The Effects of Home Computers on Educational Outcomes: Evidence from a Field Experiment with Community College Students

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

Rebecca A. London
Stanford University
rlondon@stanford.edu

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Abstract

There is no clear theoretical prediction regarding whether home computers are an important input in the educational production function. To investigate this hypothesis, we conduct the first-ever field experiment involving the provision of free computers to students. Financial-aid students attending a large community college in Northern California were randomly selected to receive free computers and were followed for two years. We find some evidence that the randomly selected group of students receiving free computers has better educational outcomes, such as grades and graduation rates, than the control group that did not receive free computers. The modest-sized estimates of home computer effects from the experiment contrast with larger non-experimental estimates generated from matched CPS data. We also find evidence that home computers improve flexibility in times using the computer and represent an important substitute for on-campus use. One caveat, however is that we find that home computer ownership appears to be associated with increased use of computers for games, networking (e.g. Facebook) and other entertainment potentially weakening their educational value. Students who were the least likely to use computers for these non-educational purposes benefitted the most from receiving home computers. The results have important implications for how we view the remaining Digital Divide in the United States.

1. Introduction

The use of computers is ubiquitous in the U.S. educational system. Nearly all instructional classrooms in U.S. public schools have computers with Internet access, with an average of more than one instructional computer for every four schoolchildren (U.S. Department of Education 2007). The federal government has made the provision of computer and Internet access to school children a top priority. Roughly $2 billion is spent per year on the E-rate program, which provides discounts to schools and libraries for the costs of telecommunications services and equipment (Puma, et al. 2000, Universal Services Administration Company 2007). The National Educational Technology Plan calls for increased teacher training in technology, e-learning opportunities for students, access to broadband, digital content and integrated data systems (U.S. Department of Education 2004). Several state, local government and private programs have also created one-to-one computing in selected schools through the provision of laptop computers to schoolchildren and teachers.

Still, 45 million households in the United States, representing 38 percent of all households, do not have computers with Internet access at home (NTIA 2008). Access to home computers is also not evenly distributed across the population: large disparities exist by race, ethnicity, and income.[1] For example, only 46 percent of the 50 million U.S. households with less than $50,000 in annual income have computers with Internet access at home compared to 87 percent of households with more than $50,000 in income. These disparities in access to home computers—known as the Digital Divide—may contribute to educational inequality. There is no clear theoretical prediction, however, regarding whether home computers are likely to have a negative or positive effect on educational outcomes. Having access to a home computer is undoubtedly useful for completing school assignments. It increases and improves flexibility in access time to a computer for writing papers, conducting research, and making calculations for

[1] See NTIA (2008), Fairlie (2006), Goldfarb and Prince (2008), and Ono and Zavodny (2007) for recent evidence on disparities in computer and Internet use

course assignments. On the other hand, home computers are used extensively for games, networking, downloading music and videos, communicating with friends, and other entertainment potentially crowding out schoolwork time similar (Beltran, Das and Fairlie 2009, U.S. Department of Commerce 2004, Jones 2002).[2] The use of entertainment-based web sites such as YouTube, Facebook, MySpace and iTunes has grown exceptionally fast among youth in recent years. The answer to whether home computers have an effect on educational outcomes is important because it sheds light on whether home computers are an important input in the educational production process and whether disparities in access to technology will translate into educational and thus future income inequality.

Although an extensive literature examines the effectiveness of computer use in the classroom, very little research has focused on the question of whether *home* computers improve educational outcomes. The handful of previous studies examining the relationship between home computers and educational outcomes find somewhat mixed results (Attewell and Battle 1999, Schmitt and Wadsworth 2004, Fuchs and Woessmann 2004, Fairlie 2005, Beltran, Das and Fairlie 2008, and Malamud and Pop-Eleches 2008). Most of the previous research potentially suffers from omitted variable bias -- specifically that the most educationally motivated families are the ones that purchase computers for their children. In this paper, we conduct the first-ever field experiment involving the provision of free computers to students.[3] Participating students were randomly selected to receive free computers and were followed for two years. The random-assignment evaluation is conducted with 286 entering students receiving financial aid at a large community college in Northern California. Baseline and follow-up surveys were conducted, but most of the information used in the analysis of educational outcomes was provided by administrative data collected by the college. The field experiment provides evidence on whether home computers represent an important input in educational production and also on the potential

[2] These concerns are similar to those over television (Zavodny 2006).
[3] To our knowledge the only other study that involves the provision of free computers is Servon and Kaestner (2008), which studies the effects of computers on the use of financial services.

mechanisms exerting both positive and negative influences on educational outcomes. The results will also provide the first evidence in the literature on the effects of home computers for post-secondary students. The conclusions from the analysis will shed light on whether we view the remaining digital divide in the United States as a difference in consumer preferences or a disparity in educational resources.[4]

2. Previous Research

Before discussing the results from the field experiment, we briefly discuss how personal computers might affect educational outcomes and the previous literature that empirically tests such models. The educational production function commonly estimated in the literature models student performance as a function of 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. The use of computers in U.S. schools is now universal and has been studied extensively, but the role of home computers as an input in educational production is not well understood.[5]

There are several reasons to suspect that home computers may represent an important educational input. First, personal computers make it easier to complete course assignments through the use of word processors, the Internet, spreadsheets, and other software (Lenhart, et al. 2001).[6] Although many students could use computers at school and libraries, home access represents the highest quality access in terms of availability and autonomy, which may provide the most benefits to the user (DiMaggio and Hargittai 2001). Almost all teenagers using home

[4] See Noll, et al. (2000) and Crandall (2000) for an example of the debate over this issue.
[5] 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) and Goolsbee and Guryan (2006) for a few recent studies.
[6] Having a home computer may be especially useful for conducting research on the Internet for school assignments because of the increased time and flexibility compared to in-school use. Nearly all teenagers report using the Internet at least occasionally to conduct research for school (Lenhart, et al. 2008).

computers use these computers to complete school assignments and nearly three out of every four use them for word processing (Beltran, Das and Fairlie 2009). 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). Home computers also allow more flexibility in how students use computers. 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, using a computer at home may avoid the social distractions of using computer on campus.

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. Nearly three-quarters of home computer users use their computers for games (Beltran, Das and Fairlie 2009).[7] Social networking sites such as Facebook and Myspace and other entertainment sites such as Youtube and iTunes have grown rapidly in recent years. The number of Facebook users alone increased from only 2 million users in 2004 to 150 million users in 2009. 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

[7] Surveys conducted by the Pew Internet Project indicate frequent game use by youth. For example, 50 percent of 18-29 year old game users and 75 percent of teenage game users report playing games at least a few times a week (Lenhart, Jones and Rankin 2008).

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, Schmitt and Wadsworth 2006, Beltran, Das and Fairlie 2008), but there is some evidence of negative effects (Fuchs and Woessmann 2004). Although in some cases these controls include prior educational attainment, typically unobservable 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 2008), 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 families are the ones that are the most likely to purchase computers, then a positive relationship between academic performance and home computers may simply capture the effect of unmeasurable motivation on academic performance.[8] The children may have done better in school even in the absence of the home computer because of the value placed on educational achievement.

A few studies have investigated this issue using instrumental variable techniques, future computer ownership, falsification tests, individual-student fixed effects, or a natural experiment. 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 2008).[9] 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. Future computer ownership, however, is not found to have a positive relationship with educational outcomes similar to the positive relationship found for contemporaneous computer ownership (Schmidt and Wadsworth 2006 and

[8] It may instead be the case that the least educationally motivated families (after controlling for child 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.

[9] Use of computers and the Internet at work by the child's mother and father, the presence of another teenager in the household, and the MSA-level home computer rate are used as excluded variables.

Beltran, Das and Fairlie 2008). Related to this approach, Beltran, Das and Fairlie (2008) also do not find evidence of a positive relationship between educational attainment and having a dictionary at home or cable television, which also might be correlated with unobservables. Malamud and Pop-Eleches (2008) address the endogeneity problem by exploiting a natural experiment created by a government program that allocated a fixed number of vouchers for computers to low-income children in Romanian public schools. Estimates from the discontinuity created by the allocation of computer vouchers by a ranking of family income indicate that Romanian children winning vouchers have lower grades and educational aspirations. Although the approach provides more credible estimates of the effects of home computers, the U.S. experience might be very different because of the much higher reliance of educational technology.

We take a new approach to address the problem of correlated unobservables by conducting the first random-assignment field experiment providing free computers to students. The only previous study that randomly assigned free computers to individuals is Servon and Kaestner (2008). Through a program with a major bank, computers with Internet service were randomly assigned to low- and moderate-income families to determine how they affect the use of financial services.[10] To our knowledge, no study has randomly provided free computers to students. Furthermore, no previous research explores the impact of home computers on the educational outcomes of college students.

3. The Field Experiment

To study the educational effects of home computers, we randomly assigned free computers to entering community college students receiving financial aid.[11] The students

[10] The treatment group receiving free computers included 159 families and the control group receiving free computers 9 months later included 84 families. They find little quantitative evidence of program effects.
[11] We did not provide Internet service as part of the experiment, but found at the end of the study that more than 90 percent of the treatment group had Internet service. Previous research indicates that Internet

attended Butte College, which is located in Northern California and has a total enrollment of over 15,000 students. The computers were provided to us by Computers for Classrooms, Inc. a computer refurbisher located in Chico, California. The program was advertised to all students receiving financial aid. A total of 286 students participated in the study, with 141 selected for the treatment group (received a free home computer) and 145 for the control group (did not receive a free home computer).

To implement the study, we first obtained a list of all financial aid students with less than 24 units attending the college in Fall 2006. The 24 unit cutoff was chosen to capture new and relatively new students as of Fall 2006. It ensures that students in the study have less than 2 previous full-time semesters at the college. In Fall 2006, there were 1,042 financial-aid students and 6,681 students in total who met the course unit restriction. We advertised the program by mailing letters to all financial aid students. Participation in the program involved returning a baseline questionnaire and consent form releasing future academic records from the college for the study. Students who already owned computers were not excluded from participating in the lottery because the free computers may represent newer, and possibly more powerful, models than what they currently owned.[12] We received 286 responses with valid consent forms and completed questionnaires, and randomly assigned free computers to 141 of these students. Winners were notified by mail and instructed to pick up their computers at the Computers for Classrooms warehouse.[13] More than 90 percent of winning students picked up their free computers near the end of November 2006. All correspondence with students was conducted

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subscription is very high among computer owners in the United States making it difficult to identify separate effects (Beltan, Das and Fairlie 2009).

[12] 81 students reported already owning a computer, but the vast majority of these computers were older models. We find that the results presented below are not sensitive to the exclusion of those students who already owned newer computers.

[13] The computers are refurbished Pentium III 450 MHz, with 256 MB RAM, 10 GB hard drives, new hardware modems, 10/100 Ethernet cards, CD drive, sound card, 17" monitor, keyboard, mouse, Windows 2000 Pro, Open Office (with Word, Excel and PowerPoint), AVG anti-virus, Spy Bot S&D, and Ad-aware. The system also comes with a 128 MB flash drive for printing student papers on campus. All systems also came with a 2 year warranty on hardware and software, and special pricing on dial-up Internet for only $8.00 per month. Computers for Classrooms also offered to replace any computer not functioning properly during the two-year period.

through the office of financial aid. We conducted a follow-up survey of study participants (treatment and control) in late Spring/Summer 2008 with a response rate of 65 percent.[14] Butte College provided us with detailed administrative data on all students in July 2008.

The focus on the educational impacts of computers for community-college students on financial aid is important. The remaining digital divide in the U.S. is concentrated within low-income populations. As noted above, less than half of households with incomes less than $50,000 have access to computers with the Internet at home. Community colleges represent a large and growing share of total post-secondary enrollments. They provide workforce training, basic skills education and a gateway to 4-year colleges for many students, especially low-income and minority students. The California Community College system, in particular, is the largest higher educational system in the nation. It includes 110 colleges and educates more than 2.6 million students per year, and has grown in recent years (California Community Colleges Chancellor's Office 2008).

Who applied for the computer lottery?

Table 1 reports administrative data for students applying for the computer-giveaway program, all financial aid students, and all entering students. These administrative data were collected at the time of application to the college. The racial composition of study participants is very similar to that of all financial aid students, which is the group initially eligible for the study. A total of 60.1 percent of study participants are white compared to 61.3 percent of all financial aid students. The largest minority group, Latinos, comprise 16.8 percent of study participants and 15.6 percent of all financial aid students. A similar percentage of primarily English language students also participated in the study compared to all financial aid students. The one difference between study participants and the population of financial aid students is that a larger percentage

[14] The response rate was 61 percent for the control group and 69 percent for the treatment group.

of women applied for the computer lottery than men. Women comprise 62.6 percent of all study participants which is higher than the 54.7 percent for all financial aid students.

Information about the student's educational goals is also collected on the application form. The most common response is "undecided on goal," which represents 37.4 percent of study participants and 36.5 percent of all financial aid students. The second most common goal reported by applicants is to "obtain an associate degree and transfer to a 4-year institution." Of the study participants, 20.6 percent reported this goal compared to 23.3 percent of all financial aid students. The next most common goal reported was to "transfer to a 4-year institution without an associate degree." Slightly more than 10 percent of both study participants and all financial aid students reported this goal. Overall, the distributions of reported goals at the time of application are very similar.

A comparison to all students reveals that study participants are more likely to be female than the total student body. Women comprise 55.3 percent of all students attending the college. Study participants as well as all financial aid students are more likely to be from minority groups than all students, but are less likely to be non-primary English language students, which may be related to applying for financial aid. These differences, however, are small.

Although study participants are a self-selected group from all financial aid students and all students, they do not appear to be that different along observable characteristics. The main exception is that they are about 8 percentage points more likely to be female. They are likely to differ, however, along dimensions directly related to participation in the study. Specifically, they are likely to have less access to computers than other financial aid students and may have less disposable income. These differences have implications for our ability to generalize the results based on study participants to all community college students receiving financial aid. But, it is important to keep in mind that students with limited access to computers represent the population of interest for any policy intervention involving the provision of free or subsidized computers.

Comparability of Treatment and Control Groups

Table 2 reports a comparison of background characteristics for the treatment and control groups. All study participants were given a baseline survey that included detailed questions on gender, race, age, high school grades, household income, parents' education, and other characteristics. The average age of study participants is 25. More than half of the students have a parent with at least some college education, and about one third of students received mostly As and Bs in high school. A little over one quarter of study participants have children and one third live with their parents. Study participants have low income levels with only 17 percent having current household incomes of $40,000 or more. The majority of study participants have household incomes below $20,000. More than half of financial-aid students participating in the study work.

The similarity of the mean values of these baseline characteristics confirms that the randomization created comparable treatment and control groups for the experiment. We do not find large differences for any of the characteristics.[15]

First-Stage Results

If handing out free computers has an impact on educational outcomes we might expect to see an increased use of computers among the treatment group relative to the control group. Home computers, however, 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 than found in crowded campus computer labs.[16] Nevertheless, it is useful to compare total hours of computer use before exploring the impacts on educational outcomes. To investigate this issue we examine data from a follow-up

[15] Although not reported, we also find comparable educational goals based on application data.
[16] Roughly one quarter of students report experiencing wait times when using computers at the college.

survey conducted in spring 2008. The follow-up survey had a response rate of 65 percent. The baseline characteristics of the respondent sample look roughly similar to those of the full sample (see Appendix 1). Although these data are not as comprehensive in terms of coverage of students as the administrative data that we use to examine educational outcomes (which are available for all study participants), they provide some suggestive information on first-stage effects.

Table 3 reports the total number of hours of computer use for the treatment and control groups for the follow-up sample.[17] The treatment group reports using computers 16.1 hours per week on average compared to 13.4 hours per week for the control group. The estimated difference of 2.7 hours is large, representing 20 percent more hours, but is not statistically significant at conventional levels for a two-tailed test. The p-value is 0.15.

Another first-stage result is to examine whether home computers allow students increased flexibility in the times when they use computers. Table 3 reports when students report using computers to complete school assignments. Students who won free computers were more likely to report using computers in the daytime, late evening, and nighttime than students who did not win free computers although none of the differences is statistically significant. The treatment and control groups were equally likely to use computers in the early morning and early evening.

Although certainly not conclusive, the estimated differences provide some suggestive evidence that the provision of the home computers increased the total time of use of computers and flexibility of use. But, was this increased use productive for education?

Compliance

As noted above, of the 141 students in the study that were eligible to receive a free computer, 129 students actually picked them up from Computers for Classrooms. Although this represents a high compliance rate (92 percent) it is useful to examine whether the group of

[17] Among follow-up survey respondents the treatment and control groups have similar baseline characteristics. The main exception is that we find a larger percentage of the control group living at home (see Appendix 1).

computer eligible students notably differs from the group of computer recipients across observable characteristics. In Table 2, separate columns are reported for all free-computer eligible students and those actually receiving free computers. The differences between the groups for all reported measures are negligible. The identification of these two groups, however, will be useful below to produce separate estimates of the intent-to-treat and the treatment-on-the-treated effects.

4. Estimating the Effects of Home Computers on Educational Outcomes

Figure 1 displays grade distributions for all courses taken by study participants after Fall 2006 (when computers were handed out) through Spring 2008. Grade information is taken from administrative data and is available for all students and all quarters in the study period. Butte College assigns letter grades of A, B, C, D, and F with no + or - grades. Students also receive non-letter grades of CR and NC. The CR grade is considered the same as a C or higher, and C grades and higher are considering passing. D grades are considered unsatisfactory. The treatment group, which was eligible for the free computer, has essentially the same likelihood of receiving an A as the control group, which was not eligible for the free computer. The treatment group is slightly more likely to receive a B (23.8 percent compared to 21.6 percent) and a C (17.3 percent compared to 15.9 percent). The likelihood of receiving a D or F is similar. The treatment group is less likely to take courses for a letter grade and is less likely to receive an NC grade.

Table 4 examines the letter grade versus non-letter grade option more closely. Among the treatment group, 95.1 percent of courses are taken for letter grades compared to 91.2 percent of courses taken by the control group. Conditioning on taking courses for a non-letter grade, 92.9 percent of courses taken by the treatment group are passed (i.e. received a CR grade) compared to 78.6 percent of courses taken by the control group.

The standard measure used by the college for measuring the success of students is the percent of courses that students receive a letter grade of C or higher or a CR grade relative to all

courses taken. Table 4 reports estimates for this measure termed the "success rate." For the treatment group, 82.5 percent of courses received a successful grade compared to 81.2 percent for the control group. The difference of 1.3 percentage points is not statistically significant as discussed below.

The progress of students with a related measure that includes withdrawals is also tracked by the college. Including withdrawals in the denominator, we find that the treatment group has a higher "completion rate" at 75.8 percent compared to 74.6 percent for the control group. The difference, however, is not statistically significant.

Before turning to the regression results for the success rate, we compare the distributions of course departments for the treatments and controls. Table 5 reports distributions for the 10 most popular departments. The most popular department for taking courses is mathematics. A similar percentage of treatment and control students take mathematics courses (11.5 percent compared to 11.1 percent, respectively). The next most popular department is business computer information systems representing 8.5 percent of the treatment group and 10.5 percent of the control group. Overall, the course distributions look relatively similar. We estimate regression models that both include and exclude course department dummy variables below. The results are not sensitive to their inclusion.

Regression Results

Table 6 reports estimates for several regressions using the course success rate as the dependent variable. The regression equation is straightforward in this context:

(4.1) $y_{it} = \alpha + \beta X_i + \delta T_i + \lambda_t + \lambda_d + u_i + \varepsilon_{it}$,

where y_{it} is the course outcome, X_i includes baseline characteristics, T_i is treatment indicator, λ_t are quarter fixed effects, and λ_d are department fixed effects. The estimate of the treatment versus control effect is captured by δ. All specifications are estimated using OLS and robust standard

errors are reported for multiple observations per person. Marginal effects estimates are similar from probit and logit models and are not reported.

Specification 1 reports estimates of the treatment effect without any controls. The point estimate for δ implies that the treatment group of students receiving free computers has a 1.87 percentage point higher course success rate than the control group not receiving free computers although the estimate is imprecisely measured. Including detailed controls for gender, race/ethnicity, age, parents' highest education level, high school grades, presence of own children, live with parents, and family income leads to a larger program effect estimate (Specification 2). These control variables are taken from the baseline survey administered to all study participants before receiving free computers. The treatment group has a 2.5 percentage point higher likelihood of successfully completing courses at Butte College. Again, the coefficient estimate, however, is not statistically significant. Specification 3 adds fixed effects for the quarter the course was taken and the course department. The coefficient estimate remains similar.

Specification 4 includes additional controls from the baseline survey. The campus locations where the student took the majority of his/her courses and whether the student was working at the time of the baseline survey are included as additional controls. The coefficient on the treatment dummy variable remains similar.

In Specification 5, we add administrative information on basic assessment tests collected by the college for most entering students.[18] Assessments in math, English and reading are available. These assessment scores are used to for student placement in various courses. Administrative data collected at the time of application also provides information on whether the student primarily speaks English. Given the importance of English language ability for course performance we include this as an additional control variable. The coefficient on the treatment

[18] Not all students take the assessment tests when entering the college, and thus may have taken the test after the start of the study.

variable increases to 3.1 percentage points, but remains statistically insignificant at conventional levels.

Compliance and Treatment-on-the-Treated Estimates

We next address impartial compliance in the both the treatment and control groups. All of the estimates discussed thus far include the full sample of computer eligible students in the treatment group. As noted above, 92 percent of eligible students pick up their free computers. To check that the "treatment-on-the-treated" estimate does not differ substantially from the previous "intent-to-treat" estimate, we estimate an instrumental variables regression. Specifically, we use computer eligibility (winning a free computer) as an instrumental variable for whether the student actually picked up the free computer. The first-stage regression for the probability of computer receipt is:

(4.2) $C_i = \alpha_1 + \beta_1 X_i + \pi T_i + u_i + \varepsilon_{it}$.

The second-stage regression is:

(4.3) $y_{it} = \alpha_2 + \beta_2 X_i + \Delta \hat{C}_i + u_i + \varepsilon_{it}$,

where $\hat{C}_i$ is the predicted value of computer ownership from (3.2). In this case, Δ provides an estimate of the "treatment-on-the-treated" effect. The IV estimate is reported in Specification 6 of Table 6. As expected given the high compliance rate, the estimate is only slightly larger than the intent-to-treat estimate.

Similar to most previous social experiments it is not possible to prevent the control group from receiving an intervention that potentially has the same effect as the treatment intervention. In this case, it was impossible to prevent the control group from purchasing computers over the study period. From the follow-up survey taken at the end of the study period, we find that 32 students in the control group report getting a new computer, which represents 38 percent of respondents. No information is available on when they purchased the computer, however. Although students in the control group who purchased their computers near the end of the study

period are not likely to substantially contaminate the program effect estimates, students in the control group purchasing computers at the beginning of the study may dampen estimated differences between the treatment and control groups.

To investigate these issues further we expand on the previous IV or "treatment-on-the treated" results. The estimates reported in Specification 6 implicitly assume that all students in the control group received a computer after the end of the study period. The other extreme is to assume that all of the students in the control group reporting obtaining a computer in the follow-up survey received that computer at the beginning of the study period. In this case, control group students obtaining computers contribute to the estimation of (3.2) with C_i=1. Specification 7 in Table 6 reports estimates. The IV estimate is now larger and is 36 percent larger than the original estimate.[19] Given this range of IV estimates, the treatment-on-the-treated effect of the free computers is between 0.031 and 0.039, which still represents a modest-sized effect relative to the average course success rate of 0.813.

We continue to focus the discussion on intent-to-treat estimates because this is the most relevant for potential policy conclusions drawn from the results. Any computer giveaway or price subsidization program will likely not experience full compliance. There will always be some students who do not participate in a program even though they showed initial interest, and the group of students who are ineligible to receive free computers cannot be restricted from purchasing them.

Controlling for Different Courses

We also have information on course outcomes over the two-year study period for all entering students in fall 2006. Although baseline and follow-up survey information are not

[19] The follow-up sample is used to estimate the first-stage regression and the full sample is used to estimate the second-stage regression to make the estimates comparable for the bound calculations. Estimates of the intent-to-treat and treatment-on-the-treated effects using only the follow-up sample are smaller, but have a similar ratio.

available for students who are not participating in the study, the college provided us with administrative data on detailed course outcomes, a few background characteristics collected at the time of application, and assessment scores.[20] More importantly, however, the use of the entire incoming class of students allows us to include fixed effects for every course taken over the study period. The inclusion of course fixed effects removes any potential for the treatment and control groups differing in course success rates because of taking courses with differing levels of difficulty.

Table 7 reports estimates for the full sample of students. The treatment coefficient captures the difference between the treatment and control groups. Students who are not participating in the study do not contribute to identifying this coefficient and only contribute to identifying the coefficients on the other variables. Specification 1 includes controls for race/ethnicity, gender, English language, math, English and reading assessment scores, and quarter and course department fixed effects. The estimated treatment effect is similar to estimates reported in Table 6. In Specification 2 we add a fixed effect for every course taken over the sample period. The estimate of 0.02 is in the range of estimates presented before. Allowing the entire entering class to identify the effects of the controls and the inclusion of course fixed effects does not change the result. We find that study participants receiving free computers performed better than study participants who did not receive free computers although the difference is imprecisely measured. They do not perform better because they take less-challenging or more easily graded courses.

Other Educational Outcomes

Table 8 reports estimates for several additional educational outcomes. We focus on the regressions that include all of the control variables. Specification 1 reports estimates for the completion rate defined as the percentage of courses in which an A, B, C or CR grade is received

[20] All identifying information for the students was removed by the college.

relative to all grades including withdrawals. The treatment group has a 3.48 percentage point higher likelihood of completing courses than the control group, although the difference is imprecisely measured.

We further examine the separate components of the full grade distribution discussed above. The separation between taking courses for letter or non-letter grades is examined first. Specification 2 reports estimates for the treatment effect for the probability of taking a course for a grade. We find that students winning free computers have a 2.87 percentage point higher probability of taking a course for a grade than students who did not win a free computer. The difference is statistically significant. Having a home computer may have increased the confidence of students in taking courses for grades. It does not appear to have changed the types of courses taken. There were no notable differences in the distribution of courses as discussed above, and the regressions include course department fixed effects indicating that the treatment effect is not being driven by different course choices.

In Specification 3, we focus on letter grades. We report estimates for a regression for GPA. The sample excludes all courses taken for a non-letter grade. The estimates indicate a 0.09 higher GPA among computer winners relative to non-computer winners. The difference is not statistically significant, however.

Finally, we estimate a specification using only the non-letter graded courses. The dependent variable is the probability of passing the course relative to not passing the course. The treatment group has a 25.9 percentage point higher probability of passing courses than the control group. The difference is statistically significant.

The estimates for these additional educational outcomes present a consistent story -- students winning free computers did better than students not winning free computers. Although the imprecision of estimates results in some statistically insignificant coefficient estimates, some estimates are significant.

Degree Receipt

Although grades and course outcomes may have improved because of the computers, it is also useful to examine whether the computers had an effect on longer term outcomes such as graduation. The college provided us with information on whether students received a degree by summer 2008. Students may have received an associates degree, vocational degree or vocational certificate. We find that 18.4 percent of computer winners received a degree by summer 2008. The rate among non-computer winners was lower at 15.9 percent. The difference of 2.5 percentage points represents roughly 15 percent of the mean graduation rate.

Table 9 reports regression estimates for the probability of graduating. The regressions indicate that the treatment group is more likely to graduate than the control group. The treatment coefficient estimate with all of the controls is 1.7 percentage points, but is not statistically significant. The instrumental variable regressions indicate that the range of treatment-on-the-treated estimates is 1.8 to 2.4 percentage points. Finally, the inclusion of all entering students also results in similar estimates of the treatment effect (see Table 7). Overall, winning free computers may have positively impacted the likelihood of receiving a degree, but the lack of precision in estimates weakens the confidence in this conclusion.

Heterogeneity of Treatment Effects

Demographic groups may have been affected by the computer lottery differently. Although the total sample size is not extremely large, we investigate heterogeneity in treatment effects across a few main groups. We focus on differences by gender, race and income. Table 10 reports regression estimates for both the course success rate and the graduation rate. There do no appear to be large differences by gender. We find a larger point estimate on the male interaction with treatment for grades, but the graduation rate estimates are roughly similar. In both cases, however, the coefficient estimates are not statistically significant.

Examining differences by race, we find an important difference. We find that minorities benefit from free computers much more than non-minorities. We find that the course rate increases by 10.7 percentage points for minorities receiving free computers compared to minorities not receiving free computers. The treatment effect is statistically significant. Providing further evidence of the benefits of home computers, we also find a positive coefficient estimate for the minority-treatment interaction in the graduation equation. Minorities in the treatment group have a 7.7 percentage point higher graduation rate than minorities in the control group, although the difference is imprecisely measured. The non-minority treatment interaction is essentially zero in both equations.

The finding of large, positive and statistically significant effects of home computers on educational outcomes for minorities is important. Minorities have much lower rates of computer ownership than non-minorities and worse educational outcomes on average. For our sample of study participants, the course success rate is 6 percentage points lower for minorities than non-minorities and the graduation rate is 11 percentage points lower for minorities. Similar patterns hold when we examine course success rates and graduation rates for all financial aid students and all students. The combination of having less computer access and lower graduation rates may result in a larger potential positive impact of computers on educational outcomes for minority students.

Opportunities for access among family and friends of the same race may be limited among minorities. Estimates from the October 2007 Current Population Survey indicate that rates of home computer Internet access are substantially lower for minorities than non-minorities. Two-thirds of white households have access to computers with the Internet at home compared to 48 percent of minority households (NTIA 2008). These results are consistent with previous research indicating large racial disparities in access to computers, the Internet and broadband at home (NTIA 2008, Fairlie 2006, Goldfarb and Prince 2008, and Ono and Zavodny 2007).

We also estimate separate treatment effects for higher-income students ($20,000 or more in household income) and lower-income students (less than $20,000 in household income). We find larger positive point estimates on the treatment variable for the low-income group than the high-income group, but the lack of precision in estimates results in statistically insignificant coefficients. These point estimates are consistent with low-income students having fewer opportunities to obtain access to using computers. Low-income families are considerably less likely to have access to home computers. Estimates from the 2007 CPS indicate that less than half of U.S. households with less than $50,000 in annual income have computers with Internet access at home compared to 87 percent of households with more than $50,000 in income (NTIA 2008).

5. Potential Mechanisms

The estimates presented thus far provide some evidence of positive effects of home computers on educational outcomes. We find large positive and statistically significant effects of home computers on grades for minorities. We also find positive and statistically significant effects for a few outcomes. Finally, the consistency of estimated positive effects on all of the available outcome measures and the consistency across specifications that control for different characteristics provide suggestive evidence of positive effects. In most cases, however, the effects appear to be modest. In this section, we attempt to identify the underlying mechanisms that are responsible for any positive effects on educational outcomes and that may have a dampening effect on outcomes.

As noted above, we find some evidence that home computers increase the total amount of time use of computers and flexibility of use of computers. Estimates from our follow-up survey conducted at the end of the study period indicate that the treatment group uses computers nearly 3 hours more per week than the control group. The next question then is what did the treatment group do with these extra hours of computer use. In Table 11, we report total time use of

computers for schoolwork, games, networking and entertainment, and email and other activities. The treatment group reports using the computer roughly one more half hour per week to complete school assignments than the control group. The treatment group used the computer 7.9 hours per week on average to complete school assignments compared to 7.5 hours per week for the control group. Access to a home computer undoubtedly results in a substantial increase in the total *potential* time for using a computer for schoolwork, but the use of computers for schoolwork at home may be more efficient than the use of computers in computer labs at school or a public library, which may have more distractions and less familiar computers.

Although the difference in hours per week using computers for schoolwork is not large, the recipients of free computers may have become more efficient at using computers because of home use. Some suggestive evidence supporting this claim is provided by examining differences in self reported computer skills. In the follow-up survey we asked students to rate their computer skills as 1) excellent, 2) very good, 3) good, 4) satisfactory, and 5) inadequate. Table 11 reports estimates. Indeed, students winning free computers were more likely to report their computer skills as being excellent or very good and less likely to report their skills as satisfactory. The increased access to computers offered by receiving a free home computer may have improved their skills at using computers.[21] The use of home computers for schoolwork may have also allowed students to use their home computers at more productive and convenient times of the day. As reported in Table 3, we find that winning free computers is associated with increased flexibility in the times of the day students used computers to complete their school assignments.

Along these lines we also interact treatment status with distance to campus. If one effect of the home computer is providing more flexible access to computers then we should find that students living farther away from campus benefit more from the free computers. Students living near the college campus would benefit less from the computer giveaway program because on-

[21] These findings have implications for the argument that technology skills are the "second dimension" or "second level" of the digital divide (Servon 2002 and Hargittai 2002).

campus computer labs are more accessible. In Table 12, we estimate regressions for the course success and graduation rates that include an interaction with distance from campus. Information on student location is gleaned from the baseline survey. Distance matters -- we find a positive coefficient on the treatment/distance interaction. For each extra mile a student lives away from campus the treatment effect increases by 0.0058 for the course success rate and 0.0061 for the graduation rate.

We also estimate specifications that include separate treatment indicators for students living close to campus and students living far from campus. Living close to campus is defined as being within 15 miles, which represents the median distance to campus among study participants. The treatment effects are positive and large for the group of students living more than 15 miles from campus. This group of students appears to benefit substantially from receiving free computers, which is consistent with home computers having the largest positive effects when the alternative of on-campus computer use is not as convenient.

In sum, home computers appear to have increased the total hours and time flexibility of use of computers for completing school assignments, improved the computer skills of their owners possibly leading to more efficient use, and have the largest benefits for students with more limited on-campus access. Although the evidence is only suggestive, all of these factors may contribute to how home computers exert a positive influence on educational outcomes such as course performance and graduation.

On the other hand, home computers may be used for non-educationally productive activities, such as games and other forms of entertainment, potentially dampening any positive effects on educational outcomes. Although the use of college computers for these purposes may be limited, home computers provide more time and unregulated use for entertainment. In the follow-up survey, we asked about hours of computer use for games, chat rooms, videos (YouTube), networking software (Facebook, MySpace), music and other entertainment. As expected, we find that game and entertainment use is higher among the treatment group than the

control group. The treatment group uses computers for these purposes 0.9 hours more per week than the control group. In fact, the 2.8 hours per week that they use computers for entertainment purposes represents nearly 1/5 of the total time they use computers. The expanded use of computers for games, networking and other entertainment may have dampened the potential positive educational impacts of providing free computers. We investigate this question further in the next section.

Students receiving free computers are also more likely to report using computers for activities other than completing school assignments and games/entertainment. The treatment group uses computers for email and other activities an average of 5.4 hours per week compared to 3.7 hours per week for the control group. The increased use of home computers for email may represent a distraction for students, but it may also be useful for communicating with fellow students, professors and searching for educational information. Other types of computer use in this category are also difficult to assess in whether they have positive or negative effects on educational outcomes. We find that a large percentage of students report using the computer for searching for job, career, college, health, and political information.

Another mechanism by which receiving a free computer could affect educational outcomes is through an income effect. If the free computers are worth $500 then this positive income shock may be partly responsible for better educational outcomes. The educational impact of this income shock is likely to be small, however, because it can only be realized in cases in which the refurbished computers handed out through the study are subsequently sold or displace an intended purchase of a computer. If this is the case, then it may result in students working less. The follow-up survey provides information on the total hours worked by students. We find that students in the treatment group worked 16.8 hours per week on average and students in the control group worked 17.1 hours per week on average. The difference in hours is very small (less than 2 percent) and does not provide evidence that students receiving free computers responded by working less.

Games and Other Entertainment

The use of home computers for games, Internet search, popular networking sites such as Facebook and MySpace, and other forms of entertainment may displace computer use for schoolwork and may have a negative effect on educational outcomes. There has been a remarkable amount of growth in the use of networking software of the past few years. For example, Facebook users have increased from 2 million in 2004 to 150 million in 2009. To investigate the question of whether game, networking and other entertainment use of home computers has negative impacts, we interact treatment status with game use to see if there are differential effects of receiving a free computer for students. One limitation of this approach is that we measure computer game use in the follow-up survey instead of a more ideal measure of pre-program propensity for playing computer games and other forms of entertainment on the computer. A question about game use on the baseline survey at the beginning of the project, however, would not have solved the problem because of the lack of initial access to home computers among students interested in participating in the study.

Table 13 reports estimates for course success and graduation rate regressions including the interaction with non-game or entertainment use of computers. The estimates indicate that study participants who do not use computers for games benefited substantially more from the free computers. The treatment/no games interaction point estimate was large and positive in both the course success regressions and the graduation regressions. In the course success rate regressions it was not statistically significant, but was very close to statistical significance at the $\alpha=0.05$ level in the graduation rate regressions. Although the estimates are not very precise, they provide some suggestive evidence that computer use for games, networking and other entertainment may have dampened the positive effects of home computers on educational outcomes.

6. Non-Experimental Estimates

Previous non-experimental studies generally indicate large positive effects of home computers on educational outcomes. In contrast, the estimates from this study indicate modest-sized effects even from the treatment-on-the-treated estimates. But, it is difficult to make comparisons because the previous research does not focus on the effects of home computers on community college students. To remedy this problem we estimate regressions for community college graduation using the latest Computer and Internet Supplement from the Current Population Survey (October 2007) to compare to the experimental estimates reported above.[22] Fortunately, the October 2007 CPS also includes the annual Education and Enrollment Supplement, which includes information on enrollment in community college.

A limitation of the CPS, however, is that the cross-sectional data cannot be used to examine whether computer ownership among enrolled community college students affects subsequent educational outcomes. To address this limitation we link the October 2007 CPS to the October 2008 CPS to create longitudinal data. Households in the CPS are interviewed each month over a 4-month period. Eight months later they are re-interviewed in each month of a second 4-month period. The rotation pattern of the CPS makes it possible to match information on individuals in a CPS who are in their first 4-month rotation period (e.g. October 2007) to information from the same month in their second 4-month rotation period (e.g. October 2008). Thus, a two-year panel can be created for up to half of all of the original October 2007 respondents. To match these data, we use household and personal identification codes provided in the CPS and remove false matches using age, race and sex codes.

In Table 14, we report estimates from regressions of the probability of graduating from community college. The variable of interest is whether the individual has a computer with Internet access at home, which is measured in the first survey year (October 2007).[23] The sample

[22] The CPS, conducted by the U.S. Census Bureau for the Bureau of Labor Statistics, is representative of the entire U.S. civilian non-institutional population and interviews approximately 50,000 households.
[23] The 2007 CPS does not include information on computer ownership without Internet service. As noted above, however, nearly all individuals with home computers have Internet access.

is limited to students enrolled in community college in this year and graduation is measured in the second survey year (October 2008). Using this definition, we find that 18.5 percent of students graduate, which is similar to the graduation rate as measured above. In all specifications, which include various controls, we find a large, positive coefficient on having a computer with Internet access at home on graduation. The point estimate indicates that the graduation rate is 7.9 percentage points higher for community college students who have home computers with Internet access than for students who do not have access after controlling for income, race and other demographic characteristics. This estimate of the effect of home computers, although not precisely measured, is much larger than the range of experimental estimates provided here, which is 1.8 to 2.4 percentage points for the treatment-on-the-treated estimates. These estimates are consistent with concerns that there might be positive selection in computer ownership and that non-experimental estimates may overstate the effects of home computers on educational outcomes.

7. Conclusions

This study provides the first experiment involving the random provision of free computers to students. The randomly selected group of students receiving free computers has better educational outcomes than the control group that did not receive free computers. The effects, however, are not large. Although most estimates lacked sufficient precision, the evidence of positive effects is remarkably consistent across different measures, samples, and included controls. A few results indicate statistically significant positive effects of having home computers on educational outcomes. For example, grades are better among minority students receiving free computers than those who did not receive free computers. Overall, the results from this novel random assignment evaluation provide some evidence of positive, but modestly sized, impacts of home computers on educational performance. The estimated effects are smaller than those from using non-experimental techniques.

Findings from the experiment also provide some suggestive evidence on the underlying mechanisms responsible for positive effects. Home computers improve flexibility in times using the computer and represent an important substitute for on-campus use. Home computers also appear to improve computer skills possibly leading to more efficient use than alternative locations of use. One factor that appears to dampen any positive effects of home computers on educational outcomes is the displacement from non-educational uses such as games, networking and entertainment. Students receiving free computers report using computers for games, networking and other entertainment more often than students not receiving free computers. The positive effects of home computers also appear to be stronger among study participants who were less likely to use computers for games, networking and other forms of entertainment.

Given these results and the large returns to education (Card 1999), do community college students appear to be under-investing in personal computers for educational purposes? An estimate of the returns to obtaining an associate's degree of roughly 8 percent or $2,500 per year relative to not obtaining one (Kane and Rouse 1999) implies a gain in the present value of lifetime earnings of $28,000.[24] The average treatment-on-the treated estimate on the graduation rate of 0.021 implies that the computer is worth $585 in present value of lifetime earnings. If the value of the computers is $500 then there may be some under-investment of personal computers although it does not appear to be large. For some students, especially low-income students, financial constraints may bind, and thus result in a suboptimal level of investment in educational technology.[25]

With the concern that home computers provide a severe distraction in terms of games, networking and other entertainment for many students, overall the findings from this experiment

[24] These estimates assume a discount rate of 5 percent, tax rate of 35 percent, and average earnings of $31,000 (U.S. Census 2008).

[25] Technical and informational constraints may also be important for low-income students because they may have less previous experience with computers. Another potential reason for suboptimal investment in personal computers is that forward-looking behavior suggests that consumers may wait until a better model arrives (Prince 2008). For students, however, this should not be that large because their demand is imminent.

suggest that disparities in access to home technology may translate into future disparities in educational, labor market and other economic outcomes. Thus, policies that address the financial, informational and technical constraints limiting the optimal level of investment in personal computers among disadvantaged students may be needed.[26] Tax breaks or special loans for educational computer purchases, and an expansion of computer refurbishing programs that provide low-cost machines may increase access for students. Another potential solution is to expand the relatively new programs that allow students to check out school laptop computers for home use. Addressing the remaining digital divide in home access is likely to become even more important over time as schools, professors and financial aid sources are increasingly using technology to provide information, communicate with students, and provide course content.

[26] See Servon (2002) for a discussion of policies addressing the digital divide.

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California Community Colleges Chancellor's Office 2008

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Appendix 1
Background Characteristics of Follow-up Survey Respondents

	All Study Participants	Follow-up Survey Respondent	Follow-up Sample Treatment Group	Follow-up Sample Control Group	P-Value for Treatment/ Control Difference
Female	63.3%	64.9%	65.0%	64.8%	0.980
Latino	17.8%	18.4%	15.5%	21.6%	0.285
Other Minority	18.2%	16.8%	19.6%	13.6%	0.282
Age	25.0	25.6	26.1	25.0	0.444
Parent some college	37.8%	41.1%	46.4%	35.2%	0.125
Parent college graduate	22.0%	21.6%	18.6%	25.0%	0.290
High school grades As and Bs	30.4%	35.7%	36.1%	35.2%	0.904
High school grades Bs and Cs	56.6%	53.0%	52.6%	53.4%	0.911
Live with own children	27.3%	28.1%	28.9%	27.3%	0.811
Live with parents	34.6%	33.0%	25.8%	40.9%	0.029
Household income: $10,000 - 19,999	31.5%	30.8%	26.8%	35.2%	0.217
Household income: $20,000 - 39,999	25.9%	26.5%	29.9%	22.7%	0.272
Household income: $40,000 or more	16.8%	18.9%	15.5%	22.7%	0.210
Takes most classes at Chico Center	25.2%	22.7%	23.7%	21.6%	0.733
Takes most classes at Glen/Other	8.4%	8.6%	8.3%	9.1%	0.840
Has job	55.0%	56.0%	51.1%	61.4%	0.164
Sample size	286	185	97	88	

Note: Based on follow-up survey conducted in spring 2008.

Figure 1
Grade Distribution for Study Participants

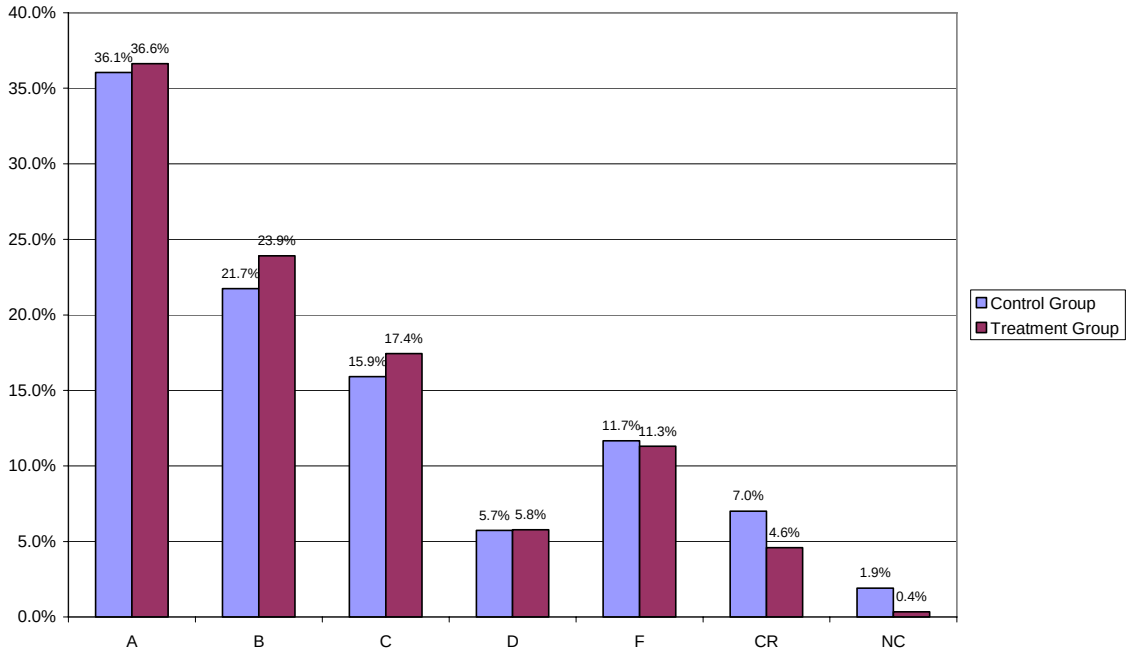

Table 1
Application Information for Study Participants, Financial Aid Students, and All Students

	Study Participants	All Financial Aid Students	All Students
Gender			
Female	62.6	54.7	55.2
Male	35.7	43.6	43.6
Missing	1.7	1.7	1.2
Race/Ethnicity			
White	60.1	61.3	65.2
Asian and Pacific Islander	8.0	8.2	7.0
African-American	3.1	3.2	2.6
Latino	16.8	15.6	13.1
Native American	2.1	2.9	2.2
Other	1.0	1.2	1.2
Unknown	8.7	7.6	8.7
English language			
English	81.8	83.7	80.1
Not English	7.0	6.7	7.8
Unknown/Uncollected	11.2	9.6	12.1
Sample size	286	1,042	6,681

Note: Based on administrative data provided by Butte College for entering students in Fall 2006.

Table 2
Background Characteristics of Study Participants

	All Study Participants	Treatment: Computer Eligible		Control: Computer Ineligible	P-Value for Treatment/ Control Difference
		All	Received Computer		
Female	63.3%	64.5%	64.3%	62.1%	0.666
Latino	17.8%	15.6%	15.5%	20.0%	0.333
Other Minority	18.2%	21.3%	20.9%	15.2%	0.182
Age	25.0	24.9	24.9	25.0	0.894
Parent some college	37.8%	41.8%	42.6%	33.8%	0.161
Parent college graduate	22.0%	18.4%	16.3%	25.5%	0.150
High school grades As and Bs	30.4%	32.6%	31.0%	28.3%	0.426
High school grades Bs and Cs	56.6%	55.3%	58.1%	57.9%	0.657
Live with own children	27.3%	27.7%	27.9%	26.9%	0.885
Live with parents	34.6%	31.2%	31.0%	37.9%	0.234
Household income: $10,000 - 19,999	31.5%	30.5%	32.6%	32.4%	0.728
Household income: $20,000 - 39,999	25.9%	27.7%	26.4%	24.1%	0.498
Household income: $40,000 or more	16.8%	14.9%	15.5%	18.6%	0.401
Takes most classes at Chico Center	25.2%	25.5%	26.4%	24.8%	0.891
Takes most classes at Glen/Other	8.4%	7.8%	7.8%	9.0%	0.724
Has job	55.0%	52.2%	54.0%	57.6%	0.358
Sample size	286	141	129	145	

Note: Based on baseline survey administered to all study participants.

Table 3
Computer Use among Study Participants

	Treatment Group	Control Group	Treatment-Control Difference	Std. Err.
Total number of hours of computer use per week	16.1	13.4	2.7	1.9
Times of day for computer use to complete school assignments				
Early morning (6:00AM-8:00AM)	18.3%	19.5%	-1.3%	5.9%
Daytime (8:00AM-5:00PM)	55.9%	49.4%	6.5%	7.5%
Early evening (5:00PM-10:00PM)	61.3%	62.1%	-0.8%	7.3%
Late evening (10:00PM-12:00AM)	37.6%	29.9%	7.7%	7.1%
Nighttime (12:00AM-6:00AM)	14.0%	6.9%	7.1%	4.6%
Sample size	97	88		

Note: Based on follow-up survey conducted in spring 2008.

Table 4
Educational Outcomes of Study Participants

	All Study Participants	Treatment Group	Control Group	Treatment-Control Difference	Std. Err.
Take Course for Grade Rate	93.0%	95.1%	91.1%	4.0%	0.1%
GPA	2.72	2.72	2.71	0.012	0.853
Credit vs. No Credit	83.3%	92.9%	78.6%	14.3%	4.3%
Course Success Rate	81.6%	82.6%	80.7%	1.9%	30.9%
Course Completion Rate	74.9%	75.9%	74.0%	1.9%	33.2%

Note: Based on administrative data provided by Butte College for study participants.

Table 5
Departments of Courses Taken by Study Participants

	Treatment Group	Control Group
Administration of Justice	3.7%	1.7%
Anthropology	2.5%	2.4%
Biology	5.1%	3.7%
Business Computer Information Systems	8.5%	10.5%
Child Development & Family Relations	4.2%	2.9%
English	7.7%	6.7%
History	4.0%	3.5%
Mathematics	11.5%	11.1%
Political Science	2.4%	2.6%
Psychology	4.4%	3.6%
All Other Departments	46.2%	51.3%
Sample Size	849	943

Notes: (1) Based on administrative data provided by Butte College for study participants.
(2) The largest 10 departments for study participants are reported.

Table 6
Course Success Rate Regressions

	OLS (Intent-to-Treat)					IV (Treatment-on-the-Treated)	
						Lower Bound	Upper Bound
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Treatment	0.0187	0.0251	0.0254	0.0238	0.0287	0.0313	0.0390
	(0.0301)	(0.0291)	(0.0286)	(0.0286)	(0.0286)	(0.0203)	(0.0389)
Main controls	No	Yes	Yes	Yes	Yes	Yes	Yes
Quarter and course department fixed effects	No	No	Yes	Yes	Yes	Yes	Yes
Campus and job activity	No	No	No	Yes	Yes	Yes	Yes
Assessments and English language (administrative data)	No	No	No	No	Yes	Yes	Yes
Mean of dependent variable	0.8159	0.8159	0.8159	0.8133	0.8133	0.8133	0.8133
Sample Size	1,792	1,792	1,792	1,762	1,762	1,762	1,762

Notes: (1) The dependent variable is whether the grade was a C, CR or better. (2) Standard errors are adjusted for multiple courses taken by study participants. (3) Main controls include gender, race/ethnicity, age, parents' highest education level, high school grades, presence of own children, live with parents, and family income. (4) Assessments include math, English and reading. (5) The dependent variable in the first-stage regression in the IV model is obtaining a new computer. See text for more details on lower and upper bounds.

Table 7
Regression Results for Outcomes Using Full Sample

	Course Success Rate (1)	Course Success Rate (2)	Graduation Rate (3)
Treatment	0.0257	0.0200	0.0275
	(0.0283)	(0.0196)	(0.0277)
Main controls (administrative data)	Yes	Yes	Yes
Quarter and course department fixed effects	Yes	No	No
Assessments and English language (administrative data)	Yes	Yes	No
Course Fixed Effects	No	Yes	
Mean of dependent variable	0.7691	0.7691	0.0594
Sample Size	24,460	24,460	6,939

Notes: (1) The dependent variable is whether the grade was a C, CR or better relative to all grades including withdrawals in Specifications 1 and 2. (2) Standard errors are adjusted for multiple courses taken by study participants. (3) Main controls include gender and race/ethnicity from administrative data. (4) Assessments include math, English and reading.

Table 8
Regression Results for Various Course Outcomes

	Completition Rate (1)	Take for Grade Rate (2)	GPA (3)	Credit vs. No Credit (4)
Treatment	0.0348	0.0287	0.0903	0.2586
	(0.0317)	(0.0135)	(0.1135)	(0.0730)
Main controls	Yes	Yes	Yes	Yes
Quarter and course department fixed effects	Yes	Yes	Yes	No
Campus and job activity	Yes	Yes	Yes	No
Assessments and English language (administrative data)	Yes	Yes	Yes	No
Mean of dependent variable	0.7467	0.9291	2.7092	0.8333
Sample Size	1,919	1,762	1,637	126

Notes: (1) The dependent variable is whether the grade was a C, CR or better relative to all grades including withdrawals in Specification 1. (2) Standard errors are adjusted for multiple courses taken by study participants. (3) Main controls include gender, race/ethnicity, age, parents' highest education level, high school grades, presence of own children, live with parents, and family income. (4) Assessments include math, English and reading.

Table 9
Regression Results for the Graduation Rate

	OLS (Intent-to-Treat)				IV (Treatment-on-the-Treated)	
					Lower Bound	Upper Bound
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	0.0258	0.0203	0.0245	0.0168	0.0184	0.0237
	(0.0447)	(0.0437)	(0.0444)	(0.0450)	(0.0498)	(0.0642)
Main controls	No	Yes	Yes	Yes	Yes	Yes
Campus and job activity	No	No	Yes	Yes	Yes	Yes
Assessments and English language (administrative data)	No	No	No	Yes	Yes	Yes
Mean of dependent variable	0.1713	0.1713	0.1738	0.1738	0.1738	0.1738
Sample Size	286	286	282	282	282	282

Notes: (1) The dependent variable is whether the student received an associates degree, vocational degree or vocational certificate. (2) Standard errors are adjusted for multiple courses taken by study participants. (3) Main controls include gender, race/ethnicity, age, parents' highest education level, high school grades, presence of own children, live with parents, and family income. (4) Assessments include math, English and reading. (5) The dependent variable in the first-stage regression in the IV model is obtaining a new computer. See text for more details on lower and upper bounds.

Table 10
Regression Results for Course Success and Graduation Rate by Gender, Race and Income

	Course Success Rate (1)	Graduation Rate (2)	Course Success Rate (3)	Graduation Rate (4)	Course Success Rate (5)	Graduation Rate (6)
Treatment*female	0.0155	0.0186				
	(0.0346)	(0.0561)				
Treatment*male	0.0426	0.0233				
	(0.0531)	(0.0748)				
Treatment*minority			0.1070	0.0766		
			(0.0507)	(0.0752)		
Treatment*nonminority			-0.0122	-0.0117		
			(0.0345)	(0.0563)		
Treatment*high income					0.0011	-0.0021
					(0.0418)	(0.0686)
Treatment*low income					0.0444	0.0372
					(0.0417)	(0.0594)
Mean of dependent variable	0.8159	0.1713	0.8159	0.1713	0.8159	0.1713
Sample Size	1,792	286	1,792	286	1,792	286

Notes: (1) The dependent variable in Specifcations 1-2 is whether the grade was a C, CR or better, and the depedent variable in Specifications 3-4 is whether the student received an associates degree, vocational degree or vocational certificate. (2) Standard errors are adjusted for multiple courses taken by study participants. (3) Controls include gender, race/ethnicity, age, parents' highest education level, high school grades, presence of own children, live with parents, and family income.

Table 11
Computer Use among Study Participants

	Treatment Group	Control Group	Treatment - Control Difference	Std. Err.
Total number of hours of computer use per week	16.1	13.4	2.7	1.9
Hours of computer use for completing school assignments	7.9	7.5	0.4	1.3
Hours of computer use for games, networking, and other entertainment	2.8	2.2	0.6	0.4
Hours of computer use for email and other activities	5.4	3.7	1.7	1.1
Self rating of computer skills				
Excellent	19.6%	17.0%	2.5%	5.7%
Very good	44.3%	33.0%	11.4%	7.2%
Good	27.8%	36.4%	-8.5%	6.9%
Satisfactory	8.2%	13.6%	-5.4%	4.6%
Sample size	97	88		

Notes: (1) Estimates are from follow-up survey conducted in spring and summer 2008.
(2) Games, networking and other entertainment include games, chat rooms, videos (YouTube), networking (Facebook, MySpace), music and entertainment.

Table 12
Regression Results for Course Success and Graduation Rate by Initial Distance to Campus

	Course Success Rate (1)	Graduation Rate (2)	Course Success Rate (3)	Graduation Rate (4)
Treatment	-0.0738	-0.0873		
	(0.0541)	(0.0783)		
Treatment*distance to campus	0.0058	0.0061		
	(0.0023)	(0.0036)		
Treatment*far from campus			0.0619	0.1129
			(0.0337)	(0.0575)
Treatment*close to campus			-0.0350	-0.1164
			(0.0511)	(0.0697)
Mean of dependent variable	0.8159	0.1713	0.8159	0.1713
Sample Size	1,792	286	1,792	286

Notes: (1) The dependent variable in Specifcations 1-2 is whether the grade was a C, CR or better, and the depedent variable in Specifications 3-4 is whether the student received an associates degree, vocational degree or vocational certificate. (2) Standard errors are adjusted for multiple courses taken by study participants. (3) Living close to campus is defined as being 15 miles or less. Controls include gender, race/ethnicity, age, parents' highest education level, high school grades, presence of own children, live with parents, and family income.

Table 13
Regression Results for Course Success and Graduation Rate for Non-Game/Entertainment Users

	Course Success Rate (1)	Course Success Rate (2)	Graduation Rate (3)	Graduation Rate (4)
Treatment	-0.0457	-0.0280	-0.0588	-0.1070
	(0.0435)	(0.0418)	(0.0875)	(0.0900)
Treatment*no games/entertainment	0.0884	0.0424	0.2016	0.2279
	(0.0622)	(0.0624)	(0.1216)	(0.1230)
Main controls	No	Yes	No	Yes
Mean of dependent variable	0.8464	0.8464	0.2011	0.2011
Sample Size	1,380	1,380	179	179

Notes: (1) The dependent variable in Specifcations 1-2 is whether the grade was a C, CR or better, and the depedent variable in Specifications 3-4 is whether the student received an associates degree, vocational degree or vocational certificate. (2) Standard errors are adjusted for multiple courses taken by study participants. (3) Controls include gender, race/ethnicity, age, parents' highest education level, high school grades, presence of own children, live with parents, and family income. (4) Games, networking and other entertainment include games, chat rooms, videos (YouTube), networking (Facebook, MySpace), music and entertainment.

Table 14
Non-Experimental Regression Results for the Graduation Rate
Matched Current Population Surveys, October 2007, 2008

	(1)	(2)	(3)
Home Computer with Internet	0.0898	0.0962	0.0794
	(0.0545)	(0.0561)	(0.0597)
Age controls	Yes	Yes	Yes
Gender, race, nativity, region and urbanicity controls	No	Yes	Yes
Income and home ownership controls	No	No	Yes
Mean of dependent variable	0.1845	0.1845	0.1845
Sample Size	374	374	374

Notes: (1) The sample includes individuals enrolled in 2-year colleges in the first-survey year in the matched CPS data. (2) The dependent variable is whether the student received an associates degree in the second survey year.