NET Institute*

www.NETinst.org

Working Paper #11-14

October 2011

The Effects of Home Computers on Educational Outcomes: Evidence from a Field Experiment with Schoolchildren

Robert W. Fairlie
University of California, Santa Cruz

Jonathan Robinson
University of California, Santa Cruz

* The Networks, Electronic Commerce, and Telecommunications ("NET") Institute, http://www.NETinst.org, is a non-profit institution devoted to research on network industries, electronic commerce, telecommunications, the Internet, "virtual networks" comprised of computers that share the same technical standard or operating system, and on network issues in general.

The Effects of Home Computers on Educational Outcomes: Evidence from a Field Experiment with Schoolchildren

Robert W. Fairlie
University of California, Santa Cruz
rfairlie@ucsc.edu

Jonathan Robinson
University of California, Santa Cruz
jmrtwo@ucsc.edu

September 2011

We thank the NET Institute (www.NETinst.org), ZeroDivide Foundation, and Computers for Classrooms, Inc. for funding. We thank participants at seminars and workshops at UC Berkeley for comments and suggestions. We also thank John Bohannon, Joanne Parsley, Bruce Besnard, Reg Govan, Gina Lanphier, Brian Gault, Lee McPeak, Tom Sharp, Zenae Scott, Rebecka Hagerty, Jennifer Bevers, David Jansen, Cynthia Kampf and many others for helping with administering the program and providing administrative data, and Miranda Schirmer, Shilpa Aggarwal, Julian Caballero, David Castaneda, James Chiu, Samantha Grunberg, Keith Henwood, Cody Kennedy, Nicole Mendoza, Nick Parker, Glen Wolf and Heidi Wu for research assistance. Finally, special thanks go to Pat Furr for providing computers for the study and for her extensive help in administering the giveaway program.

Keywords: Computers, education, technology, experiment
JEL Code: I24

The Effects of Home Computers on Educational Outcomes: Evidence from a Field Experiment with Schoolchildren

Abstract

Are home computers are an important input in the educational production function? To address this question, we conduct a field experiment involving the provision of free computers to schoolchildren for home use. Low-income children attending middle and high schools in 15 schools in California were randomly selected to receive free computers and followed over the school year. The results indicate that the experiment substantially increased computer ownership and total computer use among the schoolchildren with no substitution away from use at school or other locations outside the home. We find no evidence that the home computers improved educational outcomes for the treatment group. From detailed administrative data provided by the schools and a follow-up survey, we find no evidence of positive effects on a comprehensive set of outcomes such as grades, test scores, credits, attendance, school enrollment, computer skills, and college aspirations. The estimates also do not indicate that the effects of home computers on educational outcomes are instead negative. Our estimates are precise enough to rule out even modestly-sized positive or negative impacts. The lack of a positive net effect on educational outcomes may be due to displacement from non-educational uses such as for games, social networking, and entertainment. We find evidence that total hours of computer use for games and social networking increases substantially with having a home computer, and increases more than total hours of computer use for schoolwork.

1. Introduction

Computers are an important part of modern education. Schools spend more than $5 billion per year on computers, the Internet and other forms of technology (MDR 2004). In the United States, there is an average of one instructional computer for every three schoolchildren (U.S. Department of Education 2011). At considerable expense, a few states and many individual school districts have increased this ratio even further by implementing one-to-one laptop programs (Silvernail and Gritter 2007, Texas Center for Educational Research. 2009). The federal government also spends roughly $2 billion per year on the E-rate program, which provides discounts to low-income schools and libraries for the costs of telecommunications services and equipment (Puma, et al. 2000, Universal Services Administration Company 2007). Although schools have wholeheartedly invested in computers and technology in the classroom, parents have not invested as ubiquitously at home. Nearly 9 million children ages 10-17 in the United States (27 percent) do not have computers with Internet access at home (NTIA 2011).

How serious of a disadvantage is it to not have access to a computer at home for children enrolled in school? One reason for concern is that most of the children who do not have computers at home are poor.[1] It is possible that credit or other informational and technical constraints affect low-income households from investing in a potentially profitable technology. On the other hand, it is possible that home computers are not essential, and perhaps even a distraction, from performing well in school? Theory does not provide a clear prediction as to whether home computers exert a net negative or positive effect on educational outcomes. Having access to a home computer is

[1] See U.S. Department of Commerce (2008), NTIA (2011), Fairlie (2004), Goldfarb and Prince (2008), Ono and Zavodny (2003, 2007) for recent evidence on disparities in computer and Internet use

undoubtedly useful for completing school assignments because it increases and improves flexibility in access time to a computer for these purposes. On the other hand, home computers may crowd out schoolwork time because they are commonly used for games, networking, downloading music and videos, communicating with friends, and other entertainment among youth (Lenhart 2009, U.S. Department of Commerce 2004, Jones 2002).

Although an extensive literature examines the effectiveness of computer use in the classroom, much less research focuses on the question of whether *home* computers improve educational outcomes. This small, but growing, literature provides mixed results with several studies indicating large positive effects and others indicating negative effects (Attewell and Battle 1999, Schmitt and Wadsworth 2004, Fuchs and Woessmann 2004, Fairlie 2005, Fiorini 2010, Beltran, Das and Fairlie 2010, Malamud and Pop-Eleches 2011, and Vigdor and Ladd 2010). As with evaluating the impact of any input into the education production function, the fundamental problem is identifying exogenous variation in the input of interest. A variety of identification strategies are used in the previous literature to address this concern, however, no previous studies estimate the causal effects of home computers on educational outcomes of schoolchildren using a randomized control experiment. The only experiment of which we are aware was conducted by one of the authors among a sample of 286 low-income community college students, which found evidence of relatively small positive effects on educational outcomes (Fairlie and London 2011). The effects of home computers for college students, however, may differ greatly from those for schoolchildren.

In this paper, we conduct the largest field experiment involving the provision of free computers to students for home use ever conducted and the first experiment involving the provision of free computers to schoolchildren, to our knowledge. Middle and high school students who did not have computers at home at the beginning of the school year were randomly selected to receive free computers and were followed over the academic year. No computer training or other technology assistance was provided as part of the experiment to focus on identifying the educational effects of home computers instead of evaluating a new technology policy intervention. The random-assignment evaluation is conducted with 1,123 middle and high-school students enrolled in 15 different schools spread across 5 different school districts in California. Although baseline and follow-up surveys were conducted, detailed administrative data provided by the schools for all students is used for the analysis of educational outcomes eliminating concerns about potential attrition bias.

2. Previous Research

The educational production function commonly estimated in the literature relates student performance to student, family, teacher, and school inputs measured directly or as fixed effects (see Rivkin, Hanushek and Kain 2005 for example). The personal computer is an example of one of these inputs in the educational production process, but the usefulness of this input is not well understood.[2] There are several reasons to suspect that home computers may represent an important educational input. First, personal computers

[2] A large literature examines the impact of computers, Internet subsidies and computer-assisted software in schools generally finding mixed results. See Kirkpatrick and Cuban (1998) and Noll, et al. (2000) for reviews of this literature and Barrow, Markman and Rouse (2009), Machin, McNally and Silva (2007), Goolsbee and Guryan (2006), Banerjee, et al. (2007), and Barrera-Osorio and Linden (2009) for examples of a few recent studies.

make it easier to complete course assignments through the use of word processors, the Internet, spreadsheets, and other software (Lenhart, et al. 2001, Lenhart, et al. 2008). Although many students could use computers after school and at libraries, home access represents the highest quality access in terms of availability, flexibility and autonomy, which may provide the most benefits to the user (DiMaggio and Hargittai 2001). Almost all students using home computers use these computers to complete school assignments and nearly three out of every four use them for word processing (Beltran, Das and Fairlie 2010). Access to a home computer may also improve familiarity with software increasing the effectiveness of computer use for completing school assignments and the returns to computer use at school (Underwood, et al. 1994, Mitchell Institute 2004, and Warschauer and Matuchniak 2009). Enhanced computer skills from owning a personal computer may also alter the economic returns to education, especially in fields in which computers are used extensively. Finally, the social distractions of using a computer in a crowded computer lab on campus may be avoided by using a computer at home.

On the other hand, home computers are often used for games, networking, downloading music and videos, communicating with friends, and other forms of entertainment potentially displacing time for schoolwork (U.S. Department of Commerce 2004, Jones 2002).[3] Nearly three-quarters of home computer users use their computers for games, and a large percentage of these users report playing games at least a few times a week (Beltran, Das and Fairlie 2010, Lenhart, Jones and Rankin 2008). Social networking sites such as Facebook and Myspace and other entertainment sites such as Youtube and iTunes have grown rapidly in recent years (Lenhart 2009). The number of

[3] Valentine and Pattie (2005) find that leisure use of home computers and the Internet is negatively associated with educational attainment. See Warschauer and Matuchniak (2010) for a review.

Facebook users alone increased from only 2 million users in 2004 to 150 million users in 2009.[4] Computers are also often criticized for displacing other more active and effective forms of learning and by emphasizing presentation (e.g. graphics) over content (Giacquinta, et al. 1993, Stoll 1995 and Fuchs and Woessmann 2004). Computers and the Internet also facilitate cheating and plagiarism and make it easier to find information from non-credible sources (Rainie and Hitlin 2005). In the end, there is no clear theoretical prediction on the sign or magnitude of the effects of home computers on educational achievement, and thus an empirical analysis is needed.

To identify the effects of home computers, the starting empirical approach has been to regress educational outcomes on the presence of a home computer controlling for detailed student, family and parental characteristics. Studies using this approach generally find relatively large positive effects of home computers on educational outcomes (Attewell and Battle 1999, Fairlie 2005, Schmitt and Wadsworth 2006, Beltran, Das and Fairlie 2010, Fiorini 2010), although there is some evidence of negative effects (Fuchs and Woessmann 2004). In some cases these controls include prior educational attainment, difficult-to-find detailed characteristics of the educational environment in the household, and extracurricular activities of the student (Attewell and Battle 1999, Schmitt and Wadsworth 2006, Beltran, Das and Fairlie 2010). However, these estimates of the effects of home computers on educational outcomes may still be biased due to omitted variables. The main concern is that if the most educationally motivated students and families are the ones who are the most likely to purchase computers, then a positive

[4] The potential negative impact of the extensive use of Facebook among college students on academic outcomes has recently received some attention (Karpinski 2009 and Pasek and Hargittai 2009). These concerns are similar to those over television (Zavodny 2006).

relationship between academic performance and home computers may simply capture the effect of unmeasurable motivation on academic performance.[5]

Several studies investigate this issue using instrumental variable techniques, future computer ownership, falsification tests, individual-student fixed effects, or regression discontinuity designs (RDD). Estimates from bivariate probits for the joint probability of an educational outcome and computer ownership reveal large positive estimates (Fairlie 2005 and Beltran, Das and Fairlie 2010). Another approach, first taken by Schmidt and Wadsworth (2006), is to include future computer ownership in the educational outcome regression. A positive estimate of future computer ownership on educational attainment would raise suspicions that current ownership proxies for an unobserved factor, such as educational motivation. However, previous studies do not find a positive estimate for future computer ownership, and do not find positive estimates for additional falsification tests (Schmidt and Wadsworth 2006, Beltran, Das and Fairlie 2010, and Fiorini 2010). Vigdor and Ladd (2010) and Beltran, Das and Fairlie (2010) estimate student fixed effect models that control for time-invariant unobservables. Vigdor and Ladd (2010) find modestly-sized negative estimates of introducing home computers on math and reading test scores, whereas Beltran, Das and Fairlie (2010) find positive, but insignificant estimates of introducing home computers on school suspensions. Malamud and Pop-Eleches (2010) address the endogeneity problem with an RDD based on the effects of a government program in Romania that allocated a fixed number of vouchers for computers to low-income children in public schools. Estimates from the

[5] It may instead be the case that the least educationally motivated students and families (after controlling for individual and family characteristics) are the ones that purchase computers perhaps due to their entertainment value or because they substitute for more traditional and time-consuming forms of learning.

discontinuity created by the allocation of computer vouchers by a ranking of family income indicate that Romanian children winning vouchers have lower grades, but higher cognitive ability and better computer skills.

We build on the previous literature by conducting the largest random-assignment field experiment providing free computers to students for home use. We also provide the first experiment, to our knowledge, that conducts a randomized control experiment providing free computers to schoolchildren.[6] The random assignment of computers to schoolchildren addresses the selection problem and allows us to explore potential mechanisms for causal effects.

3. The Field Experiment

To study the educational impacts of home computers, we randomly assigned free computers to students who did not have home computers at the beginning of the school year. The students attended 15 different middle and high schools in 5 school districts in California during the 2008-09 and 2009-10 school years. These schools span the Central Valley of California geographically from Chico in the North to Fresno in the South, spanning the Central Valley of California. The schools are listed in Appendix Table 1. The computers used in the study were provided by Computers for Classrooms, Inc. a computer refurbisher located in Chico, California.[7]

[6] A few previous random experiments examine the effectiveness of computer-assisted learning and use of computers in schools (e.g. Barrow, Markman and Rouse 2009, Mathematica 2009, Banerjee, et al. 2007, and Barrera-Osorio and Linden 2009).

[7] The computers were refurbished Pentium machines with 17" monitors, modems, ethernet cards, CD drives, flash drive, Microsoft Windows, and Microsoft Office (Word, Excel, PowerPoint, Outlook). The system also came with a 1 year warranty on hardware and software. Computers for Classrooms offered to replace any computer not functioning properly during the study period.

To implement the study, we first conducted an in-class survey of all students in the 15 participating schools asking about computer ownership and use. Any student responding that he or she did not currently have a computer at home was eligible to participate in the study. The students, and even most teachers, did not know that the in-class survey would be used to determine eligibility for the experiment. Three schools handed out the surveys at the beginning of the school year, 2008-09, and 12 additional schools handed out surveys at the beginning of the school year, 2009-10.

In total, 7,337 students completed in-class surveys, with 23.9 percent reporting not having a computer at home. This rate of not having a computer at home is roughly comparable to the latest national estimate of the percent of children ages 10-17 not having a computer with Internet access at home of 27 percent (U.S. Department of Education 2011). Informational packets were sent home with the children who did not have a computer at home and were thus eligible for the study. Participation in the program involved returning a baseline questionnaire and consent form releasing future academic records from the school for the study. We received 1,123 responses with valid consent forms and completed questionnaires out of the 1,636 students eligible for the study. From the respondents, 559 students were randomly assigned to the treatment group and received their computers at school in the Fall of the school year. The control group of 564 students received their computers at school at the end of the school year. To focus on estimating the effects of having a home computer no training, assistance or course integration was offered. Basic Microsoft software that is standard with purchasing a personal computer was provided with the computers, but students were on their own to purchase Internet service or other software.

The schools provided us with detailed administrative data on educational outcomes for all students covering the entire academic year. For most outcomes that we examine the reliance on administrative data eliminates concerns over attrition bias. For some outcomes, we rely on information collected from a follow-up survey conducted at the end of the school year with an overall response rate of 77.2 percent. There does not appear to be differential attrition as the response rate was 78.7 percent for the treatment group and 76.1 percent for the control group. The difference is not statistically significant (see Appendix Table 2). The school-provided administrative data and follow-up survey provide information on a comprehensive set of computer use and educational outcomes.

Compared with the average school in the United States, our sample of schools are similarly sized, but are poorer and have a higher concentration of minority students. Our schools are also disproportionately minority. (U.S. Department of Education 2011). These differences impact our ability to generalize the results beyond this study, but low-income, ethnically diverse schools such as these are the ones most likely to enroll schoolchildren without home computers and be targeted by policies to address inequalities in access to technology (e.g. E-rate program). Another factor impacting our ability to generalize the results of the study is non-random participation in the experiment. Eligibility for the study is based on not having a computer at home. Thus, we estimate the impact of computers on the educational outcomes of schoolchildren at the margin of having a home computer and not necessarily the impact of computers for existing computer owners. Finally, one-third of students who did not have a home computer based on the in-class survey did not participate in the experiment. Most of the non-participation happened in a few schools in which there was much less promotion of

the study and follow through with students in signing up for the study. Even if most of the lack of participation is due to school related supply-side factors, however, there may be some cases where students did not participate because they lost or did not bring home the flier advertising the study, their parents did not provide consent to be in the study, or they did not want a computer. Thus, they might differ from the overall population of non-computer owners in their desire, trust, alternative access, and predicted use of computers. These differences may have some implications for our ability to generalize the results for the impacts of home computers to the full population of schoolchildren who do not currently own computers.

4. Results

4.1 Comparability of Treatment and Control Groups

Table 1 reports a comparison of background characteristics for the treatment and control groups. In the table, Columns 1 and 2 report the means for the treatment and control groups, respectively, while Column 3 reports a p-value for a t-test of equality. The information on student characteristics is provided from school administrative data and the baseline/application survey. The average age of study participants is 13 being spread across grades 6 to 10. The sample has high concentrations of minority, immigrant and non-English speaking students. The average education level of the highest educated parent is roughly 13 years of schooling. A small percentage of students do not live with their mothers (roughly 10 percent) and their mothers have relatively low employment rates. A much larger share of students do not live with their fathers (42 percent), and their fathers have employment rates of roughly 70 percent (conditional on living with the

child). Most students report that their parents have rules for how much TV they watch, have a curfew, and usually eat dinner with their parents. Students report using computers 1.6 hours per week at school and roughly 2 hours per week at outside locations such as libraries, community centers, Internet cafes, and a friend's or relative's house.

Overall, we find very few differences between the treatment and control groups. The only difference which is statistically significant is that treatment children are more likely to have rules on how much TV they watch. It is likely that this one difference is caused by random chance – nevertheless, we control for a number of covariates in all of the regressions which follow. The choice of these controls makes no difference to the regression results.

4.2. Effect of Program on Computer Ownership and Usage

The experiment has a very large first-stage impact in terms of increasing computer ownership and hours of computer use. Table 2 reports treatment effects on computer ownership rates and total hours of computer use from the follow-up survey conducted at the end of the school year. The reported treatment effects are coefficients from linear regressions that control for school, year, grade, age, gender, ethnicity, parental education, whether the student's primary language is English, immigrant status, whether the mother/father lives with the student, whether parents have rules for how much TV the student watches, and whether the mother/father has a job.[8] Estimates are very similar without these controls. From the follow-up survey, we find that the treatment group has a 55 percentage point higher rate of having a computer at home than the

[8] To avoid dropping observations, for each variable, we also include a dummy equal to 1 if the variable is missing for a student and code the original variable as a 0 (so that the coefficients are identified from those with non-missing values).

control group. This is very large, relative to the base rate in the control group: only 26 percent of control group students bought a computer by the end of the school year.[9] The follow-up survey also reveals that the treatment group is 25 percentage points more likely to have Internet service at home than the control group (mean=0.17).

The total number of hours of computer use at home is much higher for the treatment group than the control group. The treatment group reports using a home computer 2.5 hours more per week, which is a substantial gain over the control group whose use is less than 1 hour per week. The increase in home computer use by the treatment group does not crowd out computer use at school or other locations. Total computer use at all locations increases by only slightly less than home computer use.[10] Students do not appear to substitute away from using computers at school or other locations which include friends' houses when obtaining a home computer.

Table 3 shows how children use the computers. The increased use of computers among the treatment group is spread across several different activities. The treatment group uses computers for schoolwork, email, games, and social networking more hours per week than the control group. The increase in computer use for schoolwork of 0.8 hours is notably lower than the increase in computer use for games and social networking of 1.4 hours. We also find that the treatment group is more likely to have a social

[9] It is not entirely clear why more of the treatment group does not report having a home computer at the follow-up survey because only a handful of students eligible to receive computers out of the 559 students in the treatment group did not receive them from the schools. Conversations with school principals who talked to their students indicated that most of the students still had the computer at home, but it did not work anymore. We heard of no cases where students sold their computers.

[10] It is important to note that home computers only increase the potential for more computer use and actual use may decline if home computers allow for more efficient use of computers than school computers. Efficiency gains may result from increased familiarity and better suited software on home computers, but may also result from fewer distractions or less interrupted time than found in using computers after school.

networking page (reported in Column 1). These results suggest that home computers are used by schoolchildren for both educational and non-educational purposes, but non-educational uses appear to dominate.

5. Estimating the Effects of Home Computers on Educational Outcomes

5.1 Grades

Home computers might make it easier to complete and turn in course assignments. If so, having a computer may allow children to do better in classes. We examine this question in Table 4. In Panel A, Columns 1-2, we regress grade point average in quarters 3 and 4 of the academic year on treatment (with the same set of controls as before). To maximize power, we also include a control for the student's GPA in the first quarter, before they received a computer (see McKenzie 2011 for a recent discussion of this issue). To avoid dropping observations, we include a dummy variable for not having a quarter 1 GPA in all regressions and code the quarter 1 GPA as 0 for those students (such that the coefficient on quarter 1 GPA is identified off of only those with data). The results are very similar without controlling for quarter 1 GPA.

The estimated treatment effects are very close to zero, and very precisely estimated.[11] The standard errors from the "Intent-to-Treat" estimates are just 0.04 in both quarters; thus, the 95 percent confidence interval is only 0.08 GPA points, which is equivalent to roughly one-fourth of the effect of a "+ or –" (i.e. the difference between a B and a B+).[12] We can thus rule out even very modest effects of computers. In columns 3

[11] Estimates are similar when we estimate regressions using course-level data.
[12] LATE (or IV) estimates are not substantially higher because only 25 percent of the control group has a computer by the end of the school year.

and 4, we calculate a GPA for "academic" subjects (math, English, social studies, and science), and find similarly no effect.

In Panel B, we examine individual course grades in both quarters (while controlling for the quarter 1 grade in that subject). We find small, statistically insignificant effects in most specifications. We find statistically significant decreases in English grades in both quarters, though this may be due to sampling variation. In any case, these decreases are cancelled out by statistically insignificant increases in other subjects.

In Panel C, we look at course success for each class (whether the student passed the class, defined as receiving a D grade or higher). For this measure, we find a positive and significant coefficient for math, but a negative and significant coefficient for English. But, these differences are small and, again, the overall pattern is essentially one of no treatment effects.

Overall, Table 4 shows strong evidence that computers do not have an impact on grades for the average student. This finding holds for total GPA in different quarters, within subject grades, and when we replace grades with pass rates. The results are very much in line with the time usage results presented earlier, which showed that students spend more time using computers on social networking and games than on completing schoolwork.

5.2 Test Scores

Given that we find no effect of home computers on grades, it seems unlikely that we will find effects on test scores. However, previous research does find some evidence

that computer ownership affects test scores, though the direction of effects is mixed. Vigdor and Ladd (2010) find modestly-sized negative effects on math and reading test scores for students in grades 5-8 in North Carolina, whereas Malamud and Pop-Eleches (2011) find some evidence of positive effects on cognitive skills among Romanian schoolchildren and Fiorini (2010) finds evidence of positive effects on cognitive skills of Australian schoolchildren.

In our study, we are able to look at Standardized Testing and Reporting (STAR) test score results. As part of the STAR Program all California students are required to take standardized tests for math and English-language arts each spring. The schools provided us with math and English-language arts test scores for all attending students. Table 5 reports estimates of treatment effects for both test scores for English (Columns 1 and 2) and math (Columns 3 and 4). In Columns 1 and 3, we include the same controls as in the previous tables. In Columns 2 and 4 we also include STAR scores from the previous school year. For interpretability, we standardize the scores to have mean 0 and standard deviation 1 based on the control group.

With and without controlling for the previous year's test score, we find essentially no effect of home computers on test scores. The point estimates are small and very close to zero. They are also precisely estimated, and we can rule out effects as small as 0.05 standard deviations for English scores and 0.05 standard deviations for math scores.

5.3 Effects on Additional Educational Outcomes

Table 6 reports estimates for additional educational outcomes from the follow-up survey. We asked students how much time they spent on their last essay from school,

whether they passed homework in on time, and whether they planned on attending college. Home computers may affect these behavioral outcomes differently than for more objective school performance measures such as grades and test scores. Even though there seems to be some room for improvement (for example, 16 percent of students report that they “sometimes” pass in their homework on time), computer ownership has no impact on whether students turn in homework on time. Having a home computer also does not increase the amount of time spent on the school essays or projects, which may be due to home computers making it faster to write and revise essays. Finally, having a home computer does not alter students’ plans on whether to attend college or not. The lack of an effect, however, may be due to distance away from the college decision for most students in the study.

5.4. Computer Skills

The increased use time, flexibility and autonomy offered by having access to a home computer may result in enhanced computer skills for home users relative to non-home users. Home computers should improve skills among the general population, however, for schoolchildren who are already have exposure to computers at school and other locations they might have only a marginal effects on skills. We explore this question by using information on self-reported computer skills from the follow-up survey. Students were asked "How would you rate your computer skills?," and were given the possible responses of "excellent," "very good," "good," and "poor."[13] Using this measure, we find not major differences in self-reported computer skills. The treatment

[13] Self-reported technology skill measures such as this one have been found to have good predictive power for actual skills, and much more predictive power than either the amount of time spent per week or the number of years of use (Hargittai 2005).

group is less likely to report having "very good" computer skills than the control group, but half of this difference is reflected in the treatment group having a higher likelihood of reporting having "excellent" computer skills. In any case, there is no clear evidence that computer skills have improved.

We also proxy for computer skills by asking students what they use computers for and what they know how to do with computers.[14] In Panel B, we include answers to questions about for what purposes students use the computers (including MS Word, research, using a spreadsheet, and educational software). We find no major differences between the treatment and control groups in this dimension.

In Panel C, we asked students whether they knew how to use a computer for various tasks. We find no treatment difference in knowledge of how to download a file from the web, email a file, save a file to a hard drive, save a file to a flash drive, create a new folder for storing files, and enter a formula in a spreadsheet.

Finally, in Panel D, we asked students if they used the computer to show their parents how to do something on it, and whether they got help from a teacher or classmate via the internet or email. Treatment students are more likely to help a parent to do something (which is driven entirely by the fact that they are more likely to have a computer in the first place), but are no more likely to have gotten help online. The treatment group is no more likely than the control group to report that their teachers posted assignments online.

The different measures of computer skills and knowledge consistently indicate no effects of having home computers. Computer exposure at school and other locations may

[14] Examples of computer knowledge and activities were loosely based on the CPS Computer and Internet Supplement, the Microsoft Digital Literacy Test, and Hargittai (2005).

have the strongest effects of skills and knowledge and home use may only incrementally add to this base. Game use and social networking use increased from the treatment, but the skills and knowledge questions that we asked about on the follow-up survey may not have captured those related to these activities.

5.5. Administrative Outcomes

Our final set of results look at administrative outcomes provided by the school, including total credits earned, the number of unexcused absences, the number of tardies, and whether the student was still enrolled in school at the end of the year. All of these measures reflect interesting and important educational outcomes of interest. For all of these measures of educational outcomes, we find no evidence of positive effects of home computers. These results support the conclusions drawn from the grade and test score results of no effects of home computers.

6. Conclusion

A relatively large number of American households do not have access to home computers. This disparity is potentially worrying, particularly if access to computers has an effect on educational performance among schoolchildren. We provide direct evidence on this question by performing an experiment in which 1,123 middle and high school children across 15 different schools and 5 school districts in California were randomly given computers to use at home. To our knowledge, the experiment is the largest-ever field experiment involving the provision of free computers to students for home use and the first experiment involving the provision of free computers to schoolchildren. The

experiment substantially increased computer ownership and total computer use with no substitution away from use at school or other locations outside the home.

We find no evidence that home computers improved educational outcomes for the treatment group. From detailed administrative data provided by the schools, we find no evidence of positive effects on a comprehensive set of outcomes including grades, test scores, earned credits, attendance, disciplinary actions, and school enrollment. We also find no evidence of positive effects on additional outcomes such as college aspirations, time spent on essays, turning assignments in on time, computer skills, and computer knowledge from a detailed follow-up survey conducted near the end of the school year. Contrary to some recent findings in the literature, we also do not find evidence that the effects of home computers on educational outcomes are instead negative. Our estimates are precise enough to rule out even modestly-sized positive or negative impacts.

One factor that may dampen any positive effects of home computers on educational outcomes is the displacement from non-educational uses such as for games, social networking, and entertainment. We find evidence that total hours of computer use for games and social networking increases substantially with having a home computer, and increases more than total hours of computer use for schoolwork. These concerns over the non-educational uses of home computers must be weighed against the steadily increasing use of technology by schools and teachers in providing information, communicating, and delivering course content to parents and schoolchildren. A better understanding of these tradeoffs is important in designing policies to increase computer ownership and home access to technology among low-income youth (Warschauer 2006, Department for Children, Schools and Families, England 2008).

References

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

Banerjee, A., Cole, S., Duflo, E. and Linden, L (2007) "Remedying Education: Evidence from Two Randomized Experiments in India," *Quarterly Journal of Economics* 122(3), pp. 1235-1264.

Barrow, Lisa, Lisa Markman, and Cecelia E. Rouse. 2009. "Technology's Edge: The Educational Benefits of Computer-Aided Instruction," American Economic Journal: Economic Policy, 1(1): 52-74.

Barrera-Osorio, Felipe, and Leigh L. Linden. 2009. "The Use and Misuse of Computers in Education Evidence from a Randomized Experiment in Colombia," Policy Research Working Paper 4836, Impact Evaluation Series No. 29, The World Bank.

Beltran, Daniel O., Kuntal K. Das, and Robert W. Fairlie. 2010. "Home Computers and Educational Outcomes: Evidence from the NLSY97 and CPS," *Economic Inquiry*, (forthcoming).

Crandall, Robert W. 2000. "Bridging the Digital Divide: Universal Service, Equal Access, and the Digital Divide," paper presented at Bridging the Digital Divide: California Public Affairs Forum, Stanford University.

Cuban, Larry. 2001. Oversold and Underused: Computers in the Classroom. Cambridge: Harvard University Press.

DiMaggio, P. J., and Hargittai, E. 2001. "From Digital Divide to Digital Inequality: Studying Internet Use as Penetration Increases," Northwestern University Working Paper.

Educause. 2005. Educause Core Data Service: Fiscal Year 2004 Summary Report. Washington, D.C.: Educause.

Fairlie, Robert W. 2004. "Race and the Digital Divide," *The B.E. Journal of Economic Analysis & Policy*, 3(1), Contributions, Article 15: 1-38.

Fairlie, Robert W. 2005. "The Effects of Home Computers on School Enrollment," *Economics of Education Review*, 24(5): 533-547.

Fairlie, Robert W., and Rebecca A. London. 2011. "The Effects of Home Computers on Educational Outcomes: Evidence from a Field Experiment with Community College Students." *Economic Journal* (forthcoming).

Fiorini, M. 2010. “The Effect of Home Computer Use on Children’s Cognitive and Non-Cognitive Skills,” Economics of Education Review, 29: 55-72.

Fuchs, Thomas, and Ludger Woessmann. 2004. "Computers and Student Learning: Bivariate and Multivariate Evidence on the Availability and Use of Computers at Home and at School." CESIFO Working Paper No. 1321.

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

Goldfarb, Avi, and Jeffrey Prince. 2008. "Internet Adoption and Usage Patterns are Different: Implications for the Digital Divide." Information Economics and Policy, 20(1), 2-15, March.

Goolsbee, Austan, and Jonathan Guryan. 2006. "The Impact of Internet Subsidies in Public Schools," The Review of Economics and Statistics, 88(2): 336-347, May.

Hargittai, Eszter. 2002. "Second-Level Digital Divide: Differences in People's Online Skills." First Monday. 7(4).

Jones, Steve. 2002. "The Internet Goes to College: How students are living in the future with today’s technology. Pew Internet Report.

Karpinski, A.C. 2009. “A description of Facebook use and academic performance among undergraduate and graduate students,” paper presented at the Annual Meeting of the American Educational Research Association, San Diego, Calif.

Kirpatrick, H., and L. Cuban. 1998. "Computers Make Kids Smarter--Right?" Technos Quarterly for Education and Technology, 7:2.

Lenhart, Amanda. 2009. The Democratization of Online Social Networks: A look at the change in demographics of social network users over time," Pew Internet & American Life Project, Presentation at AoIR 10.0, October 8, 2009.

Lenhart, Amanda, Joseph Kahne, Ellen Middaugh, Alexandra Rankin Macgill, Chris Evans, and Jessica Vitak. 2008. "Teens, Video Games, and Civics: Teens’ gaming experiences are diverse and include significant social interaction and civic engagement," Pew Internet and American Life Project.

Lenhart, Amanda, Maya Simon, and Mike Graziano. 2001. "The Internet and Education: Findings from the Pew Internet & American Life Project," Washington, D.C.: Pew Internet & American Life Project.

Machin, Stephen, Sandra McNally, and Olmo Silva. 2007. "New Technology in Schools: Is There a Payoff?" Economic Journal, 117(522): 1145-1167, July.

Malamud, Ofer, and Cristian Pop-Eleches. 2011. "Home Computer Use and the Development of Human Capital," *Quarterly Journal of Economics*, 126: 987-1027.

Market Data Retrieval. 2004. Technology in Education. Market Data Retrieval: Shelton, Connecticut.

Mathematica. 2009. "Effectiveness of Reading and Mathematics Software Products: Findings from Two Student Cohorts," Report for U.S. Department of Education.

McKenzie, David (2010). "Beyond Baseline and Follow-up: The Case for More T in Experiments." BREAD Working Paper No. 291.

Mitchell Institute. 2004. One-to-one Laptops in a High School Environment, Piscataquis Community High School Study Final Report. Great Maine Schools Project.

National Telecommunications and Information Administration. 2011. Current Population Survey (CPS) Internet Use 2010, http://www.ntia.doc.gov/data/CPS2010_Tables_.

Noll, Roger G. Noll, Dina Older-Aguilar, Gregory L. Rosston, and Richard R. Ross. 2000. "The Digital Divide: Definitions, Measurement, and Policy Issues," paper presented at Bridging the Digital Divide: California Public Affairs Forum, Stanford University.

Ono, Hiroshi, and Madeline Zavodny, 2007. "Digital Inequality: A Five Country Comparison Using Microdata," *Social Science Research*, 36 (September 2007): 1135-1155.

Ono, Hiroshi, and Madeline Zavodny, 2003. "Race, Internet Usage, and E-Commerce," *Review of Black Political Economy*, 30, Winter: 7-22.

Pasek, Josh, and Eszter Hargittai. 2009. "Facebook and academic performance: Reconciling a media sensation with data," First Monday, Volume 14, Number 5 - 4.

Puma, Michael J., Duncan D. Chaplin, and Andreas D. Pape. 2000. E-Rate and the Digital Divide: A Preliminary Analysis from the Integrated Studies of Educational Technology. Urban Institute.

Public Policy Institute of California. 2008. PPIC Statewide Survey: Californians and Information Technology, San Francisco: PPIC.

Rainie, Lee, and Paul Hitlin. 2005. The Internet at School. Pew Internet Project.

Rivkin, Steven G., Eric A. Hanushek, and John F. Kain. 2005. "Teachers, Schools, and Academic Achievement," *Econometrica*, Vol. 73, No. 2 (March, 2005), 417–458.

Schmitt, John, and Jonathan Wadsworth. 2006. "Is There an Impact of Household Computer Ownership on Children's Educational Attainment in Britain? Economics of Education Review, 25: 659-673.

Silvernail, David L., and Aaron K. Gritter. 2007. Maine's Middle School Laptop Program: Creating Better Writers, Maine Education Policy Research Institute, University of Southern Maine.

Stoll, Clifford. 1995. Silicon Snake Oil: Second Thoughts on the Information Highway. New York: Doubleday.

Texas Center for Educational Research. 2009. Evaluation of the Texas Technology Immersion Pilot: Final Outcomes for a Four-Year Study (2004-05 to 2007-08).

Underwood, J., Billingham. M. and Underwood, G. 1994. "Predicting Computer Literacy: How Do the Technological Experiences of Schoolchildren Predict Their Computer Based Problem-Solving Skills? Journal of Information Technology for Teacher Education, 3(1), 115-125.

U.S. Department of Commerce. 2008. Networked Nation: Broadband in America 2007. National Telecommunications and Information Administration, U. S. Department of Commerce:
Washington, D.C.

U.S. Department of Education. 2004. Office of Education Technology. *Toward a New Golden Age in American Education: How the Internet, the Law, and Today's Students are Revolutionizing Expectations*. Washington, DC: 2004.
http://nationaledtechplan.org/default.asp

U.S. Department of Education. 2006. National Center for Education Statistics. Internet Access in U.S. Public Schools and Classrooms: 1994-2004, NCES 2006-015, by Basmat Parsad and Jennifer Jones. Project Officer: Bernard Greene. Washington, DC: 2005.
http://nces.ed.gov/pubs2005/2005015.pdf

U.S. Department of Education. 2011. Digest of Education Statistics 2010 (NCES 2008-022). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC.

U.S. Department of Education. 2011. "School Locator," National Center for Educational Statistics, http://nces.ed.gov/ccd/schoolsearch/

Universal Services Administration Company. 2007. Annual Report
http://www.universalservice.org/_res/documents/about/pdf/annual-report-2007.

Valentine, Gill, Jackie Marsh, and Charles Pattie. 2005. Children and Young People's Home Use of ICT for Educational Purposes: The Impact on Attainment at Key Stages 1-4, Department for Education and Skills Research Report RR672.

Vigdor, Jacob L., and Helen F. Ladd. 2010. "Scaling the Digital Divide: Home Computer Technology and Student Achievement," NBER Working Paper No. 16078.

Warschauer, Mark. 2006. Laptops and Literacy: Learning in the Wireless Classroom, Teachers College Press.

Warschauer, Mark, and Tina Matuchniak. 2010. "New Technology and Digital Worlds: Analyzing Evidence on Equity in Access, Use, and Outcomes," *Review of Research in Education*, 34(1): 179-225.

Zavodny, Madeline. 2006. "Does Watching Television Rot Your Mind? Estimates of the Effect on Test Scores," *Economics of Education Review*, 25 (October 2006): 565-573.

Table 1. Individual Level Summary Statistics and Balance Check

	Control	Treatment	Equality of means *p-val*	Obs.
Panel A. Administrative Data Provided by School				
Age	12.75	12.70	0.61	1123
	(1.67)	(1.83)		
Female	0.51	0.50	0.66	1123
	(0.50)	(0.50)		
Ethnicity = African American	0.13	0.13	0.88	1123
	(0.34)	(0.34)		
Ethnicity = Latino	0.55	0.54	0.71	1123
	(0.50)	(0.50)		
Ethnicity = Asian	0.12	0.13	0.44	1123
	(0.32)	(0.34)		
Ethnicity = White[1]	0.15	0.14	0.54	1123
	(0.36)	(0.35)		
Immigrant	0.21	0.17	0.15	1123
	(0.41)	(0.38)		
Primary language is English	0.42	0.42	0.95	1123
	(0.49)	(0.50)		
Parent's education[2]	8.43	8.17	0.49	1123
	(6.20)	(6.24)		
Number of people living in household	4.85	4.98	0.40	1123
	(2.53)	(2.59)		
Panel B. Baseline Survey				
Lives with mother	0.92	0.89	0.12	1123
	(0.28)	(0.32)		
Lives with father	0.58	0.58	0.90	1123
	(0.49)	(0.49)		
Hours of computer use at school	1.61	1.69	0.69	1049
	(3.02)	(3.57)		
Hours of computer outside school	1.93	2.24	0.26	1030
	(3.79)	(4.95)		
Computer skills are "very good"	0.39	0.37	0.48	1116
or "excellent"[3]	(0.49)	(0.48)		
Computer skills are "good"	0.53	0.57	0.27	1116
	(0.50)	(0.50)		
Do you have a social networking page?	0.38	0.42	0.12	1110
	(0.49)	(0.50)		
Do your parents have rules for how	0.78	0.73	0.04**	1123
much TV you watch?	(0.41)	(0.44)		
Do you have a curfew?	0.84	0.81	0.17	1076
	(0.37)	(0.39)		
Do your participate on a sports team?	0.32	0.35	0.24	1107
	(0.47)	(0.48)		
Do you participate on an after school club?	0.45	0.46	0.58	1107
	(0.50)	(0.50)		
Does your mother have job?[4]	0.43	0.41	0.47	1123
	(0.50)	(0.49)		
Does your father have a job?	0.47	0.45	0.38	1123
	(0.50)	(0.50)		
Do you usually eat dinner with your	0.90	0.87	0.11	1112
parents?	(0.31)	(0.34)		

*Notes: In Columns 1 and 2, means reported with standard errors in parentheses. Column 3 reports the p-value for the t-test for the equality of means. ***, **, * indicates significance at 1, 5 and 10%.*

[1] *Omitted ethnicity category is "not reported."*

[2] *This is the highest education level of either parent (which is the measure most schools in our sample collected).*

[3] *The omitted computer skills category is "poor."*

[4] *The variables for mother's and father's job is reported only for households in which the given parent lives in the household.*

Table 2. Effect of Program on Computer Ownership and Usage

	(1)	(2)	(3)	(4)	(5)	(6)
			Hours of Computer Use Per Week			
	Owns a Computer	Has Internet Connection	Total	At Home	At School	At Other Location
Treatment	0.55	0.25	2.48	2.55	-0.01	-0.06
	(0.03)***	(0.03)***	(0.48)***	(0.32)***	(0.17)	(0.29)
Observations	852	831	755	755	755	755
R-squared	0.40	0.20	0.12	0.16	0.10	0.09
Control mean	0.26	0.17	4.23	0.76	1.59	1.89

*Notes: Data is from follow-up survey completed by students. Regressions control for the sampling strata (school*year). We also include controls for age, gender, ethnicity, grade, parental education, whether the student's primary language is English, whether the student is an immigrant, whether the mother/father lives with the student, whether parents have rules for how much TV the student watches, and whether the mother/father has a job. To avoid dropping observations, for each variable, we create a dummy equal to 1 if the variable is missing for a student and code the original variable as a 0 (so that the coefficients are identified from those with non-missing values).*

****, **, * indicates significance at 1, 5 and 10%.*

Table 3. Computer Usage

	(1)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
		Hours of Computer Use Per Week					When do you use your home computer?		
	Do you have a social networking page?[1]	School-work	Email	Games	Net-working	Other	Just before school	Weekday night	Weekends
Treatment	0.07	0.80	0.42	0.80	0.57	0.17	-0.05	0.04	0.04
	(0.04)*	(0.25)***	(0.12)***	(0.22)***	(0.18)***	(0.11)	(0.03)	(0.03)	(0.03)
Observations	692	671	671	671	671	671	869	869	869
R-squared	0.14	0.13	0.15	0.10	0.11	0.08	0.07	0.09	0.07
Control mean	0.53	1.89	0.25	0.84	0.57	0.62	0.46	0.25	0.41
Control std. dev.	0.49	3.83	2.10	3.54	2.77	1.48	0.49	0.46	0.50

*Notes: Data is from follow-up survey completed by students. See the notes to Table 2 for the list of controls. Regressions also control for the sampling strata (school*year). Panel B instruments having a computer at follow-up with being sampled for treatment. See Table 2 for the first stage. There are fewer observations in Panel B because some students did not report whether they had a computer on the follow-up survey. ***, **, * indicates significance at 1, 5 and 10%.*

[1] *This question was only asked in the follow-up in the 2nd year of the program*

Table 4. Grades

	(1)	(2)	(3)	(4)
	All Subjects		Academic Subjects[1]	
Panel A. GPA	Q3	Q4	Q3	Q4
Treatment	0.00	-0.03	0.05	0.01
	(0.04)	(0.04)	(0.05)	(0.05)
Quarter 1 GPA	0.75	0.75	0.70	0.68
	(0.02)***	(0.03)***	(0.02)***	(0.03)***
Observations	1032	993	1032	991
Control mean	2.44	2.49	2.20	2.30
Control std. dev.	0.98	1.00	1.09	1.09

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Math		English		Social Studies		Science	
Panel B. Individual Class Grades	Q3	Q4	Q3	Q4	Q3	Q4	Q3	Q4
Treatment	0.08	-0.07	-0.12	-0.18	0.03	0.03	0.06	0.09
	(0.06)	(0.06)	(0.07)*	(0.08)**	(0.07)	(0.08)	(0.07)	(0.07)
Quarter 1 grade in that subject	0.63	0.61	0.49	0.46	0.58	0.57	0.57	0.51
	(0.03)***	(0.03)***	(0.03)***	(0.03)***	(0.03)***	(0.03)***	(0.03)***	(0.03)***
Observations	1137	1077	925	885	920	870	978	931
Control mean	1.99	2.08	2.37	2.44	2.26	2.28	2.12	2.37
Control std. dev.	1.37	1.35	1.29	1.32	1.36	1.37	1.38	1.32

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Math		English		Social Studies		Science	
Panel C. Indicator for Passing Individual Classes	Q3	Q4	Q3	Q4	Q3	Q4	Q3	Q4
Treatment	0.05	0.00	0.00	-0.05	-0.01	0.00	0.01	0.01
	(0.02)**	(0.02)	(0.02)	(0.02)**	(0.02)	(0.02)	(0.02)	(0.02)
Quarter 1 grade in that subject	0.15	0.15	0.09	0.09	0.12	0.11	0.13	0.10
	(0.01)***	(0.01)***	(0.01)***	(0.01)***	(0.01)***	(0.01)***	(0.01)***	(0.01)***
Observations	1137	1077	925	885	920	870	978	931
Control mean	0.75	0.78	0.84	0.86	0.82	0.83	0.78	0.84
Control std. dev.	0.44	0.42	0.37	0.35	0.39	0.37	0.41	0.37

*Notes: All regressions include controls for the sampling strata (school*year) and the same controls as in Table 2.*

****, **, * indicates significance at 1, 5 and 10%.*

[1] *"Academic subjects" include Math, English, Social Studies, Science, and Computers.*

Table 5. California STAR Test

	(1)	(2)	(3)	(4)
	English Language		Math	
Treatment	-0.05	-0.05	-0.07	-0.06
	(0.06)	(0.05)	(0.06)	(0.05)
Prior year's test score		0.69		0.62
		(0.03)***		(0.03)***
Observations	961	961	914	914
Control mean	0.00	0.00	0.00	0.00
Control std. dev.	1.00	1.00	1.00	1.00

*Notes: Test scores are normalized to have mean 0 and standard deviation 1. See the notes to Table 2 for the list of controls. Regressions also control for the sampling strata (school*year). To avoid dropping observations, for each control variable (including the prior year's test score), we create a dummy equal to 1 if the variable is missing for a student and code the original variable as a 0 (so that the coefficients are identified from those with non-missing values).*

****, **, * indicates significance at 1, 5 and 10%.*

Table 6. School Effort and College Aspirations

	(1)	(2)	(3)	(4)	(5)
	How much time did you spend on last essay?	How often do you pass homework in on time?			Do you plan on going to college?
		Always	Usually	Sometimes	
Treatment	0.04	-0.04	0.02	0.01	-0.03
	(0.81)	(0.03)	(0.03)	(0.03)	(0.03)
Observations	805	853	853	853	858
Control mean	4.38	0.47	0.37	0.16	0.85
Control std. dev.	10.16	0.50	0.48	0.37	0.35

*Notes: All regressions include controls for the sampling strata (school*year), and the same control as in Table 2.*
****, **, * indicates significance at 1, 5 and 10%.*

Table 7. Computer Skills, Usage, and Knowledge

Panel A. Rating of Computer Skills	(1) *Excellent*	(2) *Very good*	(3) *Good*	*Poor*
Treatment	0.04	-0.10	0.06	0.00
	(0.03)	(0.03)***	(0.03)*	(0.02)
Observations	854	854	854	854
Control mean	0.14	0.38	0.42	0.06

Panel B. Uses a Computer for:[1]	(1) *Word*	(2) *Research*	(3) *Spreadsheet*	(4) *Educational software*	(5) *Usage Index*[2]
Treatment	0.06	-0.04	0.02	-0.03	-0.01
	(0.03)*	(0.03)	(0.03)	(0.04)	(0.02)
Observations	854	707	707	707	707
Control mean	0.42	0.75	0.12	0.32	0.39
Control std. dev.	0.49	0.43	0.33	0.47	0.26

Panel C. Knows How to:	(1) *Download file from internet*	(2) *Email a file*	(3) *Save a report to hard drive*	(4) *Save a report to flash drive*	(5) *Create a new folder*	(6) *Enter a formula in Excel*	(7) *Knowledge Index*[2]
Treatment	0.03	0.04	-0.04	0.06	0.00	-0.03	0.01
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)	(0.02)
Observations	707	707	707	707	707	707	707
Control mean	0.49	0.46	0.62	0.55	0.66	0.21	0.50
Control std. dev.	0.50	0.50	0.49	0.50	0.48	0.40	0.32

Panel D. Parental/Teacher Help	(1) *Has shown parent how to do something on computer*	(2) *Gotten help from teacher or classmate via internet / email*	(3) *Do teachers ever post assignments online?*
Treatment	0.43	0.02	-0.03
	(0.03)***	(0.03)	(0.03)
Observations	700	851	837
R-squared	0.27	0.10	0.11
Control mean	0.12	0.37	0.44
Control std. dev.	0.32	0.48	0.50

Notes: Data is from follow-up survey completed by students. See Appendix Table A1 for statistics on attrition.
****, **, * indicates significance at 1, 5 and 10%.*

[1] *The questions in Panels B and C were only asked in the 2nd year of the program (2009-2010).*

[2] *For both knowledge and usage, the index sums the number of questions for which the student reported "yes" and divides by the total number of questions.*

Table 8. Administrative Outcomes

	(1) Total credits in 3rd quarter	(2) Total credits in 4th quarter	(3) Unexcused Absences	(4) Number of Tardies	(5) Still enrolled at End of Year
Treatment	-0.02	-0.09	-0.37	-0.21	0.01
	(0.09)	(0.09)	(0.38)	(0.93)	(0.02)
Observations	1123	1123	1104	1104	1123
R-squared	0.44	0.40	0.34	0.24	0.20
Control mean	5.71	5.83	4.94	11.53	0.88
Control std. dev.	1.88	1.89	7.84	17.00	0.33

*Notes: Regressions acontrol for the sampling strata (school*year), and the same list of control as Table 2. The variable "Left School by End of Year" is coded as a 1 if the student had no grade data in the 4th quarter. ***, **, * indicates significance at 1, 5 and 10%.*

Appendix Table A1. Computer Ownership and Participation Rates

	(1)	(2)	(3)	(4)	(5)
	Completed In-Class Survey (Given to All Students)	Students without Home Computers (Eligible for Study)		Students Participating in Computer Study (Returned Baseline Surveys)	
		Number	Percent	Number	Percent
Panel A. Year 1 (2008-09)					
Chico Junior High	472	118	0.25	99	0.84
Bidwell	625	160	0.26	56	0.35
Chico High	506			28	
Panel B. Year 2 (2009-10)					
Chico/Yuba/Marysville Schools					
Andros Karperos Middle	468	72	0.15	55	0.76
Anna McKenney Int.	420	86	0.20	65	0.76
Chico Junior High	261	25	0.10	20	0.80
Gray Avenue Middle	590	134	0.23	106	0.79
Fresno Unified School District					
George Washington Carve	193	66	0.34	49	0.74
Tehipite	452	149	0.33	89	0.60
Yosemite Middle	625	197	0.32	142	0.72
Sacramento Unified School District					
California Middle	256	96	0.38	61	0.64
Fern Bacon	631	150	0.24	128	0.85
John Still	332	52	0.16	34	0.65
Kit Carson Middle	361	75	0.21	19	0.25
Rosa Park (Goethe)	515	99	0.19	83	0.84
Will C. Wood	630	157	0.25	89	0.57
Totals	7337	1636	0.24	1123	0.67

Appendix Table A2. Attrition

	(1) Appears in follow-up dataset	(2) Appears in baseline adminstrative dataset	(3) Appears in follow-up administrative dataset	(4) Appears in grade dataset	(5) Has STAR scores
Treatment	0.02	0.00	0.00	-0.01	0.01
	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)
Observations	1123	1123	1123	1123	1123
Control mean	0.76	0.99	0.99	0.99	0.87

Notes: Regressions restricted to those students who enrolled in the program at baseline (those who completed a baseline survey and a consent form).

****, **, * indicates significance at 1, 5 and 10%.*