organization of equipment for safety, access, and maintenance.

Over the next few years, many people will be investigating the physical setting as a matter of necessity. Key to this exploration will be to challenge the existing belief systems and to create a process that not only allows for reflection and invention but also supports change.
References


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