APPLE CLASSROOMS OF TOMORROW

Research

Evaluation Study: First- and Second-Year Findings

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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.

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Preface

The Apple Classrooms of Tomorrow (ACOT) research project explores learning when children and teachers have immediate access to interactive technologies. ACOT's longitudinal research and development efforts examine the impact of technology on teaching and learning and create more powerful applications.

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.

Introduction

In 1987, the UCLA Center for Technology Assessment began examining the impact of the ACOT program on students, staff, and parents. UCLA's long-term goal was to develop a model for evaluating educational uses of computers and other technologies.

This report summarizes the results of the first two years of the project. The original assessment model, consisting of primarily traditional measures, has since evolved into a model that requires development of new assessment tools that measure non-traditional outcomes such as understanding complex phenomena, problem-solving skills, and changes in classroom processes.

In 1987, a year after ACOT provided teachers and students in five public school sites with personal computers for school and home use, UCLA Center for Technology Assessment initiated a long-term examination of the impact of ACOT's innovative program on students, staff, and parents. The goal was to develop a model of technology assessment appropriate for evaluation of educational uses of computers and other technologies.

Recognizing the imperfections of existing measures to assess outcomes in classrooms that are notably different from traditional classrooms, the model emphasized the need for data collection from several perspectives and for responsiveness to a variety of outcomes. Consequently, the model included a range of measures and multiple benchmarks from which to assess progress and impact. This model continually challenged the sensitivity of existing measures and has since shifted focus to the development of new assessment tools that can better capture the diverse and complex outcomes of ACOT. A new tool development mission thus has evolved naturally from within the assessment project, encompassing the development of technology-based tools to assist the research and evaluation process.

This report summarizes the results of the first two years of the project. Initial work in the 1987–88 school year explored the appropriateness of the original assessment design and developed a baseline profile of students' performance on traditional measures. Data collected included students' achievement on standardized tests, writing performance, and attitudes. In 1988–89, the research team added measures and initiated development of new instruments to document ACOT's impact on teachers, parents, students' problem-solving skills, and classroom processes.

The final section of this report outlines the status and future plans for developing new assessment tools to document the kinds of changes that are reported by ACOT participants but not adequately assessed by existing instruments. These include measures to assess students' understanding of complex phenomena, problem-solving skills, affect, portfolios of accomplishments over time, and an observation measure to assess changes in the nature of teaching and learning in the classroom.

The Study

Overview

In 1987–88, the team gathered data on students' achievement on standardized tests, writing performance, and attitudes. Informal data were also collected on students' problem-solving skills and process writing, highlighting the need to develop measures that assess these outcomes.

The initial focus of the research was to study the diverse effects of ACOT's technology-rich environment on students, teachers, and parents. During the first year, 1987–88, the UCLA team gathered baseline data on student outcomes using validated measures that would permit comparisons of ACOT students' performances with a national sample and over time. Outcomes included students' achievement on standardized tests, writing performance, and attitudes. Equally important was the collection of qualitative data to identify apparent effects which were not well assessed by available measures. Outcomes such as growth in students' problem-solving skills and improved writing highlighted the need for developing new assessment tools.

In 1988–89, many of the same measures were applied, as well as new ones to assess students' writing, attitudes, and teachers' stress. New measures under development that year included tools to assess students' deep understanding of history material, problem-solving skills, and classroom process.

The intent of year two, 1988–89, was to carry forward the essential structure of the 1988 evaluation plan while adapting or developing additional measures as needed to augment the design. Primary goals were to secure appropriate comparison classrooms for all sites, reapply measures of student achievement and attitudes, and develop and administer measures of ACOT's impact on teachers and parents. Furthermore, UCLA collaborated with teachers in the design of alternative writing assessments and adopted new normed instruments for primary students' attitudes and for teachers' occupational stress. Extensive work also was undertaken to develop several new measures for administration in 1989–90: a measure of students' deep understanding of history material using HyperCard® as the assessment medium, an assessment of elementary students' problem-solving abilities, and a technology-based observation tool for documenting classroom process in high-access technology environments.

Data Collection

During the first two years, the team applied several measures to document changes in ACOT participants' achievement, attitudes, and practices. Student measures included standardized achievement tests, evaluation of writing samples, and multiple measures of attitudes.

Over the two-year period, the team applied a variety of traditional and innovative measures to document changes in ACOT participants' achievement, attitudes, and daily practices.

Student Achievement

Student achievement was assessed by administering selected Iowa Tests of Basic Skills (elementary) or the Iowa Tests of Educational Development (secondary), and by collecting writing samples of narrative, descriptive, persuasive, or expository writing.

Teacher measures included an occupational stress inventory and questionnaire. Parents' views were documented by a specially developed questionnaire.

In 1987–88 samples were collected of all students' writing across two or three genres, but in 1988–89 each site focused just on those genres emphasized by the local instructional program. Also in 1988–89, the team collaborated with teachers at several sites in the design and development of an experimental version of the writing assessment measure that permitted students to revise their essays on the second day. The prompts were derived or adapted from those used in the International Association for the Study of Educational Achievement (IEA) Study of Written Composition (Baker, 1987).

In 1987–88, specially trained raters scored all student essays on IEA scales for Overall Impression, Organization, Content, and Style. In 1988–89 IEA scales were used only for students in grades 5 and up, since the IEA national samples were drawn from grades 6 and 10; the essays of students in grades 2–4 were rated with scales developed and used by Conejo Valley School District, a southern California district that has developed its own rubric (derived from the same sources as the IEA scales) for assessing the competence of its 3rd graders in narrative writing.

Student Attitudes

Student attitudes were assessed using five different approaches: 1) responses to a nationally normed measure, the School Attitude Measure (SAM), for grades 4–8; the Self-Concept and Motivation Inventory (SCAMIN), for grades K–2; 2) ratings of students' attitudes toward computers in their persuasive essays on a computer topic; 3) responses of teachers to questionnaire and interview items concerning their perceptions of students' attitudes; 4) responses of parents to questionnaire and interview items concerning their perceptions of students' attitudes; 5) examination of student attendance and mobility patterns for sites that were able to provide these data.

Teachers' Practices, Perceptions, and Attitudes

Teachers were asked to complete a specially designed questionnaire as well as a nationally normed instrument, the Occupational Stress Inventory (OSI). The Teacher Questionnaire focused on a range of topics including curricular practices, perceptions of students' achievement, and attitudes toward work. The OSI is a self-report survey consisting of three dimensions of occupational adjustment: Occupational Roles, Personal Strain, and Coping Resources.

Parents' Views, and Home Uses of Computers

To assess the impact of ACOT on parents and home interactions, the specially developed Parent Questionnaire solicited parents' perceptions of the impact of ACOT on their children, parents' aspirations for their children, and family members' uses of the computer at home.

Findings reported here are based on measures used in the first two years, not the ones developed more recently. Additional constraints include the extreme diversity of the sites, district restrictions, and difficulty in procuring comparison groups.

Findings and Interpretations

Findings reported here are based on data from the measures administered during the first two years of the study; any conclusions from them about the effects of ACOT on students and other outcomes would be premature. In addition to the frustration brought about by the existing measures, other constraints included: extraordinary diversity among the five sites in student characteristics, curriculum emphases and activities, parent and home characteristics, and the nature of the comparison samples. Comparison classrooms were difficult to procure because few were willing to be compared to high-tech classrooms. In addition, district restrictions, scheduling conflicts, and staffing limitations interfered with the consistent administration of each measure across all sites, leaving gaps which weakened the grounds for interpretation. Finally, and importantly, some nontraditional outcomes, which are most highly valued by ACOT participants and other advocates of education reform (e.g., Sizer, 1985), such as critical thinking and performance on complex tasks, were not included in the formal assessments at that time. Nevertheless, some inferences are possible.

Students maintained performance levels on standard measures of achievement, and they sustained positive attitudes.

Teachers reported a variety of benefits and personal challenges resulting from the ACOT experience. Most were quite satisfied with students' progress.

Parents generally felt ACOT had benefited their children in their knowledge of computers, attitudes towards learning, and achievement. Home computers were used for school work, games, personal writing, practicing, and graphics.

Results of Data Analyses

Students

Results showed that ACOT students maintained their performance levels on standard measures of educational achievement in basic skills, and they sustained positive attitudes as judged by measures addressing the traditional activities of schooling. Generally, the ACOT program was at least as effective in promoting commonly measured student outcomes as the more typical instructional programs provided by the comparison sites, and in at least one site there were indications of advantage for ACOT students. Results of the experiment in the assessment of writing process showed that secondary level students were more able to improve the quality of their essays in their rewrites, however, more systematic administration of this version is need.

Teachers

Analyses of 1988–89 data indicated that ACOT had considerable personal and professional impact on its teachers. Some teachers appeared to be constructing new interpretations of their own and their students' abilities and of students' roles in their own learning. Some had developed higher expectations for their students, and most teachers were quite satisfied with their students' academic and socio-emotional progress, though some expressed concerns about covering the standard curriculum. Many teachers noted the value of computers in their teaching and the positive impact on their job interest and performance. Many reported improved teacher-student roles and positive feelings of self-worth. Although most teachers experienced personal stress, they reported the challenge and growth to be more significant.

Parents and the Home

ACOT parents generally felt the project had benefited their children in their knowledge of computers, attitudes toward learning, and achievement, though they had some concerns about curriculum coverage. Home use varied considerably across site and grade, providing provocative data on possible relationships between computer use and socioeconomic level (e.g., computers are a novelty in lower SES homes) and grade (e.g., homework demands upon secondary students limit access for other family members). The computers appeared to be increasingly integrated in home activities, most children using them for homework, games, personal writing, practicing, and graphics.

Interpretations

Students maintained performance levels on standardized tests even though they spent considerable time learning to use computer hardware and software. Further, informal observation suggests that ACOT students did improve in other unmeasured areas. Consequently, new measures are under development to assess students' deep understanding and changes in classroom process such as increased collaborative learning and attention to higher-level cognitive tasks.

These results can be viewed as positive when ACOT is placed in the context of the larger school setting. First, the ACOT environment differs from traditional classrooms in that it requires adapting to a host of new technological possibilities. Students spend time learning word processing and other software that otherwise would be spent on traditional school subjects. Similarly, teachers spend time acquiring technology skills and familiarity with supportive software that might result in less time spent in curriculum planning. Further, class time is used for technical instruction, experimental use of new software and hardware, and simply recovering from technical failures. Any of these short-term problems could result in less than expected academic growth or an undermining of motivation and attitudes. These negative consequences on student outcomes have not been observed.

Second, and more importantly, informal observation suggests the experience of ACOT itself appears to be resulting in significant new learning experiences for students and greater attention to complex, higher level processing. Because more time in complex problem solving may translate into less time in basic skills instruction, some decrement in basic skills test performance also might be expected. From both these vantage points, then, maintenance of pre-ACOT performance levels is viewed as an accomplishment.

Beyond maintaining performance on standard indicators, ACOT sites show promising evidence of effectiveness in supporting student growth in competencies that are not well assessed by traditional measures. Non-standard measures developed in the second year to address these outcomes (measures that involve student construction of HyperCard stacks to represent deep understanding) were administered in 1989–90, but have not yet been analyzed. Classroom observations also suggest that ACOT has effects on instructional processes that will very likely lead to positive outcomes; for example, some ACOT classrooms feature greater emphasis on higher-level cognitive tasks, student initiative, and cooperative group activities than do traditional classrooms. As the newly developed observation instrument is being used to validate these impressions, the team is also moving forward in developing new measures to better tap the likely outcomes of such changes.

Finally, with strong impressions of ACOT-related gains in student attitudes, the assessment team is experiencing some frustration with existing measures. Most measurement experts have serious reservations about the validity and reliability of currently existing scales dealing with such affective domains as motivation, responsibility, and student self-concept (Wittrock, 1990; McCombs, 1990). Further, these measures focus on traditional school contexts and activities. Because the measures do not reflect the technology-rich environment of ACOT, interpretation of student responses is difficult. Devising more suitable measures of students' attitudes in high-access technology environments is another goal of the assessment team.

Current and Future Directions

ACOT is a living laboratory in which participants explore and refine the innovative possibilities of technology for teaching and learning. One of the unique characteristics of the program is that it fosters continued experimentation, which stimulates new goals, alternative instructional approaches, and new outcomes. Its evolutionary character also presents special assessment challenges requiring close-up interaction with sites to understand the changes, and new tools to capture the unique changes and complex outcomes being produced. The insufficiency of standard measures for assessing such change is one clear conclusion from the assessment efforts to date. Thus, while the team will continue to monitor and document the effects and impact of ACOT in the longitudinal research sites, the focus is now on development of new measurement tools that can adequately represent project outcomes as they evolve.

The insufficiency of standard measures for assessing non-traditional outcomes is one clear conclusion from the assessment efforts to date. Thus, the focus is now on development of new measurement tools that accurately represent project outcomes as they evolve.

The innovative assessments currently being developed draw on technology as a stimulus to educational outcomes and as a medium for measurement of those outcomes. Following are some of the assessment strategies and tools currently under development at UCLA Center for Technology Assessment.

Some of the assessment strategies and tools under development include the following:

- *A classroom observation instrument that captures the cognitive, social, and affective dimensions of classroom tasks. The measure documents changes in subject matter, social organization, materials given to students, expected responses, role of adults, and other categories.*
- *A HyperCard-based tool for measuring students' deep understanding of complex phenomena. In the first experiment, students used a specially designed HyperCard stack to construct concept maps o f their Depression-era history knowledge.*

A New Mirror for the Classroom

In 1988-89, the assessment team developed a technology-based classroom observation instrument to capture the effects of technology on classroom instruction. The instrument focuses on the instructional tasks in which students are engaged, documenting cognitive, social, and affective dimensions of each task during specific observation periods. Observation categories include: subject area of instruction, social organization, the nature of materials given to students, the nature of the responses students are asked to produce, resources in use, the role of adults, and apparent affective responses to each task.

The observation form is a three-page scannable form. Scanning and desktop management and analyses tools used in conjunction with the instrument enable instant updating of the observation database and rapid analysis of emerging hypotheses. Desktop display and a variety of graphic capabilities can also enhance staff development as well as research applications.

- *A measure of the level and transferability of students' problem-solving skills. The team designed problems to be solved both on-computer and off which were similar to those given frequently at certain sites.*
- *A strategy for assessing students' collected work over time. In 1989–90, students accumulated monthly writing samples and special projects in portfolios, which will be evaluated on scales (to be developed) of competence.*

The instrument was used in 1989–90 at two ACOT sites. A primary function of the 1989–90 data collection was to begin the empirical documentation of commonly reported changes in classroom practices of high access environments. Researchers and educators seem to agree, for instance, that computer use leads to more time on task, greater student motivation, more peer assistance, less directive teaching and more teacher facilitation, and more frequent group projects. However, prior to ACOT there has been little empirical documentation of these changes.

A Hypermedia Measure of Knowledge Representation

The HyperCard assessment project is constructing relationships between instructional uses of computers and new approaches to assessing student performance. Addressing the specific problem of access to students' understanding of complex phenomena, the project investigates how technology can provide opportunities to assess learning with new levels of cognitive and instructional validity.

The inquiry is an outgrowth of a long-term, Department of Education-funded study on the assessment of deep understanding through the use of extended student essays. Results of prior studies (Baker, 1988; Baker et al., 1990) show that deep understanding of a subject can be assessed by the extent to which student essays on the subject are premise-driven; elaborated with prior knowledge; and exhibit significant levels of interrelationships among facts, concepts, and principles. However, the quality of students' verbal expression affects raters' ability to assess the quality of student content understanding.

In an effort to investigate whether HyperCard representations could provide a more direct measure of understanding, the ACOT assessment team conducted a study with eleventh-grade history students. Students used a specially designed HyperCard stack to construct concept maps of their Depression-era history knowledge before writing essays on given topics. Scoring schemes for analyzing these HyperCard knowledge representations are being developed and their relationships to other measures investigated. The generalizability of the assessment schemes to science topics will be tested in subsequent studies.

New Measures of Problem Solving

The interactive, responsive, and flexible character of computer use provides an inviting context for learning problem-solving skills. Many elementary-level teachers have been attracted to instructional software packages that foster higher-level reasoning abilities such as collection, organization, and appropriate use of information when making inferences. Because there is conflicting evidence in psychological and educational research on the transfer of cognitive skills from one subject to another, and thus limited potential usefulness of isolated problem-solving practice, the assessment team felt it was important to document what kinds of gains, if any, could be demonstrated from use of problem-solving software.

Based on 1988–89 field observations and teachers' descriptions of their problem-solving instruction, the team designed tasks for solution both on-computer and off which were structurally and functionally similar to those practiced frequently at certain ACOT elementary sites. These tasks were administered twice during 1989–90 (fall and spring) to a sample of ACOT and comparison children who were rated as either high or low in academic ability at one of two different grade levels. While the results of the study are expected to provide useful feedback to users of instructional problem-solving software, the study can also be used as a model for the assessment of cognitive outcomes, one that stresses carefully motivated tasks based on documented classroom practices.

Systematic Assessment of Student Portfolios

There is a dramatic movement in the field of educational measurement to go beyond standard, multiple choice tests to develop measures which better represent instructional outcomes and enable students to demonstrate skills. One major facet of this interest is the assessment of student portfolios. ACOT provides an appropriate context to investigate how to systematically assess student portfolios, starting with those comprised of writing samples. In 1988–89 examples of student writing were collected, as well as information from teachers about their writing curriculum. Based on this fieldwork and informed by knowledge of colleagues' portfolio assessment efforts, particularly the work of Robert Tierney (Tierney, in press), the team designed a portfolio evaluation procedure which was implemented at an elementary level ACOT site in 1989–90.

The portfolios contain monthly samples of students' "best" writing in two genres that were emphasized at this site, as well as samples of other "showcase" projects that a student chose to include. ACOT teachers collaborated with UCLA's on-site researcher in developing criteria for inclusion as well as procedures for documenting the instructional process that preceded the final product. The resulting data set contains a series of writing samples to be evaluated on scales (to be developed) of writing competence; a set of student-selected projects that will inform our understanding of the students' views of their ACOT experience; and documentation of teachers' methods of writing instruction.

There is exciting potential for hypermedia portfolios in all subject areas, and for coordination of UCLA efforts with Robert Tierney at Ohio State University. Although the initial effort is devoted to collection and analysis of hard copies of written work, the goal is to develop computer-based portfolios. The range of product types that can be stored in hypermedia formats is virtually unlimited, from written samples (scanned if handwritten), to art work (again scanned if not computer-based), to video, to audio, to HyperCard reports. The ACOT sites provide unique contexts for exploring these possibilities in that ACOT students have easy access to hypermedia technology for storing their work, and many of their projects are already hypermedia products that are most effectively displayed, reviewed, shared, and evaluated in a hypermedia format.

Future Work—A Measure of Students' Attitudes

Sensitive assessment of the effects of ACOT as well as other innovations in educational technology requires a varied measurement tool kit to capture a full range of high probability changes. Changes in students' attitudes—their persistence, independence, pride in work, among other attributes—are not only informally observed effects of ACOT, but subjects of continuing national dialogue on this country's productivity and future competitiveness. Devising better measures of these constructs, likely grounded in observational, performance-based instruments, is a future goal of the ACOT assessment component.

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