In the past twenty years, computers have become an essential tool for communication, work and entertainment. For the new generation of children born in industrialized countries, a world without computers and video games seems more preposterous than a little green man from Mars. Computer-related occupations are the fastest growing segment of the modern job market, and the mastery of computer technology gives a competitive edge to individuals and nations alike. To address this growing need for a technology-savvy population, policymakers and administrators are scrambling for money to bring computers into the classroom, while critics argue that this money can be better employed on traditional instructional methods. This debate is critical, particularly for developing countries, due to the magnitude of the investment involved in buying and maintaining computer hardware and software, and providing adequate training for teachers and school staff.

As a contribution to this debate, this article summarizes four research reports on:

1. the relationship between the use of computers and mathematics achievement;
2. the impact of computers in classrooms on the academic achievement of elementary school children;
3. the use of computer assisted instruction to improve the reading; and
4. how computers are used in classrooms internationally.


Focus: The study focuses on the relationship between technology characteristics and educational outcomes and addresses the question of “what kind of computer use has what kind of effect, on which groups of students.”

Methods: The researcher used a technique of structural equation modeling with four variables: (1) frequency of school computer use for mathematical tasks; (2) access to/frequency of home computers use; (3) professional development of mathematics teachers in technology use; and (4) higher-order and lower-order use of computers by mathematics teachers and their students. Higher-order activities for fourth graders were learning games and for eighth graders were applications and simulations, while drill and practice were defined as lower-order use. Data was obtained from a national sample composed of 6,227 fourth-graders and 7,146 eighth-graders controlled for socioeconomic status, class size, and teacher characteristics (education level, years of experience, presence/absence of degree in mathematics). Outcomes included academic achievement in mathematics and the social environment of school. Models were accepted when goodness of fit indices were better than .9 and results were statistically significant at .05 level.

Findings:

1. The greatest inequities in the use of technology were related to how computers were used, rather than the frequency of use. For instance:
   - Among eighth-graders, students who were black, poor, and from urban and rural areas were less likely to be exposed to higher-order uses of computers and more likely to be exposed to lower-order uses than students who were white, non-poor and from the suburbs.
   - For both fourth- and eighth-graders, mathematics teachers in urban and rural schools were less likely to have received professional development in technology over the last five years than teachers in suburban schools.

2. Academic achievement in mathematics and the social environment of the school were positively related to:
   - teacher’s professional development in technology;
   - the use of computers to teach higher-order thinking skills; and
   - the frequency of home computer use (eighth-graders only).

3. Academic achievement in mathematics was negatively
related to:
♦ the frequency of school computer use;
♦ the frequency of home computer use (fourth-graders only); and
♦ the use of computers to teach lower-order thinking skills (eighth-graders only).

4. Professional development and use computers for higher-order thinking skills were each associated with:
♦ more than one-third of a grade level increase in mathematics as measured by the National Assessment of Educational Progress for eighth-graders; and
♦ a negligible contribution (about a tenth of a grade level) for fourth-graders.

Observations: The researcher cautioned that:
1. The research does not solve the issue of whether the uses of technology promote high levels of academic achievement or whether high-achieving students are more likely to use technology in certain ways.
2. Computers may be one of the many media used to teach higher-order thinking skills and that all of these media are conducive to high levels of academic achievement.

www.milkenexchange.org/research/wvirginia_summary.html

Focus: The report presents an evaluation of the Basic Skills/Computer Education (BS/CE) Program, a statewide eight-year project to implement computer technology in West Virginian elementary schools. The project, which began with the kindergarten class of 1990-1991, included the distribution of hardware to schools to ensure easy and regular access to technology, the development and distribution of basic skills software compatible with the state’s educational goals, and teacher training on the use of technology.

Methods: Researchers collected data from state and publishers’ test files, Stanford-9 achievement test scores, surveys, on-site documentation, case analyses and interviews. Data were analyzed in relation to access, attitude and training. Results were statistically significant at .001 level.

Findings:
1. Students showed significant improvement in scores on the Stanford-9 achievement test; gains in score were positively related to the amount of experience the students had on each component of the model.
2. Children who did not have computers at home made the biggest gains in total basic skills, language, reading and vocabulary scores.
3. Contrary to the idea that girls are not technology-driven, girls used computers as much as boys and had similar score gains in math and reading tests.
4. Students who had access to computers in their classrooms had higher overall scores and math scores than students who were taught in laboratory settings.
5. Teachers who had computers in the classroom reported higher skill levels in delivering instruction, planning lessons, managing paperwork and word processing, and more time using computers for reading, math and writing instruction than teachers whose access was limited to computer laboratories.
6. Almost half (48%) of the teachers rated technology as the number one explanation for the student learning gains.
7. Cost benefit analysis showed that the BS/CE program is more effective in improving students’ achievement than other interventions, including class size reduction, increased instructional time, and cross age tutoring programs.

Observations: Researchers cautioned that:
1. The instructional learning system used in the program was a decade old and outdated both in terms of the pedagogy underlying the system and the technology employed (newer systems and technology could result in more significant gains).
2. The program fits the learning and teaching realities of West Virginia at that time and may not be appropriate for schools in other localities.

Focus: The study examines the effects of computer-assisted instruction (CAI) on the reading skills of first graders during the course of a complete academic year.

Methods: The students received sixty minutes per week of CAI on a PLATO/WICAT System 300, a minicomputer with hard-disk storage that supports up to 30 students' workstations with graphics, animation and audio capabilities. The computer interfaced with each student individually. The software, WICAT Primary Reading curriculum, included interactive exercises and the reading outcomes required by the state. The study included 85 first graders enrolled in two elementary schools in Oklahoma, approximately half in a school with computers (experimental group) and the other half in a school with no computer facilities (control group). The two groups were matched for gender, socioeconomic status and reading skills at the beginning of the school year. Pre- and post-test scores were analyzed for both groups.

Findings:
1. Extended use of CAI appears to significantly influence the development of reading skills in first graders (approximately 10 percent of variation in pre-post test change).
2. Boys in the experimental group showed statistically significant gains in reading skills compared to boys in the control group (at .01 significance level).
3. Although the girls in the experimental group showed improvements, their gains were not statistically significant when compared to girls in the control group.
4. Students with the lowest scores made the greatest advances, making up an average deficit of 60 points.

Observations: Researchers caution that:
1. Gender-related differences might reflect the influence of gender socialization, or the fact that most girls had already high scores in the pre-test.
2. Improvement in scores may be a function of the greater interest and motivation shown by the students in the experimental classrooms (an indirect effect of CAI).


Focus: The Computers in Education Study is one of the first studies to assess the use of computers in different countries. The study, conducted under the auspices of the International Association for the Evaluation of Educational Achievement (IEA), describes how, and to what extent, computers are used in education, the changes in uses over time, the factors that influence these changes, and the effects of computers on students' knowledge and attitudes toward technology.

Methods: The study was conducted in two stages. Stage I, from 1987-1990, collected information on the use of computers to assist the instruction of traditional academic subjects and the organization of computer-specific instruction, such as programming and word processing. Participants were school principals and teachers of elementary and secondary schools in 21 countries, including users and non-users of computers. Stage II was conducted from 1991 to 1994. It focused on students' use of computers, their attitudes toward technology and the knowledge of instructional technology as measured by a standardized test. This stage involved 69,000 students in grades 5, 8, and 11 in 2,500 schools in about 12 different countries.

Findings: Among the major findings of Stage II were:
1. The availability of computers for instructional use is increasing in all participating countries; in 1989, the United States was the only country that reported having computers available for instructional use in all elementary and secondary schools; in 1992, all countries had schools equipped with computers.
2. However, access to computers for instructional use varies significantly among participating countries (for instance, in 1992 in Japan, 65% of elementary schools and 29% of secondary schools had computers, while in India, computers were available in only 42% of the schools).
3. Access to external networks is still rare, except in the U.S., Austria and the Netherlands, and their regular use is infrequent in all participating countries.
4. Although the quantity of software available to schools has improved since 1989, shortage of software is still seen as an important problem.
5. Computers are mostly used for teaching about computers.
and their applications among secondary school students and, for elementary school children, computers are mostly used to play games.

6. Only a minority of students uses computers regularly to learn about academic subjects, such as mathematics, science and mother tongue.

7. The use of computers outside schools for schoolwork increases as students move from elementary to secondary level.

8. Computer-related curricula vary enormously among countries and even within a same country and so does the knowledge of students on computer-specific topics.

9. Students seem to learn more about computers outside school.

10. Although most students strongly perceive computers as relevant for their future, they do not always enjoy computer-related activities.

11. A large number of students tend to agree with illegal practices, such as copying software, indicating a need for schools to focus on the ethical uses of computers.

12. Although the knowledge and skill level of the teachers who provide computer-related instruction is quite high, many teachers indicate the need for further training.

13. The majority of schools use as computer coordinator a regular teacher who has no time to plan and implement ongoing training for other teachers.

14. Although the integration of computers in the overall curriculum happens only to a small extent, there are indications that this type of use is becoming more important.

15. Overall, male students score higher in a standardized test and are less intimidated by computers than female students.

**Conclusions:**

Research on the instructional use of computers is incipient and, as it happens with any other topic in education, it is marred in ideological fights and questionable studies. The summaries above present well designed carefully implemented research that deals with the influence of the educational use of computers on students’ academic achievement. As the *Computer in Education Study* shows, the questions to be asked in such studies are overwhelming. It is not enough to know that schools are using computers. It is important to assess who is using the computers, how frequently and for what purposes, how outdated or upgraded the hardware and software are, how integrated the computer use is to the overall curriculum, who is receiving the instruction and how much instruction is being received. In addition, it is also important to evaluate the social and cultural factors that influence the instructor, the student and the instructional process. It is possible that socially defined gender roles influence the amount of computer exposure offered to male and female students both at school and at home. This would explain the gender-related differences in the use of computer and achievement gains found in three of the studies above, but not in the Western Virginia project. Without further research, these are only conjectures. The studies summarized for this article show a positive relationship between instructional use of computers and students’ scores, particularly for those students most in need. The studies also show that positive effects are related to how the computers are used, a variable linked to the quality of educators and their professional development. However, to focus the research on how students score on standardized tests may be the wrong approach. Our educational structure, including curricula and the tests designed to assess curricular mastery, were developed a long time ago, during and for another economic reality. Even if the instructional use of computers does not increase mathematics scores in current standardized tests, it is important to assess its impact on students’ familiarity with technology, and on the encouragement of creative thinking and scientific curiosity -- valuable skills in a global, knowledge-based economy. These questions are yet to be asked. In the meantime, policymakers and school administrators must decide on how to spend education money. We hope that these and future summaries will promote more informed decision making processes.

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