Computers and Young Children: Social Benefit or Social Problem?*

PAUL ATTEWELL, *City University of New York*
BELKIS SUAZO-GARCIA, *City University of New York*
JUAN BATTLE. *City University of New York*

Abstract

Using time-diary data from a national sample of young school-age children, we examine the correlates of time spent at home on computing for cognitive and other measures of well-being. We observe modest benefits associated with home computing on three tests of cognitive skill, and on a measure of self-esteem. Most young children who spend time at home on computer-based activities spend no less time on activities such as reading, sports or outside play than children without home computers. However, young children who use home computers a lot, for over 8 hours a week, spend much less time on sports and outdoor activities than non-computer-users. They also have substantially heavier body mass index than children who do not use home computers.

The Digital Divide as a Social Problem

In recent years, government, scholars, and the media have heralded the emergence of a new social problem: the *digital divide*. In its narrowest sense, this term refers to the phenomenon of unequal access to personal computer technology, a divide separating families who have computers and access to the Internet at home from families who do not (U.S. Department of Commerce 1995, 1998, 1999, 2000, 2002.) Behind this definition stands a broader concern that people who already suffer economic or social disadvantages are likely to experience even worse problems in the future because they are being excluded from a computer revolution that is redefining social and economic life in our society.

* *This research was supported by NSF grant IIS 0079976.* *Direct correspondence to Paul Attewell, CUNY Graduate Center, 365 Fifth Ave. New York, NY 10016*.

 Social Forces, September 2003, 82(1):277-296

Children's education has become a focal point in discussions of the digital divide. If computers are powerful tools for learning, then children who lack access to computers in their homes or in their schools are likely to suffer serious disadvantages that may accumulate throughout their childhood years.

The digital divide metaphor can stretch beyond matters of unequal access from home and include children's access from school and adults' access from work. Furthermore, the metaphor can highlight inequalities in the *quality of involvement* with computing. Educational and social inequality may increase if less affluent children or children of lesser educational ability use inferior computers at school (fewer, older, slower, nonnetworked) or if their teachers are not well trained in the use of computers, or if their school's curriculum makes less effective or less advanced use of information technologies than other schools (cf. Attewell 2001; Becker 1999; Wenglinsky 1998).

The perception of the Digital Divide as a serious social problem is contested. Some commentators view the problem as short-lived, soon to be corrected via free-market forces (Samuelson 2002; Thierer 2000). Other scholars deplore the current enthusiasm for computers as misplaced. As detailed below, these researchers claim that information technologies can harm children, especially *young* children.

This debate between technology enthusiasts and technology detractors has been heavily speculative, discussing what might or could or will happen, rather than documenting the actual experiences of children with home and/or school computers. Consequently in scholarly reviews one finds disclaimers that factual information and empirical research are in short supply (Subrahmanyam et al. 2000:139).

This article examines empirical evidence that speaks to certain factual disputes about young children's use of computers that are important in Digital Divide debates. We draw from a special supplement to the Panel Study of Income Dynamics (PSID) to address claims that computer activities displace other forms of recreation or learning opportunities among young schoolchildren aged 13 and younger. The supplement also measures young children's cognitive skills, self-esteem, and other aspects of well-being, allowing us to determine whether children who use computers at home differ on these outcomes compared to those who lack technological access, after controlling for a wide range of demographic and family background variables. In sum, we bring quantitative evidence to bear on certain claims of both boosters and critics of computer technology for young children.

Literature Review

Computers and Children's Education

One of the most eminent proponents of computing in the home and at school is Seymour Papert, a mathematician at the Media Laboratory at MIT and author of *Mindstorms: Children Computers and Powerful Ideas* (1980), *The Children's Machine: Rethinking School in the Age of the Computer* (1992) and *The Connected Family: Bridging the Digital Generation Gap* (1996). From his earliest work as the developer of the LOGO computer language for children, Papert has argued that computers unleash the creative impulse in children and allow children to become aware of how they think and learn.

Given this positive assessment of the computer's potential, Papert has argued for more intensive computing at school and at home. Computers should be integrated into regular classrooms, and the pedagogical approach should be drastically restructured, so that many types of schoolwork are pursued via computer.

At the other extreme, one finds commentators such David Bolt and Ray Crawford (2000) and Jane Healy (1998). Healy identifies many potential dangers of children's computer use, from vision problems to bad posture, but her main worry is that computers will adversely affect childhood learning experiences. For young children, she is concerned that computer use will cut into play and physical activities that are important for emotional and cognitive development, warning: "A child with lopsided experiences is likely to end up with a lopsided brain" (133).

Similar sentiments have led the Alliance for Childhood (2000) to advocate a moratorium on computing for younger children. Its manifesto *Fool's Gold: A Critical Look at Computers and Childhood* marshals arguments that computers are a threat to the normal developmental processes of young children. Invoking Piaget, the authors claim that young children are not ready for computer-based learning. They learn instead through hands-on interactions with tangible materials, through play, and by interacting with nature. Young children need to spend lots of time outdoors, and time in social interaction with teachers and other children. Computers threaten to *displace* these "normal" learning experiences, as children redirect their time to computer activities that evoke ways of thinking that are age inappropriate.

These manifestos are examples of what Iacono and Kling (1986) call utopian and anti-utopian technological discourses. Technological utopians trumpet the existence of a social problem that, they argue, can be solved by technology. In Papert's case, a moribund education system that ought to be profoundly restructured around an infusion of technology. For technological anti-utopians such as Healy, the social problem is the uncritical adoption of an inappropriate technology and its dire effects on children.

Most empirical research is less sweeping than either of these positions. One body of research studies the effects of specific pieces of computer software on children's learning, through demonstration projects in schools. This literature is clear-cut. In hundreds of school-based experiments, computer applications have improved children's performance in reading, writing, and basic mathematics. Drill-and-practice software has repeatedly been shown to work. Improvements can be large: students in an experiment's computing group gain roughly three months over their noncomputer counterparts, using the educational progress made in a normal school year as a yardstick (Melmed 1995:20). A second type of software intended to improve problem-solving skills offers a more mixed picture, working in some cases but not in others (Coley et al. 1997:34; Software & Information Industry Association 1999).

This positive news, however, from demonstration projects and school-based experiments has to be weighed against research based on large representative national samples of schoolchildren. Drawing on the National Assessment of Educational Progress (NAEP), one such study showed that 8th grade students who use computers more frequently at school have lower mathematics test scores than students who use computers less often, after controlling for family background (Wenglinsky 1998). A later NAEP study found no significant effect of school computing on reading, even among students whose teachers had computer training (Johnson 2000). Several studies have also reported that poor and minority school children use computers more often at school, compared to affluent children: a reverse digital divide (Coley et al. 1997; Wenglinsky 1998:15).

Taking an ethnographic approach, Cuban (2001) observed that computing in schools rarely has a substantial impact on children's learning, mainly because classroom computers are not used for very much of the school day, and when used they tend to be deployed in an auxiliary way to support teachers' traditional pedagogical activities and lesson plans. Cuban argues that this is *not* due to teachers' fear of computers or lack of technical know-how — noting that many teachers make active use of computers at home — but instead reflects practical problems in deploying computer technology in classrooms. More frequent or ambitious use of classroom computers would require teachers to invest more time than they have available in developing new teaching activities and would oblige teachers to overcome widespread logistical and technical difficulties associated with school computers, including hardware crashes, software glitches, slow internet connections, and a lack of fit between available software and the teacher's curricular needs (Cuban 2001:173). In sum, computers do not currently have a strong impact on student learning because most teachers find them to be of limited utility and hard to deploy in their daily teaching, and therefore use them in small doses.

Henry Jay Becker and his colleagues paint a different picture, based upon a national survey of teachers. Educational applications of computers beyond drill and practice and word processing tend to be associated with a constructivist pedagogy that emphasizes project- and group-work and problem solving. Classroom use of computers in this style is associated with (1) teachers' commitment to a constructivist pedagogical philosophy, (2) the level of teachers' professional engagement, (3) teachers' computer skills, and (4) the extent of computer access in the classroom (Becker 1999; Becker & Riel 2000; Ravitz, Becker & Wong 2000.) The absence of any of these acts as a barrier, reducing the frequency of computing in school.

Turning to computing in the home, one early ethnographic study of children from affluent families discovered that little educational computing was going on (Giacquinta et al. 1993.) About half the families had purchased computers with their children's education in mind. Nevertheless, most children avoided purely educational products and played games instead. Only 20% of the children were using the technology to develop skills in mathematics, reading, science or critical thinking. Even among this group, educational software use was sporadic and of short duration. In essence, children were using home computers for everything but education.

In that study, the very few middle-class children occupied with academic computing received substantial encouragement and involvement from parents and older siblings. The authors concluded that the "social envelope" around computing — the competencies and involvement of parents and siblings — was crucial to any kind of educational outcome. By implication, children of the poor would be disadvantaged when using home computers for education.

Attewell and Battle (1999) tested that implication, using the National Educational Longitudinal Survey (NELS88) to assess the effects of home computers on 8th grade children. Among children with equivalent family backgrounds, those who had access to a home computer had slightly higher test scores in reading and math than those who lacked a home computer. The effects of computer ownership were modest: having a home computer was about as advantageous as the use of the public library in terms of raising test scores. The authors also identified a "Second Digital Divide." Even among children whose families did own computers, the benefits of having a home computer — in terms of higher test scores — were substantially greater for children from more affluent and educated families than from poorer and less-educated ones. Boys benefited significantly more than girls, and whites more than minorities. These disparities remained apparent even after controlling for parental involvement in a child's education, trips to museums, and several other aspects of social advantage.

Several studies have examined the effects of specific computer games on cognitive skills that are closely related to the game being played. For example, a game in which children used a joystick to guide a marble improved visualization of an object's path (Subrahmanyam & Greenfield 1994). Similarly, playing computer games enhanced "iconic skills," and playing a video game increased students' ability to monitor the periphery of a computer screen for pop-up events (Greenfield et al. 1994a, 1994b).

Computers may have a greater effect on the emotions or personality development of young children than on their cognitive development or skills. Among teens and adults, one study found greater use of the Internet was associated with a small significant decline in involvement in social networks and increased feelings of loneliness (Kraut et al. 1998). Roberts et al. (1999) also found that children who were heavy users of electronic media, including but not limited to computers, were "less contented." However, other studies found no differences in sociability or even increased sociability associated with computer game usage (Subrahmanyam et al. 2000:132).

Several critics of educational computer use are concerned that time spent by children on the computer results in less time spent on other, perhaps more useful, activities. Studies of computer use among *adults* suggest there is no such displacement effect: heavier computer use is associated with significantly *greater* participation in cultural activities and in greater use of other mass media (Robinson, Barth & Kohut 1997; Robinson & Kestnbaum 1999; Robinson et al. 2000.) We will analyze displacement effects among children below, using the PSID data.

Finally, some scholars have raised the possibility that computers might contribute to obesity in children. No one has reported this directly, but since previous research has linked heavy television use to obesity, scholars infer that heavy computer use might produce a similar effect (Subrahmanyam et al. 2000:126).

Data and Methods

The Panel Study of Income Dynamics, (PSID), is a survey research project that has followed a representative national sample of American families since 1968, repeatedly interviewing the same subjects to track their family finances, jobs, marital status and related issues. In a special supplement undertaken in 1997, the PSID collected time-diary data on children's activities at home, in day care, and in school. Our focus is upon the 1680 school-aged children, ages 4 to 13, for whom the PSID supplement collected activity data.

After training, a parent filled out a time diary, with the aid of the child, that recorded the child's activities during two systematically sampled days: one day during the week, the other on a weekend. A teacher filled out the diary for that child during the school day. The diaries recorded activities at ten-minute intervals. They noted each type of activity and whether the child was doing it alone, with other children, or with an adult (Hofferth et al. 1998).

Scholars have claimed that a time diary methodology is quite accurate, because activities are recorded when they occur or shortly thereafter (Juster 1985; Yeung et al. 1998).

The PSID staff coded the children's activities recorded in the time diaries. They also linked the data to: (1) information on the families/parents of each child, including demographics, income, and education of parents; (2) performance of the children on a series of age-standardized cognitive tests plus a scale measuring self-esteem (detailed below); (3) each child's weight and height.

Our analyses used population weights for the child data, provided by the PSID, to accurately represent the nation's children. We also followed the procedure of previous scholars in transforming this diary data into minutes or hours spent per week on various activities (Hofferth 2000; Hofferth 2002; Sandberg & Hofferth 2001).

Child Characteristics

Three dummy variables represent race/ethnicity: Black, Latino and Asian (with non-Hispanic white as the reference category.) Gender is a dummy where value one indicates a male child. Each child's age is measured in years. We translated a child's bodyweight and height into a child body-mass index, using a formula recommended by the Center for Disease Control (2002.)

Family Background

These variables were used as control variables. Total annual family income is in $10,000 units. A dummy variable indicates whether this income, adjusted for family size, was below the federal poverty threshold. Education of a child's parent is in years. We used the Passage Comprehension Score, a subtest of the Woodcock-Johnson Revised Test of Achievement, as a measure of parental cognitive skill (Woodcock & Johnson 1989).

Home and School Computer Use

These are the main predictors of interest in the analyses below. Each child's home diary recorded the number of minutes a child used a computer at home, and the time spent using a computer at school. The modal value for the former was zero time. Given this skewed distribution, we created a set of dummy variables for home usage. The reference category is no home computer use at all. The first dummy variable takes a value of one for some weekly use up to but not including 8 hours per week, zero otherwise. The second dummy variable takes a value of one for children who used a home computer for 8 or more hours per week, and zero otherwise. In addition, we used a measure of

TABLE 1: Description of Variables (Weighted)

	N	Min.	Max.	Mean	S.D.
Children's background					
White	1,601	0	1	.677	.468
Black	1,601	0	1	.175	.380
Latino	1,601	0	1	.122	.327
Asian	1,601	0	1	.026	.160
Sex	1,680	0	1	.496	.500
Age	1,518	4	13	8.65	2.30
Height	1,603	35	75	53.26	6.74
Total family income (per $10,000)	1,678	0	151.20	5.14	5.53
At or below the poverty line	1,678	0	1	.14	.351
Parent years of education	1,668	1	17	12.87	3.04
Parent passage comprehension score	1,417	4	43	31.83	5.22
Home computer activities					
Home computer use in minutes	1,680	0	1,500	47.95	147.40
Home computer use less than 8 hours	1,680	0	1	.159	.365
Home computer use 8 hours or more	1,680	0	1	.020	.140
Breakdown of home computer use in minutes for children with a home computer. Children's home computing activities may have been done with an adult.					
Any home computer use with an adult	299	0	1	.222	.416
Educational and learning activities	299	0	1,050	32.03	118.94
Games	299	0	1,220	192.53	210.97
Communication, surfing and media activities	299	0	804	36.19	109.79
Paid work, financial services and shopping	299	0	575	2.62	31.35
Other computing activities	299	0	230	6.15	30.24
Other home and school activities					
Reading	1,680	0	1,890	71.07	139.93
Sports and outdoor activities	1,680	0	5,210	437.36	457.18
Watching television	1,680	0	5,510	788.92	577.08
Social/cultural activities	1,680	0	5,675	163.57	353.10
Unstructured leisure activities	1,680	0	2,070	127.47	199.10
Elementary and middle school computer use	1,040	0	1,325	84.04	152.95

each child's computer use at school (minutes per week) as a control variable to distinguish these two sites of computing.

Social and Cultural Activities

We represented children's social and cultural activities outside of school by the total time in minutes per week that a child spent on the particular activity. Activities included reading (books, magazines or newspapers), watching television, and participation in sports activities or playing outdoors.

TABLE 1: Description of Variables (Weighted) (Continued)

	N	Min.	Max.	Mean	S.D.
Cognitive Performance, Self-esteem and Body Weight Variables					
Letter word recognition age-standardized scores: Age 4 and older, tests symbolic learning and reading identification	1,378	49	197	106.53	19.28
Passage Comprehension age-standardized scores: Age 6 and older, measures comprehension and vocabulary skills	1,228	38	166	106.29	16.45
Applied problems age-standardized scores: Age 4 and older, measures skills in solving practical mathematical problems	1,374	28	159	109.93	17.51
Mathematical calculation age-standardized scores: Age 6 and older, measures performance on mathematical calculations (such as additions and subtraction) and quantitative ability	1,221	6	156	103.66	17.50
Short term memory age-standardized test: Age 4 and older	1,535	0	29	12.60	4.41
Self-esteem: Age 8 and older, an index that measures child's general self-perception	972	5	56	44.62	7.06
Body mass index	1,341	2.79	47.84	18.13	4.36

Child's Cognitive and Emotional Measures

Seven dependent variables measured aspects of children's cognitive performance, self-perception, and health. Only two cognitive subtests were administered to children under five: letter-word recognition and an applied quantitative reasoning problem test (Woodcock & Johnson 1989). Children aged 6 or more completed those two plus additional subtests for passage comprehension and basic mathematics. The letter-word recognition test requires children to match pictures with words, to identify letters and read simple words. The passage-comprehension test uses multiple choice and fill in the blank formats to measure vocabulary items and comprehension of whole passages of text. An applied mathematics problem subtest assessed practical mathematics such as time and money. A calculation subtest assessed addition and subtraction skills and quantitative ability more broadly (Hofferth et al. 1998.) The PSID data set provided age-standardized scores for each of these measures.

The PSID also reported children's performance on the Memory Digital Span assessment that is part of the Wechsler Intelligence Scale for Children. In the first part of this test, a child listens to and then repeats a sequence of numbers spoken by the interviewer. In the second part, the child listens and then reports a spoken sequence of numbers in reverse order. The sequences increase in length until a child is unable to repeat the sequence correctly (Wechsler 1974).

A measure of a child's global self-concept combined questions that asked whether the child did many important things, likes him/herself, had many things to be proud of, felt as good as other people, had good qualities, felt as good as most people, felt others think of him/her as a good person, and felt s/he does things well. The reliability (α) of this scale, as reported by the PSID, was 0.77. The PSID measured this construct only for children aged eight or older. Our measure of each child's academic performance combined teachers' reports of each child's overall academic competence, reading ability, and math ability. This scale had an alpha of .87.

Missing Data

Because the PSID restricted cognitive and emotional measures to children in certain appropriate age ranges, as detailed above, the sample sizes in our regressions differ according to the particular dependent variable being used. This is not due to missing data in the conventional sense, but due to the age restriction for a given measure. In a small number of cases, children did have missing demographic information, on variables such as family education or income. We used a multiple imputation technique to impute values for these missing values (King et al. 2001).

We also tested the regression models reported below for multicollinearity. None of the models had multicollinearity problems, using conventional cut-offs (Belsley, Kuh & Welch 1980.)

Our analyses begin by addressing the claim that home computer use displaces other children's activities such as outdoor play. We first regress time spent on a given activity upon our computer use variables, controlling for a range of demographic and family socioeconomic variables, and simultaneously controlling for time spent on other noncomputer activities, in order to guard against spurious correlation.

Next, we turn to the cognitive and emotional and physical correlates of home computer use, regressing each of the PSID outcome measures on computer use plus sociodemographic controls. We again include measures of TV watching, time spent reading, and time spent outdoors, as controls in these models, since the purpose is to determine whether computer use per se is associated with different levels of cognitive skill and emotional well-being, net of differences in sociodemographic background and net of differences in noncomputer activities.

TABLE 2: Predicting Displacement of Time Spent on Reading, Sports and Outdoor Activities, and Television Watching by Other Home Activities Unstandardized (and Standardized) Ordinary Least Squares Regression Coefficients

	Reading	Sports and Outdoor Activities	Television Watching
Home computer less than 8 hours	22.654* (.059)	45.570 (.037)	–45.691 (–.031)
Home computer use 8 hours or more	.654 (.001)	–188.280* (–.058)	32.322 (.018)
Black	–12.651 (–.035)	–102.410** (–.088)	87.696 (.046)
Latino	.790 (.002)	202.920*** (–.145)	–32.216 (–.019)
Asian	103.840*** (.118)	–151.540* (–.053)	289.670** (.082)
Male child	–12.276 (–.044)	157.310*** (.172)	.476 (.000)
Age of child	1.020 (.017)	3.421 (.017)	20.268*** (.090)
School computer use time (minutes/per week)	.002 (.002)	–.023 (.008)	–.288** (–.059)
Reading at home(minutes/per week)		–.248** (–.076)	–.317** (–.076)
Sports/outdoor activities (minutes/per week)	–.023** (–.075)		–.088** (–.064)
Television watching (minutes/per week)	–.019** (–.077)	–.056** (–.071)	
Total family income (per $10,000)	.241 (.010)	–1.482 (–.018)	–3.464 (–.036)
At or below the poverty line	–7.828 (–.020)	11.711 (.009)	141.000** (.088)
Parent years of education	6.385*** (.139)	–5.589 (–.037)	–17.097** (–.092)
Parent reading comprehension score	.852 (.032)	–1.621 (–.019)	–2.619 (–.023)
N of cases	1,680	1,680	1,680
Adjusted R^2	.062	.056	.068

* $p < .05$ ** $p < .01$ *** $p < .001$

TABLE 3: Effects of Home Computer Use on Children's Cognitive Performance Unstandardized (and Standardized) Ordinary Least Squares Regression Coefficients

	Letter-word Recognition	Reading Comprehension	Applied Mathematical Problems	Mathematical Calculation Problems
Predictors				
Home computer less than 8 hours	2.775* (.055)	2.337* (.054)	1.201 (.027)	2.813* (.062)
Home computer use 8 hours or more	–5.147 (–.036)	–3.713 (–.033)	–.230 (.002)	–843 (–.007)
Black	–4.028* (–.087)	–3.071* (–.079)	–7.543*** (–.180)	–.578 (–.014)
Latino	-1.568 (.013)	-4.526 (–.047)	–11.322*** (–.107)	–1.114 (–.010)
Asian	4.805 (.012)	9.475 (.031)	40.046* (.109)	21.783 (.059)
Male child	–2.536** (–.065)	–2.462** (–.078)	3.491*** (.100)	1.102 (.032)
Age of child	1.263*** (.089)	–.121 (.015)	.337 (.044)	–.204 (–.024)
School computer use time (minutes/per week)	.004 (.034)	.003 (.023)	–.000 (–.002)	.004 (.032)
Reading at home (minutes/per week)	.009* (.063)	.005 .(.040)	.004 (.035)	.003 (.026)
Sports/outdoor activities (minutes/per week)	–.001 (–.016)	.000 (.001)	.000 (.009)	.001 (.015)
Television watching (minutes/per week)	-.001 (-.042)	–.002* (–.056)	–.003*** (–.090)	–.001 (–.029)
Total family income (per $10,000)	.338*** (.105)	.200** (.075)	.236** (.080)	.228** (.081)
At or below the poverty line	2.489 (.043)	–.340 (–.007)	1.585 (.030)	–1.284 (–.024)
Parent years of education	.854*** (.108)	.991*** (.149)	1.208*** (.169)	1.387*** (.196)
Parent reading comprehension score	.865*** (.218)	.778*** (.227)	.595*** (.165)	.551*** (.142)
N of cases	1,378	1,228	1,374	1,221
Adjusted R^2	.193	.206	.253	.141

* p < .05 ** p < .01 *** p < .001

TABLE 4: Effects of Home Computer Use on Children's Short-term Memory, Self-esteem and Body Weight Unstandardized (and Standardized) Ordinary Least Squares Regression Coefficients

	Short Term Memory	Self-esteem	Body Mass Index
Home computer 8 hours or less	.150 (.013)	1.875*** (.105)	–.129 (–.011)
Home computer 8 hours or more	–.671 (–.022)	.908 (–.020)	1.951* (.061)
Black	.230 (.021)	.329 (.018)	.694* (.062)
Latino	–.544 (–.039)	–.788 (–.036)	1.721** (.112)
Asian	.462 (.018)	–2.735 (–.063)	.510 (.016)
Male	–.405* (–.046)	–.243 (–.017)	.564* (.064)
Age	1.145*** (.596)	.151 (.031)	.551*** (.287)
School computer use time (minutes/per week)	.000 (.013)	.003 (.061)	.000 (.001)
Reading at home (minutes/per week)	.000 (.015)	–.000 (–.000)	–.000 (–.001)
Sports and outdoor activities	.000 (.021)	.000 (.012)	–.000 (.018)
Watching television (minutes/per week)	–.000 (–.002)	–.000 (–.036)	–.000 (.008)
Total family income (per $10,000)	.056*** (.072)	–.080* (–.071)	.018 (.024)
At or below the poverty line	–.114 (–.009)	.088 (–.004)	–.970* (–.073)
Parent years of education	.143*** (.099)	.327*** (.142)	–.157** (–.097)
Parent reading comprehension score	.117*** (.139)	.059 (.043)	.011 (.013)
N of cases	1,535	972	1,379
Adjusted R^2	.426	.044	.112

$^{*}p < .05$ $^{**}p < .01$ $^{***}p < .001$

Findings

Table 1 shows that children who do have a home computer spend almost no time on this computer accompanied by an adult. This finding should be considered in the context of Giacquinta's (1994) observation that active involvement by an adult is important for children to obtain educational benefits from a home computer. Roberts et al. (1999) similarly report that children's consumption of electronic media is typically done alone, usually in the child's bedroom, away from adults. Table 1 also shows that young children mainly use home computers for playing games. On average a young child with a computer at home spends roughly 3 hours per week playing games and only half an hour a week on learning or educational activities.

Central to the concerns of Healy (1998) and other critics is the notion that young children who use computers a lot will spend less time on other more developmentally fruitful activities. These displacement effects are addressed by Table 2, where time spent in a particular activity (e.g., reading) is predicted by time spent on other activities (e.g., computing, TV watching, sports) plus controls for family income, education, parental reading score, etc.

Table 2 does show that amount of time spent by children on certain activities is associated with less time spent on certain other activities. For example in the first column of Table 2 we see that, on average, time spent watching television and time spent outdoors reduce the time spent by a child in reading. And in column two we see that television time and time spent reading are both associated with less time spent on sports and outdoors activities. So, watching television clearly *does* displace other activities that researchers believe are productive for intellectual development.

Critics like Healy argue that home computing has similar deleterious displacement effects to TV watching. However, in the first column of Table 2, children who use computers at home for under 8 hours per week spend significantly *more time* reading at home than children without computers, net of family background and other controls (on average 23 more minutes per week.) The amounts of time that moderate users of home computers spend on sports or watching TV are not statistically different than the time spent on those activities by children without home computers (the reference category). Thus, for home computer use under 8 hours, we observed none of the posited deleterious displacement effects of computing.

To identify *atypical children* who evidence a more lopsided use of time, we included in Table 2 an additional dummy variable for spending a lot of time on computers (eight or more hours per week). The reference category is still nonusers of home computers. Only 2% of schoolchildren in the sample fall in this extreme heavy use subgroup. Heavy computer use did not affect time spent reading or watching television. However, children who were heavy users of home computers did spend much less time on sports and outdoor activities

(3 hours less per week) than children who did not use computers at all, a finding we return to below.

Turning to the cognitive and emotional correlates of computer usage, we ran separate regression models predicting five cognitive scores, where the predictors included the home computing dummies, time spent on computing at school, time spent on reading, watching television, and participation in sports and outdoor activities, plus several family background variables including family income and parental education and reading scores (Tables 3 and 4).

Children who used computers at home for less than 8 hours per week had significantly higher scores on measures of letter-word recognition, reading comprehension, and mathematics calculation problems than children without home computer use (Table 3). They also had significantly higher self-esteem (Table 4.) However, home computer use under 8 hours is not associated with different scores on applied a mathematics problems test or with a test of short-term memory, or with a measure of body mass. In sum, home computer use for less than 8 hours per week is associated with higher scores on three tests of cognitive skill and higher self-esteem.

In terms of effect size, however, the positive home computer effects on cognitive skills are modest. Compared to children without home computer use, moderate home computer users had letter-word, reading comprehension, and calculations scores 2.7, 2.3, and 2.8 points higher respectively, on scales where the mean score was roughly 100 points. Alternatively, children with moderate use of home computers scored on average .14 standard deviation units higher on letter-word and on reading comprehension, and .16 standard deviations higher on the calculation measure, compared to children who did not use home computers, after controlling for family background, etc.

Focusing on heavy computer users — the very small proportion of children who used home computers for eight or more hours per week — we observed a different set of outcomes. They spent almost four hours less time per week in sports and outdoors activities (Table 2) than otherwise equivalent children. Their skill scores were not statistically different from nonusers (Table 3.) Strikingly, they had a significantly higher body mass index than other children, after controlling for family background, age, self-esteem level, and time spent on outdoor and other activities (Table 4.) Heavy computer users had an average body-mass index nearly 2 units higher than noncomputer users; they were on roughly 12 pounds heavier than children of equivalent height and age who did not use home computers, even after we had controlled for time spent on sports and outdoor activities. This amount of body mass difference among children between 4 and 13 years of age is substantial.

Discussion

Two opposed groups of social commentators argue that the spread of computers in our society has produced a serious new social problem. From the enthusiasts' side, the social problem is that some children lack access to this technology. In this view, children are therefore deprived of something positive and important (hence the digital divide.) From the detractors' perspective, the social problem is that young children are being harmed by premature exposure to computing, stunting their natural cognitive and emotional development.

This article has not challenged the validity of the Digital Divide concept itself. Instead, we have focused on certain important factual disputes within the debate: whether computing enhances or undermines young children's cognitive and educational development and well-being. Our findings fail to corroborate the more extreme claims of both boosters and detractors of home computing.

One central claim behind criticisms of young children's computing is that computing drives out other more educationally productive activities. We found little empirical support for that idea. Using a computer at home for under 8 hours per week is not associated with less time spent on reading, sports or outdoor activities, and in fact is associated with more time spent reading at home, net of family background.

On the other side, proponents of young children's computing argue that computing can profoundly enhance learning. For three of five cognitive measures, we found statistically significant differences between home computer users and nonusers after controlling for sociodemographic background. For letter-word recognition, reading comprehension, and mathematical calculations, moderate home computer users performed better than nonusers. However, these computer effects are far more modest in size than one would expect from the writings of advocates of computing for young children: roughly 2 or 3 points higher on scales with an average score of about 100.

These modest but generally beneficial correlates of home computing in general, plus an association with higher self-esteem, have to be balanced against two troubling findings. Among young children, heavy use of home computers (8 or more hours per week) is associated with much less time spent on sports and outdoor activities. Heavy use of computing is also associated with substantially heavier body mass index among young children, even after controlling for the amount time spent on outdoor and sports activities as well as for family background.

This phenomenon is not widespread. It occurs only among the 2% of young children who use home computers for eight hours per week or more. Obesity, however, is a serious and growing health risk among American children (Hill & Peter 1998), so this finding should be a cause for concern, even if the number of children affected is small.

Since we used cross-sectional data, making causal inferences from an association between computing and body mass requires caution. First, we should emphasize that the regression predicting body mass index from heavy computer usage already controlled for time spent on TV, on reading and on sports/outdoor activities, as well as controlling for race/ethnicity, family income, poverty, parental education, and parental reading comprehension. Hence several factors that might create a spurious relationship between body mass and time spent on computing at home have already been ruled out.

However, an issue of causal direction remains. It could be the case that already-heavy children gravitate towards computer use as a leisure activity, rather than the case that spending many hours at the computer increases children's bodyweight. Both of these mechanisms (or causal directions) could produce the association we observe between heavy computer use and body mass. To disentangle such issues of causal direction would require longitudinal data to determine which occurs first: heavy computer use or high bodyweight. We know of no currently available longitudinal data that speak to this issue, though we hope that future research may clarify this.

For the moment, however, it seems sensible to note that spending many hours on a home computer is associated both with less sports and outdoor play and with heavier body mass among young children. That possibility was raised by certain critics of computing for young children, and is borne out by our data. Equally important, however, our analyses show there is *no* negative association between home computing and leisure activities — the so-called displacement effects — for the overwhelming majority of young children who use home computers for less than eight hours per week. Further, there are indications of beneficial effects from home computing on some cognitive outcomes, findings that disconfirm the speculations of computing critics.

References

Alliance for Childhood. 2000. *Fool's Gold: A Critical Look at Computers and Childhood.* Alliance for Childhood.

Attewell, Paul. 2001. "The First and Second Digital Divides" *Sociology of Education* 74:252-59.

Attewell, Paul, and Juan Battle.1999. "Home Computers and School Performance." *The Information Society* 15:1-10.

Becker, Henry Jay. 1999. "Software Use in Classes of Different Levels of Student Ability." Snapshot #8 from "Teaching, Learning and Computing 1998: A National Survey of Schools and Teachers." Center for Research on Information Technology and Organizations, University of California, Irvine. [http://www.crito.uci.edu/tlc/html/findings.html]

Becker, Henry Jay, and Margaret Riel. 2000. "Teacher Professional Engagement and Constructivist Compatible

Computer Use." Center for Research on Information Technology and Organizations, University of California, Irvine. [http://www.crito.uci.edu/tlc/html/findings.html]

Belsley, David, Edwin Kuh, and Roy Welsch. 1980. *Regression Diagnostics*. Wiley.

Bolt, David, and Ray Crawford. *2000. Digital Divide: Computers and Our Children's Future.* TV Books.

Centers for Disease Control and Prevention. 2002. "How to Calculate Body Mass Index For Children." [http://www.cdc.gov/nccdphp/dnpa/bmi/bmi-definition.htm]

Coley, Richard, John Cradler, and Penelope Engle. 1997. *Computers and Classrooms: The Status of Technology in U.S. Schools*. The Educational Testing Service.

Cuban, Larry. 1986. *Teachers and Machines: The Classroom Use of Technology Since 1920*. Teachers College Press.

———. 2001 *Oversold and Underused: Computers in the Classroom*. Harvard University Press.

Giacquinta, Jospeh, JoAnne Bauer, and Jane Levin. 1993. *Beyond Technology's Promise: An Examination of Children's Educational Computing at Home.* Cambridge University Press.

Goolsby, Austan and Peter Klenow. 2002. "Evidence on Learning & Network Externalities in the Diffusion of Home Computers." Working Paper. Department of Economics, University of Chicago. [http://gsbadg.uchicago.edu/vitae.htm]

Greenfield, P.M,. Camaioni, L.E., and P. Ercolani. 1994a. " Cognitive Socialization by Computer Games in Two Cultures" *Journal of Applied Developmental Psychology* 15:59-85.

Greenfield, P.M., de Winstanley P., and H. Kilpatrick. 1994b. "Action Video Games and Informal Education." *Journal of Applied Developmental Psychology* 15:106-123.Jane M. Healy. 1998. *Failure to Connect: How Computers Affect Our Children's Minds — for Better and Worse*. Simon and Schuster.

Hill, J.O., and J.C. Peter. 1998. "Environmental Contributions to the Obesity Epidemic." *Science* 280:1371-74.

Hofferth, Sandra L. 1999. "Family Reading to Young Children: Social Desirability and Cultural Biases in Reporting." Paper presented at Workshop on Measurement of and Research on Time Use, Committee on National Statistics. Washington, D.C.: National Research Council, May 27-28.

———. 2000. "How American Children Spend their Time." *Journal of Marriage and the Family* 63:295-308.

———. 2002. "Race/Ethnic Differences in Father Involvement with Young Children." *Journal of Family Issues* 24:185-216.

Hofferth, S.L., P. Davis-Kearn, J. Davis, and J. Finkelstein. 1998. *Child Development Supplement Manual of the Panel Study if Income Dynamics 1997 User Guide.* PSID Web.

Hofferth, Sandra L., and Zita Jankuniene. 2001. "Life After School." *Educational Leadership* 58:19-23.

Iacono, Suzanne, and Rob Kling. 1986. "Computerization Movements and Tales of Technological Utopianism." Pp. 85-105 in *Computerization and Controversy,* 2d ed., edited by Rob Kling. Academic Press.

Johnson, Kirk. 2000. *Do Computers in the Classroom Boost Academic Achievement?* Heritage Foundation.

Juster, F. Thomas. 1985. "Conceptual and Methodological Issues Involved in the Measurement of Time Use." Pp. 19-31 in *Times, Goods and Well-Being*, edited by F. Thomas Juster and Frank P. Stafford. Survey Research Center, Institute of for Social Research.

Juster, F. Thomas, and Frank P. Stafford. 1985. *Time, Goods and Well-Being*. Institute for Social Research.

King, Gary, James Homaker, Anne Joseph, and Kenneth Scheve. 2001. "Analyzing Incomplete Political Science Data: An Alternative Algorithm for Multiple Imputation." *American Political Science Review* 95:49-69.

Kraut, Robert, M. Patterson, and V. Lundmark. 1998. "Internet Paradox: A Social Technology That Reduces Social Involvement and Psychological Well-being." *American Psychologist* 53:1017-31.

Leigh, Andrew, and Robert D. Atkinson. 2001. Clear Thinking on the Digital Divide. Policy Report, June 2001, Washington D.C.: The Progressive Policy Institute. [www.ppionline.org]

Marini, Margaret M., and Beth Anne Shelton. 1993. "Measuring Household Work: Recent Experience in the United States." *Social Science Research* 22:361-83.

Melmed, Arthur. 1995. *The Costs and Effectiveness of Educational Technology: Proceedings of a Workshop*. Rand Corporation.

Nichols, L.M. 1992. "The Influence of Student Computer-Ownership and In-Home Use on Achievement in Elementary School Computer Curriculum" *Journal of Educational Computing Research* 4:407-21.

Papert, Seymour. 1980 *Mindstorms: Children Computers and Powerful Ideas.* Basic Books.

———. 1992 *The Children's Machine: Rethinking School in the Age of the Computer*. Basic Books.

———. 1996 *The Connected Family: Bridging the Digital Generation Gap.* Longstreet Press.

Ravitz, Jason, Henry Becker, and Yantien Wong. 2000. "Constructivist Compatible Beliefs and Practices among U.S. Teachers." Center for Research on Information Technology and Organizations, University of California, Irvine. [http://www.crito.uci.edu/tlc/html/findings.html].

Roberts, Donald F., Ulla Foehr, Victoria Rideout, and Mollyann Brodie. 1999. *Kids* & *Media @ the New Millennium*. The Henry J. Kaiser Family Foundation.

Robinson, John, Kevin Barth, and Andrew Kohut. 1997. "Personal Computers, Mass Media, and Use of Time." *Social Science Computer Review* 15:65-82.

Robinson, John, and Meyer Kestnbaum. 1999. "The Personal Computer, Culture, and Other Uses of Free Time."*Social Science Computer Review* 17:209-16.

Robinson, John, Meyer Kestnbaum, Alan Neustadtl, Anthony Alverez. 2000. "Mass Media and Social Life Among Internet Users" *Social Science Computer Review* 18:490-501.

Samuelson, Robert J. 2002. Debunking the Digital Divide. Newsweek. March 25 2002 p.37

Sandberg, John F., and Sandra L. Hofferth. 2001. "Changes in Children's Time with Parents, U.S. 1981-1997." *Demography* 38:423-43.

Software and Information Industry Association. 1999. *1999 Report on The Effectiveness of Technology in Schools,* 6th ed.

Subrahmanyam, Kaveri, and P.M. Greenfield. 1990. "Effect of Video Game Practice on Spatial Skills in Girls and Boys." *Journal of Applied Developmental Psychology* 15:13-32.

Subrahmanyam, Kaveri, Robert E. Kraut, Patricia Greenfield, Elisheva Gross. 2000. "The Impact of Home Computers on Children's Activities and Development." *The Future of Children* 10:123-44.

Thierer, Adam. 2000. *How Free Computers are Filling the Digital Divide.* Washington D.C.: The Heritage Foundation. United States Department of Commerce, National Telecommunications and Information Administration.

———. 1995. *Falling through the Net: A Survey of the "Have Nots" in Rural and Urban America*. U.S. Department of Commerce.

———. 1998. *Falling through the Net II: New Data on the Digital Divide.* U.S. Department of Commerce.

———. 1999. *Falling through the Net: Defining the Digital Divide.* U.S. Department of Commerce.

———. 2000. *Falling through the Net: Towards Digital Inclusion.* U.S. Department of Commerce

———. 2002. *A Nation Online: How Americans are Expanding Their Use of the Internet.* U.S. Department of Commerce

Wechsler, D. 1974. *Wechsler Intelligence Scales for Children–Revised*. The Psychological Corporation.

Wenglinsky, Harold. 1998. *Does It Compute? The Relationship between Educational Technology and Student Achievement in Mathematics*. The Policy Information Center of the Educational Testing Service.

Woodcock, R.W, and M.B. Johnson.1989. *Tests of Achievement: Standard Battery, Form B*. Riverside.

Yeung, Jean W., John F. Sandberg, Pamerla E. Davis-Kean, and Sandra L. Hofferth. 2001. "Children's Time with Fathers in Intact Families." *Journal of Marriage and Family* 63:136-54.