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ABSTRACT

Apple Classrooms of Tomorrow (ACOT) is a long-term research project sponsored by Apple Computer, Inc., to explore how learning and teaching change when teachers and students have access to interactive computer technologies. ACOT adheres to a philosophy that instruction should be learner controlled; i.e., students take responsibility for their own learning and the teacher's role changes to that of being a mentor or coach who guides them in their construction of knowledge. This approach, which is called constructivism, places the emphasis on students learning how to build their own knowledge of subjects. Six years of research reveals that microcomputers and other interactive educational technologies are most powerfully used in learning activities where children are engaged in tasks with real purpose. ACOT research shows there are differences in self-confidence levels, problem solving skills, and positive attitudes, between students who have high-access to technology and those who have no or limited access to computers for learning. A sample of current projects includes: (1) StoryShow, an electronic composing environment for very young children; (2) Software for Quantitative Competence (Function Probe), a software tool that helps students learn about the concept of function; (3) SimBase, a simulation environment; (4) Science for Living: The Circulatory System, an interactive multimedia resource; (5) Teaching Science through Digital Image Processing; (6) Intelligent Physics Tutor, interactive software that helps students develop problem solving skills; and (7) Computer-Supported Intentional Learning Environments, a knowledge processing environment that promotes collaborative learning. Noting that ACOT schools are designated either Experimental Learning Centers or Longitudinal Research Centers, an addendum entitled "What's Happening Where" provides a detailed list of Apple Classrooms of Tomorrow projects and participants in 14 states, the District of Columbia, and Toronto, Canada. (DB)

Apple Classrooms of Tomorrow

Apple Classrooms of Tomorrow sm (ACOT) is a major, long-term research project sponsored by Apple Computer, Inc. The project explores how learning and teaching change when teachers and students have access to interactive computer technologies. ACOT, which is in its sixth school year, seeks not only to demonstrate innovative uses of technology, but also to influence educational reform by sharing its results with educators, parents, legislators and school administrators. The information gained by ACOT also is fed back to Apple engineers to help them develop new and better products. ACOT's goal is to improve instruction, technology and assessment.

Philosophy

ACOT adheres to a philosophy that instruction should be learner centered, not teacher centered. That means students take responsibility for their own learning and in doing so, reach a state of "owning" the information in a fundamentally different way than when information is presented by teacher-centered instruction.

Traditionally, teachers ask students questions, students offer answers and teachers explain if those answers are right or wrong. This type of teaching does not encourage student inquiry and it doesn't necessarily encourage students to learn the interdependencies of the various facts presented. For instance, a student could know a lot of facts about wolves: what they eat, how often they mate, where they live, but without looking at the larger ecosystem including how deer interact with wolves and how deer interact with grasses, students miss the important and fundamental larger picture. This approach says that understanding the interdependencies of facts is as important as knowing the facts themselves. By discovering these interdependencies and articulating them, students gain a deep and lasting knowledge of a subject. This approach is called constructivism, meaning the emphasis is on students learning how to build their own knowledge of subjects.

ACOT's constructivist approach doesn't diminish the role of a teacher, however. Rather it changes the teacher's role from being primarily a lecturer who transfers knowledge to students, to that of being a mentor or coach who guides students in their construction of knowledge.

What's Different about Learning with Technology

A learner-centered environment isn't dependent on computers. However, computers in this context can offer learners fundamentally different experiences than other mediums such as paper and pencil.

Computer technology is interactive. It can respond to users.

Computers can be used to integrate information. Data from a variety of sources, in a variety of forms can be viewed and manipulated in one place —the computer screen. Technology is fluid or malleable. Because information displayed on a computer screen is digitally based (regardless whether it's text, graphs or full-motion images), users can change how it is represented. Text can become a graph, numbers can become a picture.

Computers can expand and compress space and time. For example, simulation software can compress events of long duration, such as evolution, into a few seconds. Computers can allow students to do things that are otherwise impossible. Simulations can, for instance, allow a student to journey to our moon and experience its weaker gravitational force. Simulations can be powerful ways to teach students inquiry, analysis and problem solving skills.

The Big Questions

ACOT believes that technology is best used in a learner-centered environment that encourages children to create their own knowledge. With that as a philosophical base, ACOT sets out to determine the potential of technology, students and teachers in environments where high access to computers exists. University-based researchers examine questions such as:

- *How does high access to technology affect curriculum and instruction?*
- *How can computers be used to empower students to take responsibility for learning?*
- *How do students organize and use information when they have constant access to computers?*
- *How can the learning outcomes of high computer environments be fairly assessed?*

Broad Findings

ACOT, as a research project, is not out to prove one thing or another. Instead, its goal is to continually improve how teachers and students employ technology to enhance learning and teaching.

Six years of observation and research in ACOT classrooms reveal that technology is most powerfully used in learning activities where children are engaged in tasks they see as real work with real purpose. During these activities students do and create as well as interact with teachers, technology and other children. These observations are the basis for the creation of three kinds of learning environments that ACOT will pursue in the coming years: collaborative learning, media-rich composing and simulations and modeling.

ACOT research shows there are differences between students who have high-access to technology and those who have no or limited access to computers for learning. Not unexpectedly, ACOT students are able to use computers productively but they also differ from non-ACOT students in other significant ways. Some of those differences are that they are more effective at communicating ideas and using tools to communicate those ideas than their non-ACOT peers. In addition, they have a higher degree of social awareness and self-confidence; they are more independent and have more positive attitudes about learning and themselves; they are able to experiment and problem solve with greater ease; they see themselves as collaborators and experts, and they have a positive orientation about the future.

ACOT research also shows that children using technology develop skills that aren't accurately measured by traditional or standard testing measures. Therefore ACOT has developed new strategies and tools that assess students' instructional change, including a new classroom observation tool created in conjunction with UCLA and a HyperCard ® -based student portfolio assessment tool implemented in both elementary and secondary schools.

Another key finding of ACOT research is that teachers, given the support and opportunity, are significantly challenged by using technology because it causes them, in a deep and personal way, to examine what they know about teaching and learning and to evolve new instructional practices that are far better than their old practices.

Real Classrooms

ACOT is unique in its conception, in its form and in the opportunities it poses for its partners. When ACOT was launched six years ago, it was among the first research-based efforts designed to understand the role technology might one day play in education. But it was distinct in that it approached its study treating technology as only one of the important factors in a complex learning system. That system comprises learners, teachers, curriculum, instruction, assessment, physical limitations posed by classrooms, institutional policies and traditions, and teacher professional development. ACOT avoided a technocentric approach in favor of a human and systemic one.

Structure

Under the ACOT umbrella are approximately 38 research and development projects that combine current learning theories, advanced technologies and innovative research procedures. Research and development teams collaborate with teachers to build curriculums, tools and environments that can be tested by more than 45 ACOT teachers and eventually integrated into other classrooms. Projects range from the development of interactive media tools for writing to an intelligent tutoring system for physics to hypermedia tools that link procedural and conceptual knowledge in mathematics.

This work progresses in real classrooms where Apple Computer and public school districts have created learning environments where students share constant access to a variety of technologies. ACOT research spans 1st through 12th grade and involves more than 1,000 children in urban, rural and suburban schools. Children are randomly selected to participate.

The ACOT sites are as diverse as their students and teachers; they pursue their own goals and develop their own models. ACOT teachers, recognized as key to the project's success, make significant contributions to the ongoing education program and receive support for individual innovation projects.

Classrooms are designated as either Experimental Learning Centers or Longitudinal Research Centers. In addition, ACOT's Nashville site has taken on a new role as ACOT's first teacher development center, where technology as a catalyst for teacher development is being designed and studied.

Rich Instruction

At Experimental Learning Centers (ELCs), ACOT creates and studies a wide variety of instructional ideas and computer hardware and software tools. The duration of a project varies depending on the research goals. The number of schools designated as ELCs varies depending on research needs. In 1991, ELC classrooms exist in primary and secondary schools in 10 states and Canada. ELC teachers and students work closely with researchers and software developers.

At ACOT's Longitudinal Research Centers (LRCs), the project builds classroom environments that provide teachers and students constant access to computer-based technologies. Access to computers allow ACOT teachers and students to explore new uses of technology in all aspects of their teaching and learning. The establishment of LRC schools allows ACOT to work with the same students and teachers for a period of years.

To support this growth process, ACOT provides its teachers with information about current learning theories and exposes them to new curriculum ideas. Software or instructional ideas tested at ELCs are often transferred to LRCs for a more vigorous examination. There are three LRCs in the ACOT project: an elementary school in Cupertino, California; a middle school in Tucson, Arizona, and a high school in Columbus, Ohio.

Information technology in the service of learning is ACOT's *raison d'etre.* Learning activities where technology is most powerful are those that engage children in tasks they see as real work with real purpose. During these activities students do and create as well as interact with technology, teachers, and other children.

Based on these principles, ACOT develops and researches three kinds of learning processes: collaborative learning, media-rich composing, and simulation and modeling. ACOT students and teachers use a wide variety of technology including Macintosh® and Apple II® personal computers, laserdisk players, video cameras, scanners, voice recorders, CD players, modems and on-line communication services. Software tools include word processors, databases, spreadsheets, graphics programs, HyperCard®, as well as specially-developed multimedia composition, digital image processing and simulation software programs. Also, some ACOT students and teachers have conducted learning experiments with "wireless" computing and communication technologies including pen-based portable computers, radio-frequency modems, cellular telephones and cellular fax machines.

High Hurdles

With a practice of avoiding a technocentric approach in favor of a human and systemic one, ACOT was created as a mutually benefitting collaboration among a corporation, universities, school districts and other technology providers. The ground rules, however, were unique. Apple made a very conscious and deliberate effort to develop the ACOT sites strictly for research and not for marketing its products. Even photographs of sites and participants are restricted from promotional use of products. This distinction has helped build a lasting and trusting relationship among parents, educators, university-based researchers and Apple's employees. Proof of the success of this collaboration lies in the lasting nature of the relationships among partners, the steady growth of the project and the contributions all participants make to the project's fiscal and operational well being.

ACOT's initiation required overcoming several hurdles. First came capturing the imagination of a profit-motivated corporation to support a long-term research project that had no obvious connections to the sales of its products. Next, school districts that would adopt the vision had to be identified. Trust between this corporation and its non-profit partners had to be built and maintained. Researchers had to be convinced of the clear research mission of ACOT; it took several years to build the national reputation that now allows the best research institutions to join ACOT without fear of some hidden corporate agenda.

All of these hurdles were somewhat abstract, but the project is implemented in a very real world with finite resources. Once in the schools, ACOT had to overcome the limitations of old classrooms with too little power and space and too much dust and heat. The learning curve for teachers and students was steep. Teachers had to learn all of the technological basics before they could once again feel

like competent and creative instructional leaders. Once they were comfortable with the technology, most completely redid their instructional approach. The time and personal dedication required was monumental for there were no guides or paths to follow. Students had to become accustomed to new levels of responsibility and ways of working and relating.

Keeping the project alive for the long-term within school districts with shifts in administration and funding requirements proved a significant task. Trust proved to be something that had to be renewed among partners again and again. There was a profound suspicion about a corporation working so closely in schools. Means for constant and rapid communication among all partners had to be established. Each year, partners seemed surprised that ACOT was back and delivering on its promises. The rate of technology change, especially when educators are working with members of the Advanced Technology Group of an innovative company, can be overwhelming. ACOT had to find a sane pace for change that would allow time for ideas to flourish yet protect participants from burnout.

Different Opportunities

ACOT also provides extensive and special opportunities for its most important participants — students and teachers. Students and teachers have regularly reported to their own boards of education, administrators, and district planning committees. They have served on state education committees in California, Tennessee, and Minnesota and met with governors and state and federally elected officials from many states as well.

Twice, ACOT students and teachers testified about and demonstrated new uses of technology for learning at hearings of the Joint Committee on Space, Science, and Technology in Washington, D.C. Their work was subject of several pages of description in the Office of Technology Assessment report, Power On! ACOT's teachers' and students' advice is sought by hardware and software developers and curriculum publishers. Lastly, with ACOT support, ACOT teachers have developed their own curriculums, perspectives, and research projects, and many have published in books and periodicals.

In addition, ACOT teachers and students work with university-based researchers from several universities and research organizations including the University of California at Los Angeles, the University of California at Berkeley, Boston University, Ohio State University, Cornell University, Bank Street College of Education, the University of Arizona, Stanford University, Southeastern Massachusetts University as well as the Institute for Research on Learning of Palo Alto, Calif., the New Jersey Institute of Technology, the Technology Educational Research Center of Cambridge, Mass., and the Ontario Institute for Studies in Education.

Several of ACOT's Experimental Learning Center projects are being conducted in partnership with federally-funded scientific agencies such as the U.S. Geological Survey, the National Aeronautics and Space Administration and the National Oceanic and Atmospheric Administration.

Summation

The success of this program is difficult to measure, even demonstrate to hard-minded corporate executives and promise-wary educators. Traditional measures showed modest success that accelerated over time. But ACOT's hunches about the most powerful gains — changing views of personal efficacy, new approaches to problem solving, changing work norms among students and teachers — proved illusive and difficult to document. Despite ACOT's intuition, developing more valid and reliable measures and means of documentation for changes in the learning and instructional process continues to loom ahead as a most significant challenge for the program.

Given the broad use and acceptance of technology in other sectors of society, ACOT believes that technology will become pervasive in education. What ACOT learns and shares during the next years will make an important contribution to the way in which technology is used in tomorrow's schools. ACOT's findings also provide guidance to Apple engineers in creating better technology for learners and teachers.

A Sample of Current Projects

Media-rich composing

- StoryShow, an electronic composing environment for very young children that allows them to integrate speech, action, images and writing into presentations that they can share with children and adults.
- Software for Quantitative Competence, a prototypical multi-representational software tool (Function Probe) that helps students learn about the concept of function, by facilitating student movement between tabular, graphic and algebraic representations of functions and data.

Simulations

- SimBase, a simulation environment that includes tools and interfaces that support more systematic approaches to inquiry. The initial simulation environment used a HyperCard interface running on top of STELLA models. This environment is being redesigned around the constructs of "Artificial Life," a paradigm which, through formative research, was shown to resonate more naturally with student cognition.

- Science for Living: The Circulatory System, an interactive multimedia resource that provides access to living circulatory systems, interpretive supports that link text with images and provides demonstrations, animations and simulations (with researchers at Stanford University).

- Teaching Science through Digital Image Processing, a project that introduces digital image processing to classrooms based on the notion that people learn more effectively from visual images than from the traditional coded (math and language) ways of teaching science. ACOT has developed an extensive Macintosh ® based set of photographic-quality image data.

- Intelligent Physics Tutor, in conjunction with NASA, a prototype of a new kind of software that helps students create problem solutions by interactively developing a diagram of the problem (if appropriate), choose variables and relations, and perform algebraic and arithmetic operations. The tutor observes the student's behavior as a solution is developed and interacts, as needed, to assist the student in acquiring good problem-solving skills.

Collaborative Learning:

- Computer-Supported Intentional Learning Environments (CSILE), a knowledge processing environment that also facilitates knowledge generation vital for learning with meaning and hence understanding. At the heart of CSILE is a student-generated database. CSILE supports knowledge manipulation and construction by helping students work with information in the database helping them notice gaps, formulate questions and plan external searches for information for entry into the database.

Members of the ACOT staff are: David Dwyer, Ph.D., project manager and principal scientist; Wayne Grant, R&D manager and senior scientist; Keith Yocam, senior scientist and manager in charge of teacher development; Rick Borovoy, education technology engineer; Mary Fallon, communications manager; Gina Funaro, Experimental Learning Centers specialist; Jacqui Giddings, site manager for the Longitudinal Research Centers; Loree Vitale, business manager, and Connie Troy-Downing, area associate.

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(See ACOT document "What's Happening Where" for a detailed list of all ACOT projects, participants and locations.)

Apple Classrooms of Tomorrow (sm)

Apple Classrooms of Tomorrow (sm) (ACOT) schools have two designations: **Experimental Learning Centers (ELC) or Longitudinal Research Centers (LRC).** At both kinds of sites, instruction, technology and assessment are equally important.

At Experimental Learning Centers (ELC), ACOT and other researchers create, test and study a wide variety of instructional ideas and computer hardware and software tools to determine their impact on learning and teaching. The duration of any project varies depending on its research goals. The number of schools designated as ELCs varies depends on research needs.

At Longitudinal Research Centers (LRC), ACOT builds classrooms that provide teachers and students constant access to computer-based technologies. These technologies include Macintosh ® and Apple II ® personal computers, laserdisk players, video cameras, scanners, voice recorders, CD players, modems, and on-line communication services. In addition, an assortment of software programs and tools are available including word processors, databases, spreadsheets, graphics and page layout programs, HyperCard ®, as well as specially-developed multimedia composing, digital image processing and simulation software programs. Access to computers allow ACOT teachers and students to explore new uses of technology in all aspects of their teaching and learning.

To support this growth process, ACOT provides its teachers with information about current learning theories and exposes them to new curriculum ideas. Software or instructional ideas tested at ELCs are often transferred to LRCs for a more vigorous workout. There are three LRCs in the ACOT project.

What's Happening Where

ARIZONA - **Orange Grove Middle School in Tucson** became ACOT's latest Longitudinal Research Center and its first entire school site in 1991. Orange Grove today has an enrollment of 458 students in grades 6 through 8, with 31 teachers and 17 teacher assistants and support staff. Plans for integrating ACOT research and computer technologies are underway.

Orange Grove had been an ACOT Experimental Learning Center and continues as such for the purpose of one of ACOT's most ambitious experiments. Called "Wireless Coyote," it was a unique experiment in wireless communications and computing. In May 1991, a group of Orange Grove 6th graders using wireless communication devices and pen-based portable computers created a local area network while on a field trip in a national park. While on this wireless local area network, they communicated with each other, with students at their school and students in Ohio and Minnesota on a wide area network.

Orange Grove also is the site of a project about systems thinking and simulations that is integrated into the science curriculum.

In addition, how school architecture impedes or enhances learning, pedagogical developments and the interactive use of technology is being studied at Orange Grove.

ARIZONA - **A teacher at Nazlini Boarding School in Ganado** is one of 20 teachers around the country participating in a project called JEDI or Joint Education Initiative to develop a scientific inquiry curriculum and materials to go along with a specially-designed CD-ROM database of images about earth science . *(See Virginia entry for more information)*

ARIZONA - **More than a dozen science teachers in classrooms around the state** are part of a larger consortium of 32 teachers nationally who are using **digital image processing** technology much like it is being used by space scientists and biomedical researchers. ACOT and Richard Greenberg of the University of Arizona are studying the impact digital image processing has on science learning including how it changes students cognition and motivation. Teachers attend workshops and collaborate with each other via telecommunications. During the summer of 1991, an additional 30 teachers around the country will join in on this digital image processing curriculum design work. **Participating Arizona schools are in Tucson, Prescott, Sierra Vista, Globe, Scottsdale, Kingman, Tempe, Mesa and Holbrook. In addition to Arizona, participating teachers and schools are from New Mexico, California, Ohio, Minnesota and Texas.**

CALIFORNIA - **Stevens Creek Elementary School in Cupertino** was an original ACOT classroom and is a Longitudinal Research Center. The ACOT project involves 180 students in grades 1 through 6, six teachers and one coordinator. Because of its LRC status, Stevens Creek is the site of a number of research efforts involving multimedia composing, assessment and cognition. In addition, how school architecture impedes or enhances learning, pedagogical developments and the interactive use of technology is being studied at Stevens Creek.

CALIFORNIA - **Davidson Middle School in San Rafael** is an Experimental Learning Center site using the project name "MacMagic." MacMagic is a curriculum that draws upon the unique experiences of a multi-cultural, multi-lingual class of students, who have diverse abilities, and the tools to support that curriculum. A key tool is called MultiMedia Works, which aids students in the research, creation, analysis and synthesis of information displayed as text, graphics, full-motion images and sounds. ACOT and LucasFilms have created extensive multimedia tools to help students discover and express historical and cultural knowledge. Researcher Roy Pea of the Institute for Research on Learning is studying how multimedia documents are judged by students and teachers and how they arrive at those judgements.

CALIFORNIA - **Henry M. Gunn Senior High School in Palo Alto** is an Experimental Learning Center where simulations and their use to improve students' understanding and skills of scientific inquiry are under study as a project called SimBase.

CALIFORNIA - **Students at schools in San Francisco and Berkeley** are using a computer simulation about velocity and acceleration called the "Envisioning Machine" so that researcher Jeremy Roschelle of UC Berkeley can determine new ways to help students understand scientific concepts. The project is developing a curriculum that couples learning-by-doing with an interactive process called "meaning-alignment" that helps students replace faulty concepts about velocity and acceleration with accurate ones.

CALIFORNIA - **A teacher at Edison High School in Stockton** is one of 20 teachers around the country participating in a project called JEDI or Joint Education Initiative to develop a scientific inquiry curriculum and materials to go along with a specially-designed CD-ROM database of images about earth science . *(See Virginia entry for more information)*

CALIFORNIA - **Two science teachers at Gage Elementary and Abraham Lincoln Preparatory schools in San Diego** are using digital image processing technology much like it is being used by space scientists and biomedical researchers. ACOT is studying the impact digital image processing has on science learning including how it changes students cognition and motivation. *(See Arizona for more information)*

IDAHO - **A teacher at Centennial High School in Meridian** is one of 20 teachers around the country participating in a project called JEDI or Joint Education Initiative to develop a scientific inquiry curriculum and materials to go along with a specially-designed CD-ROM database of images about earth science . *(See Virginia entry for more information)*

MARYLAND - **Teachers at both Margaret Brent Middle School in Helen and J.T. Baker Intermediate School in Damascus** are two of 20 teachers around the country participating in a project called JEDI or Joint Education Initiative to develop a scientific inquiry curriculum and materials to go along with a specially-designed CD-ROM database of images about earth science . *(See Virginia entry for more information)*

MASSACHUSETTS - **At Weston High School, Newton High School and Belmont High School** students and teachers are using computer simulations and "hands-on" activities to do scientific experiments to learn new mathematics skills and develop a deeper understanding of subjects such as probability and fractal

geometry. Researchers H. Eugene Stanley and Paul Trunfio of Boston University are investigating how the learning of abstract mathematical concepts could be enhanced with computers. This ELC project is called "Learning Science through Personal Discovery."

MASSACHUSETTS - **Fletcher Elementary School in Cambridge** is an Experimental Learning Center where 5th and 8th graders are doing hands-on data integration using a new visual tool called TableTop, which helps students organize and analyze data and improves their scientific inquiry skills. Chris Hancock of the Technology Education and Research Center is studying the capacity for children at these grades to build and use data in sophisticated ways.

MASSACHUSETTS - **Education Development Center of Boston** is building a software tool that allows teachers to do on-line, as opposed to on-paper, assessment of students' work.

MASSACHUSETTS - **James Kaput of Southeastern Mass. University in North Dartmouth** is doing a project called "Images of a Technological Future," video scenarios that depict innovative mathematics software. These videos will serve as a visual guide to help mathematics teachers and software designers produce a coherent mathematics learning system that would inspire children to learn math. The videos display an integrated set of tools, a common interface and a command structure across topic and grade levels. Animated segments demonstrate how to teach middle school students the basics of calculus.

MINNESOTA - **Blue Earth School in Blue Earth** was an original ACOT site and now is an Experimental Learning Center with a special focus on using global telecommunications to enhance learning and to integrate multi-cultural information into the curriculum. The ACOT project involves 160 students in grades 5 and 6, six teachers and a coordinator.

MINNESOTA - **A science teacher at Mayo High School in Rochester** is using digital image processing technology much like it is being used by space scientists and biomedical researchers. ACOT is studying the impact digital image processing has on science learning including how it changes students cognition and motivation. *(See Arizona for more information)*

NEW MEXICO - **Six science teachers in Aztec, Corrales, Farmington, Las Cruces and Silver City** are using digital image processing technology much like it is being used by space scientists and biomedical researchers. ACOT is studying the impact digital image processing has on science learning including how it changes students cognition and motivation. *(See Arizona for more information)*

NEW YORK - **Bronx High School of Science in New York City** has an Experimental Learning Center project where technology supports a curriculum focused on teaching inquiry skills. This project explores a "systems thinking" approach to student investigations. Students use STELLA simulation software, HyperCard ®, MacWrite II ®, MacPaint ®, and LabView software to do their systems thinking projects.

OHIO - **West High School in Columbus** was an original ACOT site and is a Longitudinal Research Center. The ACOT project involves 120 students in grades 9 through 12 and an integrated team of eight teachers and one coordinator. As they enter, 9th grade, students are randomly selected to participate in the ACOT project and may remain through graduation. In the ACOT classrooms, teachers of different subject specialties team teach. As an LRC, West High School is the site of a lot of research including studies about a new software tool that makes it easier for students to learn the concept of functions in math, a new intelligent tutor in physics, digital image processing applications and an interactive multimedia resource about the circulatory system. At West High School, ACOT is trying a variety of new student assessment tools including using portfolios as well as testing collaborative teaching, learning, problem solving and critical thinking.

In addition, at West High how school architecture impedes or enhances learning, pedagogical developments and the interactive use of technology is being studied.

OHIO - **A teacher at Worthington High School in Worthington** is one of 20 teachers around the country participating in a project called JEDI or Joint Education Initiative to develop a scientific inquiry curriculum and materials to go along with a specially-designed CD-ROM database of images about earth science . *(See Virginia entry for more information)*

SOUTH DAKOTA - **A teacher at Brandon Valley Middle School in Brandon** is one of 20 teachers around the country participating in a project called JEDI or Joint Education Initiative to develop a scientific inquiry curriculum and materials to go along with a specially-designed CD-ROM database of images about earth science . (See Virginia entry for more information)

TENNESSEE - **Dodson Elementary School in Hermitage** (a Nashville suburb) was one of the original ACOT classrooms and is the Experimental Learning Center designated as ACOT's first teacher development center. New strategies that build on the potential of technology as a catalyst for teacher development are being designed and studied. The ACOT project at Dodson involves 86 children in grades 3 and 4 as well as those with learning disabilities, three teachers and a coordinator.

TENNESSEE - **Lester Demonstration School in Memphis** was one of the original ACOT classrooms and is now an Experimental Learning Center with a special focus on developing a holistic view of language arts with the help of technology. The ACOT project involves 90 students in grades 4 to 6, three teachers and a coordinator.

TEXAS - **Clear Creek High School in Clear Creek** (a Houston suburb) is the Experimental Learning Center helping Bowen Loftin of the University of Houston and NASA create and test an intelligent tutor that helps students learn physics. This new kind of software helps students create solutions by interactively developing a diagram of a problem (if appropriate), choose variables and relationships, and perform algebraic and arithmetic operations. The tutor observes a student's behavior as he or she develops a solution and then interacts, as needed, to assist the student in acquiring good problem-solving skills.

TEXAS - **A science teacher at San Jacinto Junior High School in Midland** is using digital image processing technology much like it is being used by space scientists and biomedical researchers. ACOT is studying the impact digital image processing has on science learning including how it changes students cognition and motivation. *(See Arizona for more information)*

VIRGINIA - **Students and teachers at 10 schools in Virginia as well as schools in Arizona, California, Idaho, Maryland, Ohio, South Dakota, Washington, D.C., and Wyoming** are participating in JEDI, the Joint Education Initiative initiated by William Greenwood of the U.S. Geological Survey. JEDI's main goal is to invigorate the teaching of earth sciences in primary and secondary schools. Teachers and scientists at federally-funded agencies such as the USGS, the National Aeronautics and Space Administration and the National Oceanic and Atmospheric Administration are developing a scientific inquiry curriculum and new teaching materials. These materials include a CD-ROM database of earth and astrological images.

Under study is whether providing opportunities for students to do "real" science with professional tools and databases spurs their intellectual development and allows them to make new scientific discoveries. **Participating Virginia schools are in Burke, Leesburg, Ashland, McLean, Henrico, Alexandria, and Falls Church.**

WASHINGTON, D.C. - **Teachers at Phoebe Hearst Elementary School and The Smithsonian Institution** are two of 20 teachers around the country participating in a project called JEDI or Joint Education Initiative to develop a scientific inquiry curriculum and materials to go along with a specially-designed CD-ROM database of images about earth science . *(See Virginia entry for more information)*

WYOMING - A teacher at **Dean Morgan Jr. High School in Casper** is one of 20 teachers around the country participating in a project called JEDI or Joint Education Initiative to develop a scientific inquiry curriculum and materials to go along with a specially-designed CD-ROM database of images about earth science . *(See Virginia entry for more information)*

CANADA - **Huron School in Toronto, Ontario along with Marlene Scardamalia and Carl Bereiter of the Ontario Institute for Studies in Education (OISE)** are partners in an ELC project called "Computer-Supported Intentional Learning Environments" or CSILE. At the heart of CSILE is an unusual database that includes various kinds of student-generated information as well as an encyclopedia and dictionary and tools for drawing and other functions. This database supports knowledge manipulation and construction as students collaborate on language arts and social studies projects. CSILE is designed to help students notice gaps in their information, formulate questions and plan searches for new information outside thedatabase for inclusion later on.

In addition to the researchers and institutions mentioned above, ACOT is partners with researchers at the following institutions:

Ohio State, Bank Street College of Education in New York, the University of California at Los Angeles and the Institute for Research on Learning in California where alternative ways of assessing student achievement are being investigated and tested. These studies use data culled from many ACOT schools.

Cornell University in New York where new tools for collecting, managing, analyzing and displaying qualitative research data are being created.

Ohio State and UCLA where a new classroom observation instrument to better document instructional tasks done by students is being created.
Institute for Research on Learning in Palo Alto, Calif. is developing a software tool to facilitate the use of video media for research on learning.

New Jersey Institute of Technology is studying how school architecture impedes or enhances learning, pedagogical developments and the interactive use of technology at ACOT's Longitudinal Research Center schools in Arizona, California and Ohio.

7