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Academic achievement, technology and race: Experimental evidence☆

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ABSTRACT

Although a large literature explores the achievement gap between minority and non-minority students, very little is known about whether disparities in access to technology are partly responsible. Data from the first-ever field experiment involving the random provision of free computers to low-income community college students for home use are used to explore whether home computers are beneficial to minority students. I find that minority students receiving free computers achieved better educational outcomes than the control group that did not receive free computers. Minority students may have benefitted more from receiving free computers because of fewer alternatives for accessing home computers due to lower rates of computer ownership among family, friends, and relatives. Implications for the achievement gap and policy are discussed.

1. Introduction

A sizeable gulf exists between minority and non-minority students in college attendance and completion. Minorities are three-fourths as likely to be enrolled in college compared with non-minorities (U.S. Department of Education, 2010). Minorities also have substantially lower graduation rates from post-secondary institutions resulting in less than one-third of minorities ages 25–34 having a college degree compared with nearly half of all non-minorities.

Disparities in community college enrollment may be especially important for the achievement gap between minority and non-minority students. Community colleges enroll the majority of all minority students attending public universities and nearly half of all students attending public universities in the United States and an even higher percentage in some states (U.S. Department of Education, 2011). In California, for example, community colleges enroll more than 70% of all public higher education students (Sengupta & Jepsen, 2006). Community colleges serve as an important gateway to 4-year colleges in addition to providing workforce training and basic skills education. With rising tuition costs their role as a transfer function to 4-year universities is becoming increasingly important.[1] In California, nearly half of all students attending a 4-year college previously attended a community college (California Community Colleges Chancellor's Office, 2009). Although enrollment disparities are smaller than for 4-year colleges,

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[1] Community college enrollments are also likely to increase substantially given current economic conditions (Betts & McFarland, 1996).

minority students are much less likely than non-minority students to graduate with an Associate's Degree or transfer to a 4-year college (Sengupta & Jepsen, 2006; U.S. Department of Education, 2007). Surprisingly little attention has focused on the role of community colleges in providing education for minority students.

One factor that may contribute to the achievement gap between minority and non-minority students in community colleges is the disparity in access to educational technology. Unlike 4-year colleges where many students live on campus and have access to large computer labs, community college students often have limited access to on-campus technology. For community college students, inequality in access to computers at home may thus translate into disparities in the quality and quantity of overall access to computers and the Internet. Large and persistent disparities in access to home technology exist across racial groups in the United States (Fairlie, 2004; Goldfarb & Prince, 2008; Ono & Zavodny, 2003, 2008; Prieger, 2004; U.S. Department of Commerce, 2008; Warschauer, 2003). Less than half of minority households have access to computers with the Internet at home (U.S. Department of Commerce, 2008). In contrast, two-thirds of white households have access to computers with the Internet at home. These differences suggest that access to computers may be more limited for minority students attending community college and that fewer alternative places of access could mean that access to home computers is even more important educationally for minorities.

The limited previous evidence on the importance of access to home computers on educational outcomes, however, is mixed. Both positive and negative effects have been found in the previous literature (see Attewell & Battle, 1999; Beltran, Das, & Fairlie, 2010; Fairlie, 2005; Fiorini, 2010; Fuchs & Woessmann, 2004; Malamud & Pop-Eleches, 2010; Schmitt & Wadsworth, 2006 for example). These findings are consistent with the lack of a clear theoretical prediction regarding whether home computers are likely to have a negative or positive effect on educational outcomes. Having access to a home computer increases and improves flexibility in access time to a computer which is useful for writing papers, conducting research, and making calculations for schoolwork, but home computers are also used extensively for games, networking, downloading music and videos, communicating with friends, and other entertainment among youth potentially crowding out schoolwork time (Jones, 2002; U.S. Department of Commerce, 2004; Warschauer & Matuchniak, 2010).[2] The use of entertainment-based web sites such as YouTube, Facebook, MySpace and iTunes has grown exceptionally fast among youth in recent years (Lenhart, 2009; Pasek & Hargittai, 2009).

In this paper, I explore whether minority students benefit from access to home computers in academic achievement and whether lower levels of access to home technology limit educational achievement. To test the hypothesis, data from the first-ever field experiment providing free personal computers to college students for home use are used. Participating students were randomly selected to receive computers to use at home and their academic performance was followed for two years through administrative records (removing concerns about differential response rates). The random-assignment evaluation is conducted with 286 entering students receiving financial aid at a large community college in Northern California. The experiment improves on the approach taken in the previous literature because it does not suffer from selection bias. In particular, it removes the concern that the most educationally motivated students are the ones that are the most likely to purchase computers.

Previous findings for all study participants in the field experiment provide some evidence that the randomly selected group of students receiving free computers achieved better educational outcomes than the control group that did not receive free computers (Fairlie & London, 2012). The effects of the home computers on educational outcomes, however, are not large for the full sample of financial aid students.[3] Because of limited opportunities for alternative access minority students might benefit more from receiving a free computer. An examination of racial differences and implications for the achievement gap, however, has not been previously conducted. The results from this study provide the first evidence in the literature on the effects of home computers for minority post-secondary students and insights into whether differences in access to home technology represent an important disparity in educational resources.

2. The field experiment

This section briefly describes the experiment with a more detailed discussion provided in Fairlie and London (2012). Free computers were randomly assigned to entering financial aid students in Fall 2006 at Butte Community College located in Northern California. Butte College has a total enrollment of over 20,000 students and is part of the California Community College system, which is the largest higher educational system in the nation and includes 110 colleges and educates more than 2.9 million students per year (California Community Colleges Chancellor's Office, 2009). The computers used in the study were provided by Computers for Classrooms, Inc. a computer refurbisher located in Chico, CA.[4]

The program was advertised to all students receiving financial aid, which totaled 1042 students. Participating students were required to return 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

[2] These concerns are similar to those over television (Zavodny, 2006).

[3] Another important finding is that comparing non-experimental estimates from matched CPS data and estimates from this field experiment for all study participants indicate much larger non-experimental estimates. This finding suggests that non-experimental estimates may be biased (Fairlie & London, 2012).

[4] The computers were refurbished Pentium III 450 MHz machines with 256 MB RAM, 10 GB hard drives, 17″ monitors, modems, ethernet cards, CD drives, and Windows 2000 Pro Open Office (with Word, Excel and PowerPoint).

lottery because these computers may have been old and not-fully functioning computers. I find that 33% of non-minority students and 21% of minority students reported already owning a computer. The results presented below are not sensitive to the exclusion of these students. But, the differential reporting of having a computer at baseline suggests that it could lead to differential treatment estimates by race. I also investigate this issue below and find that it does not underlie racial differences in treatment effect estimates.

There were 286 students who participated in the study with 141 of these students receiving free computers. Of these students, 102 were minority students of which 52 won free computers. More than 90% of eligible minority and non-minority students picked up their free computers by the end of November 2006. Butte College provided administrative data on several background characteristics and educational outcomes for all study participants removing concerns about attrition bias. For a few "first-stage" and intermediate measures, a follow-up survey of study participants (treatment and control) was conducted in late Spring/Summer 2008 with an overall response rate of 65% (62% for minority students).

The racial composition of students participating in the field experiment is very similar to that of all financial aid students, the underlying population targeted for the study. Table 1 reports administrative data from the original application to the college for students participating in the computer-giveaway program, all financial aid students, and all entering students. A total of 60.1% of study participants are white compared with 61.3% of all financial aid students. The largest minority group, Latinos, comprise 16.8% of study participants and 15.6% of all financial aid students. The next largest group, Asians, comprise 8.0% of study participants and 8.2% of all financial aid students. Smaller minority groups also have similar representations among study participants and all financial aid students. Study participants are more likely to be from minority groups than all entering students, but the differences are small. There are some differences by gender, however, as study participants are more likely to be women than are students on financial aid.

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	1042	6681

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

Table 2 reports background characteristics for the treatment and control groups from the Fall 2006 baseline survey. Randomization of free computers through the experiment results in similar characteristics for the treatment and control groups. I do not find large differences for any of the characteristics, and none of the differences are statistically significant. Minorities comprise 37% of the treatment group and 35% of the control group. Although not reported, I do not find large and statistically significant differences between the treatment and control groups for the share from specific minority groups, such as Latinos, Asians, African-Americans, Native-Americans, and other minorities. I do not focus on individual minority groups in the primary analysis because of small sample sizes although I report some separate estimates below. The

Table 2
Background characteristics of study participants.

	All study participants	Treatment group	Control group	*p*-Value for treatment/control difference
Female	63.3%	64.5%	62.1%	0.666
Minority	35.7%	36.9%	34.5%	0.674
Age	25.0	24.9	25.0	0.894
Parent some college	37.8%	41.8%	33.8%	0.162
Parent college graduate	22.0%	18.4%	25.5%	0.149
High school grades As and Bs	30.4%	32.6%	28.3%	0.426
High school grades Bs and Cs	56.6%	55.3%	57.9%	0.657
Live with own children	27.3%	27.7%	26.9%	0.885
Live with parents	34.6%	31.2%	37.9%	0.233
Household income: $10,000–19,999	31.5%	30.5%	32.4%	0.728
Household income: $20,000–39,999	25.9%	27.7%	24.1%	0.499
Household income: $40,000 or more	16.8%	14.9%	18.6%	0.400
Takes most classes at Chico Center	25.2%	25.5%	24.8%	0.891
Takes most classes at Glen/other	8.4%	7.8%	9.0%	0.724
Has job	55.0%	52.2%	57.6%	0.358
Sample size	286	141	145	

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

Table 3
Background characteristics of study participants by race.

	All study participants	Treatment group	Control group	*p*-Value for treatment/control difference
Minority students				
Female	61.8%	59.6%	64.0%	0.653
Age	23.4	23.6	23.2	0.826
Parent some college	29.4%	19.2%	40.0%	0.022
Parent college graduate	11.8%	17.3%	6.0%	0.075
High school grades As and Bs	30.4%	32.7%	28.0%	0.610
High school grades Bs and Cs	54.9%	51.9%	58.0%	0.542
Live with own children	22.5%	23.1%	22.0%	0.898
Live with parents	42.2%	36.5%	48.0%	0.246
Household income: $10,000–19,999	28.4%	25.0%	32.0%	0.439
Household income: $20,000–39,999	26.5%	34.6%	18.0%	0.057
Household income: $40,000 or more	17.6%	11.5%	24.0%	0.103
Takes most classes at Chico Center	21.6%	19.2%	24.0%	0.563
Takes most classes at Glen/other	8.8%	9.6%	8.0%	0.776
Has job	50.5%	52.0%	49.0%	0.767
Sample size	102	52	50	
Non-minority students				
Female	64.1%	67.4%	61.1%	0.371
Age	25.8	25.7	26.0	0.811
Parent some college	42.4%	55.1%	30.5%	0.001
Parent college graduate	27.7%	19.1%	35.8%	0.011
High school grades As and Bs	30.4%	32.6%	28.4%	0.543
High school grades Bs and Cs	57.6%	57.3%	57.9%	0.936
Live with own children	29.9%	30.3%	29.5%	0.899
Live with parents	30.4%	28.1%	32.6%	0.506
Household income: $10,000–19,999	33.2%	33.7%	32.6%	0.878
Household income: $20,000–39,999	25.5%	23.6%	27.4%	0.559
Household income: $40,000 or more	16.3%	16.9%	15.8%	0.846
Takes most classes at Chico Center	27.2%	29.2%	25.3%	0.550
Takes most classes at Glen/Other	8.2%	6.7%	9.5%	0.499
Has job	57.4%	52.3%	62.1%	0.181
Sample size	184	89	95	

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

study participant sample includes 51 Latinos, 23 Asians, 13 Native-Americans, 12 African-American, and 4 other minority students. It should also be noted that the Asian participant group is almost entirely comprised of disadvantaged Asian groups (e.g. Hmong) and not Indian, Chinese, Korean and Japanese students.

In Table 3, I report the treatment/control comparison separately for minority and non-minority students. Minority students in the treatment and control groups have similar characteristics. None of the differences are statistically significant with the exception of parental education. However, we would expect some statistically significant differences due to chance when making this many comparisons. Similarly the differences between the randomly assigned treatment and control groups for non-minority students are small and not statistically significant, with the only exception being parental education. All of these baseline characteristics are controlled for in the regressions reported below to further insure the comparability of the treatment and control groups.

3. Racial differences in student performance

Minority students do not perform as well on average as non-minority students in college. Minority students tend to receive lower grades than non-minority students at both the 4-year university level and the community college level. Table 4 reports estimates of the grade point average distribution for minority and non-minority students for all U.S. colleges and all entering students at Butte College in Fall 2006. At 4-year colleges, 57.1% of non-minority students have GPAs of at least a 3.0. In contrast, 41.9% of minority students have GPAs at this level. The finding of lower grades among minority students is not unique to 4-year colleges – minority students enrolled in 2-year colleges also tend to receive much lower grades than non-minority students. Slightly more than 50% of whites students enrolled in 2-year colleges have a GPA of 3.0 or higher compared with 37.5% of minority students. Minority students enrolled in community colleges are more likely to have GPAs below 2.0 than are non-minority students.

Administrative data for all entering students at Butte College indicate similar racial patterns in educational performance. Grades are for all courses taken after Fall 2006 through Spring 2008. Minority students have lower GPAs than non-minority students. At the college, 31.3% of minority students have a GPA of 3.0 or higher compared with 41.2% of non-minority students. Minority students are also more likely to have GPAs below 2.0.

Focusing on the full distribution of course grades that includes courses taken for non-letter grades, Fig. 1A displays grades for minority and non-minority students at Butte College, respectively. Butte College assigns letter grades of A, B, C, D, and F with no + or − grades. Students

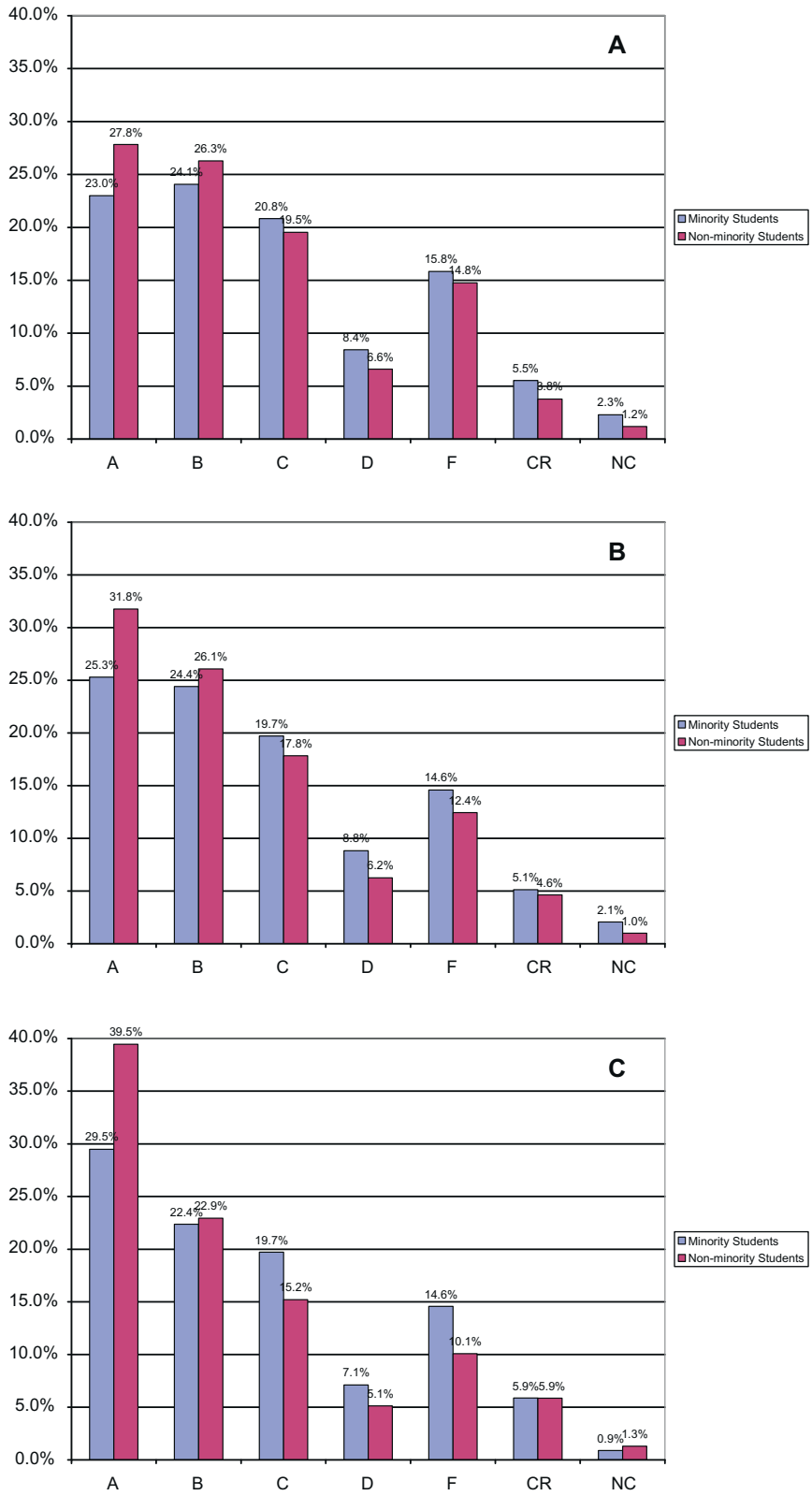

Fig. 1. (A) Grade distributions by race for all entering students, (B) grade distributions by race for all financial aid students, and (C) grade distributions by race for study participants.

Table 4
Grade point average distributions by race and type for all U.S. Colleges National Center for Educational Statistics 2007/2008.

	GPA: 0–1.0	GPA: 1.0–2.0	GPA: 2.0–3.0	GPA: 3.0–4.0
U.S. 4-year colleges				
Total	1.9%	7.7%	38.4%	52.0%
Minority	2.4%	10.5%	44.6%	42.5%
Non-minority	1.6%	6.3%	35.0%	57.1%
U.S. 2-year colleges				
Total	4.5%	13.6%	36.5%	45.4%
Minority	5.6%	16.2%	40.2%	38.0%
Non-minority	3.8%	11.7%	34.0%	50.5%
Butte College entering students 2006				
Total	14.0%	16.9%	30.2%	39.0%
Minority	15.2%	20.3%	33.2%	31.3%
Non-minority	13.5%	15.9%	29.4%	41.2%

Notes: (1) Estimates for U.S. 4-year and 2-year colleges are from National Center for Educational Statistics (2007/2008). (2) Butte College data are from administrative records for all entering students in Fall 2006.

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 considered satisfactory. D grades are considered passing, but unsatisfactory, and an NC grade is considered unsatisfactory or failing. Minority students in the Fall 2006 entering class are less likely to receive As and Bs in courses, and are more likely to receive Cs, Ds and Fs. Minority students are also more likely to take courses for a non-letter grade (i.e. CR/NC) than are non-minority students.

Similar patterns hold for comparisons with only financial aid students and study participants. Fig. 1B displays grades for all minority and non-minority students receiving financial aid in Fall 2006, and Fig. 1C displays grades for study participants. Minority students are less likely to receive As and Bs in courses and are more likely to receive Cs, Ds, Fs and non-letter grades.

There is a sizeable performance gap between minority and non-minority students which applies to all groups of students examined here. The performance gap is large for the study sample and is similar in size and magnitude to the gap for all financial aid students and entering students at Butte College. Furthermore, the minority performance gap at Butte College does not differ substantially from the gap found for all 2-year and 4-year colleges in the United States.

4. Educational effects of home computers

Is the achievement gap partly explained by low levels of access to home computers among minority students? For this to be important, minority students must benefit from having home computers. As a first pass at answering this question, Fig. 2A displays grade distributions by treatment status for minority students participating in the study. Among minority students, the treatment group is more likely to receive Bs and Cs, and less likely to receive Ds and Fs than the control group. Additionally, the treatment group is more likely to take courses for a letter grade and is subsequently less likely to receive an NC grade.

The differences in grade distributions between the treatment and controls groups, however, are much smaller for non-minority students (see Fig. 2B). Non-minority students have similar likelihoods of receiving As, Bs and Cs in the treatment and control groups. The main difference between the two distributions for non-minority students is that the treatment group is more likely to take courses for a letter grade and is subsequently less likely to receive an NC grade.

Table 5 examines several course outcome measures that focus on different parts of the grade distribution. First, I examine differences in the rate of courses taken for grades. For minority students, 95.6% of courses are taken for letter grades by the treatment group compared to 91.1% of courses taken by the control group. Conditioning on taking courses for a non-letter grade, a higher percentage of courses taken by the treatment group are passed than for the control group. Among courses taken for letter grades, the treatment group had a 2.56 grade point average compared to 2.41 for the control group. For non-minority students, the treatment group also has a higher rate of taking courses for grades and receiving a CR grade conditioning on not taking courses for grades than the control group, but has essentially the same grade point average. The full sample that includes both minority and non-minority students shows no difference for GPA, but does shows large differences for taking courses for grades and credit vs. non-credit grades.

The college primarily relies on the percentage of courses in which students receive a satisfactory or higher grade (i.e. C, B, A or CR grade) for measuring the success of students. Table 5 also reports estimates for this measure termed the "course success rate." Among minority students, 81.6% of courses received a successful grade for the treatment group compared with 73.6% for the control group. The college also tracks students' progress with a related measure that includes withdrawals in the denominator, called the course completion rate. Using this measure, I find that the treatment group has a higher course completion rate at 73.7% compared with 67.2% for the control group. In contrast to these results, the treatment and control groups have similar course success and completion rates for non-minority students. The treatment/control differences are positive, but smaller for the full sample.

Overall, these results suggest that the free computers may have improved grades among minority students, but had much less of an effect for non-minority students. The

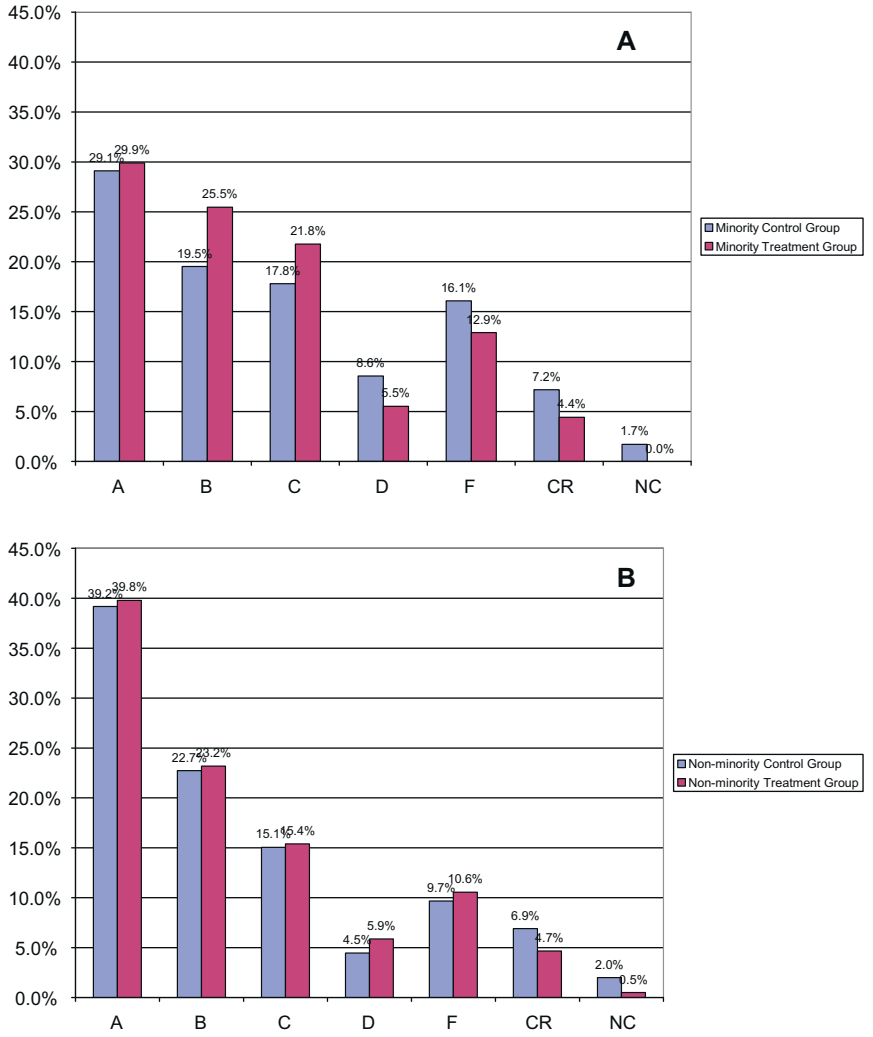

Fig. 2. (A) Grade distributions by treatment status for minority students, and (B) grade distributions by treatment status for non-minority students.

full sample also shows a few large differences, but overall it shows modest treatment effects which are discussed and examined in more detail in Fairlie and London (2012). I now turn to a more complete discussion of grade differences in the following regression analysis, first focusing on the course success rate. The precision of many of these estimates improves when controlling for other factors.

4.1. Regression results

Table 6 reports estimates from several regressions using the course success rate as the dependent variable. The regression equation is:

$$y_{ij} = \alpha + \theta M_i + \delta^M T_i M_i + \delta^N T_i(1 - M_i) + \beta X_i + \lambda_t + \lambda_d + u_i + \varepsilon_{ij}, \quad (4.1)$$

where y_{ij} is the outcome for student i in course j, $M_i = 1$ for minority students, $T_i = 1$ for students receiving free computers (treatment), X_i includes baseline characteristics, λ_t are quarter fixed effects, λ_d are department fixed effects, and $u_i + \varepsilon_{ij}$ is the composite error term (i.e. individual and individual/course specific components). The effect of winning a free computer or the "intent-to-treat" estimate of the giveaway program is captured by δ^M for minority students and δ^N for non-minority students. All specifications are estimated using OLS and robust standard errors are reported with adjustments for multiple observations per student (i.e. clustered by student). Marginal effects estimates are similar from probit and logit models.

Treatment effect estimates with the main controls are reported in Specification 1. Detailed controls are included for gender, age, parents' highest education level, high school grades, presence of own children, live with parents, and family income.[5] All of the control variables are from the baseline survey administered to study participants before receiving free computers. Minority students receiving free computers have a 9.9 percentage point higher likelihood

[5] The treatment effect estimates are very similar if the full set of ethnic/racial dummies is included instead of the reported minority dummy.

Table 5
Educational outcomes of study participants.

	All study participants	Treatment group	Control group	Treatment-control difference	Treatment-control standard error
Minority students					
Take course for grade rate	93.3%	95.6%	91.1%	4.5%	2.8%
GPA	2.48	2.56	2.41	0.158	0.239
Credit vs. no credit	86.8%	100.0%	80.8%	19.2%	8.7%**
Course success rate	77.4%	81.6%	73.6%	7.9%	5.4%
Course completion rate	70.3%	73.7%	67.2%	6.5%	6.3%
Non-minority students					
Take course for grade rate	92.8%	94.8%	91.1%	3.7%	2.7%
GPA	2.82	2.80	2.85	−0.049	0.169
Credit vs. no credit	81.8%	90.0%	77.6%	12.4%	7.7%
Course success rate	83.5%	83.0%	83.9%	−0.8%	3.6%
Course completion rate	77.0%	76.9%	77.0%	−0.1%	4.2%
All students					
Take course for grade rate	93.0%	95.1%	91.1%	4.0%	2.1%*
GPA	2.72	2.72	2.71	0.012	0.140
Credit vs. no credit	83.3%	92.9%	78.6%	14.3%	6.0%**
Course success rate	81.6%	82.6%	80.7%	1.9%	3.0%
Course completion rate	74.9%	75.9%	74.0%	1.9%	3.5%

Note: Based on administrative data provided by Butte College for study participants.
* Denotes statistical significance at 0.10 level.
** Denotes statistical significance at 0.05 level.
*** Denotes statistical significance at 0.01 level.

of successfully completing courses at Butte College than minority students who did not receive free computers. In contrast, the estimated effect of receiving free computers is essentially zero for non-minority students after controlling for baseline characteristics. Minority students are less likely to successfully complete courses overall than are non-minority students after controlling for other characteristics.

Table 6
Course success rate regressions.

	(1)	(2)	(3)	(4)	(5)	(6)
Minority treatment	0.0986*	0.0995**	0.1005**	0.1100**		
	(0.0507)	(0.0502)	(0.0512)	(0.0497)		
Non-minority treatment	−0.0091	−0.0082	−0.0073	−0.0022		−0.0033
	(0.0346)	(0.0339)	(0.0335)	(0.0340)		(0.0340)
Minority	−0.0810*	−0.0748	−0.0742	−0.0696	−0.0186	
	(0.0455)	(0.0456)	(0.0464)	(0.0443)	(0.0340)	
Latino treatment						0.1440**
						(0.0613)
Asian treatment						0.0248
						(0.1194)
Other minority treatment						0.1163
						(0.1082)
Latino						−0.0760
						(0.0505)
Asian						−0.1315
						(0.0957)
Other minority						−0.0451
						(0.0859)
Treatment					0.0326	
					(0.0283)	
Quarter and course department fixed effects	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	0.8159	0.8159	0.8159	0.8159	0.8159	0.8133
Sample size	1792	1792	1792	1792	1792	1762

Notes: (1) The dependent variable is whether the grade was a C, CR or better. (2) Robust standard errors are reported and adjusted for multiple courses taken by study participants. (3) All reported specifications include gender, 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.
* Denotes statistical significance at 0.10 level.
** Denotes statistical significance at 0.05 level.
*** Denotes statistical significance at 0.01 level.

The results are not sensitive to the inclusion of additional variables as expected due to randomization of treatment. First, I estimate a specification that adds fixed effects for course departments and the quarter in which the course was taken (Specification 2). This specification addresses the concern that students may have taken different types of courses which ultimately are responsible for differences in grades.[6] The coefficient estimate on the minority treatment variable remains similar. Specification 3 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 minority treatment dummy variable remains similar. In Specification 4, administrative information on basic assessment tests collected by the college for most entering students is added.[7] Assessments in math, English and reading are available. These assessment scores are used for student placement in courses. Administrative data collected at the time of application also provide information on whether the student primarily speaks English. Given the importance of English language ability for course performance I include this as an additional control variable. The coefficient on the minority treatment variable increases slightly to 11 percentage points. In all cases the non-minority coefficient remains very small and insignificant. Combining the two treatment effects results in an overall treatment effect (reported in Specification 5) results in a small, positive estimate which is not significant at conventional levels (see Fairlie & London, 2012, for more analysis).

As noted above, the sample sizes make it difficult to examine separate treatment effects for each minority group. Of all minority study participants, 50% are Latinos and 23% are Asians. Native-Americans and blacks comprise only 13 and 12% of all minority students, respectively. Given these shares, I estimate a specification that includes separate treatment interactions and main effect dummies for Latinos, Asians, and all other minorities. Estimates are reported in Specification 6. Receiving a free computer has a large, positive effect on course success for Latinos. The treatment group is 14 percentage points more likely to successfully complete a course than the control group. Other minorities have a similarly large positive treatment effect, but the difference is imprecisely measured. For Asians, the point estimate of 2.5 percentage points is smaller than for Latinos and other minorities. There may be some interesting racial and ethnic differences within the minority group, but the sample sizes are too small to make strong conclusions. I continue to combine all minority groups in the analysis.

[6] I also find that minority and non-minority students do not differ substantially in their course departments. For both minority and non-minority students the three most common course departments are Mathematics, Business Computer Information Systems, and English.

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

4.2. Controlling for different courses

Administrative data on course grades over the two-year study period is available for all entering students in Fall 2006. Although baseline and follow-up survey information are not available for students who are not participating in the study, after removing all identifying information the college provided administrative data on grades, a few background characteristics collected at the time of application, and assessment scores. The use of the entire incoming class of students allows for the inclusion of fixed effects for every course taken in each quarter over the study period. The inclusion of course fixed effects removes the possibility that differences between the treatment and control groups in course success rates are the result of taking courses with differing levels of difficulty. The inclusion of fixed effects for the separate offerings of courses also implicitly controls for differences in instructor quality and grading practices.

Table 7 reports estimates for the full sample of students. The minority and non-minority treatment coefficients capture the difference between the treatment and control groups for each group. 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 because separate dummy variables are included for other financial aid students and non-financial aid students. Specification 1 includes controls for 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, I add fixed effects for every course taken over the sample period. The estimate of 0.086 is in the range of estimates presented before. I also continue to find essentially no effect of the computer giveaway program for non-minority students. These estimates indicate that minority students receiving free computers do not perform better in their courses because they take less challenging or more easily graded courses.

4.3. Additional course grade measures

Table 8 reports estimates for several additional course outcomes. Specification 1 reports estimates for the course completion rate defined as the percentage of courses in which an A, B, C or CR grade is received relative to all grades including withdrawals. The minority treatment group has a 10.6 percentage point higher likelihood of completing courses than the control group. Similar to the course success rate, which does not include withdrawals, the non-minority treatment effect is essentially zero. The inclusion of withdrawals thus has little effect on the results.

I further examine the separate components of the full grade distribution discussed above. Specification 2 reports estimates of the treatment effect for the probability of taking a course for a grade. The coefficient on the minority treatment effect is positive, but it is imprecisely measured. The non-minority treatment estimate is also positive, but larger. In Specification 3, I focus on letter grades. I report estimates for a regression in which the dependent variable is the GPA. The sample excludes all courses taken for non-letter grades. The point estimate indicates a higher

Table 7
Regression results for outcomes using full sample.

	Course success rate (1)	Course success rate (2)	Graduation rate (3)
Minority treatment	0.0896*	0.0860**	0.0756
	(0.0495)	(0.0348)	(0.0581)
Non-minority treatment	−0.0013	−0.0088	0.0037
	(0.0341)	(0.0237)	(0.0604)
Minority	−0.0966**	−0.0916***	−0.1490***
	(0.0447)	(0.0294)	(0.0539)
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	6939

Notes: (1) The dependent variable is whether the grade was a C, CR or better in Specifications 1 and 2, and whether the student received an associates degree, vocational degree or vocational certificate in Specification 3. (2) Robust standard errors are reported and are adjusted for multiple courses taken by study participants when needed. (3) Main controls include gender from administrative data. Dummy variables are included for other financial aid students and non-financial aid students. (4) Assessments include math, English and reading.

* Denotes statistical significance at 0.10 level.
** Denotes statistical significance at 0.05 level.
*** Denotes statistical significance at 0.01 level.

GPA among computer winners relative to non-computer winners for minorities, but the difference is not significant at conventional levels (the *p*-value for a two-tailed test is 0.12). The non-minority treatment estimate is very small. Finally, I 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 minority treatment group has a 0.34 higher probability of passing courses than the control group. Non-minorities in the treatment group are also more likely to pass courses conditional on not taking them for grades than the control group.

The estimates for these additional educational outcomes present a consistent story – minority students winning free computers did better than minority students not winning free computers. Minority students also generally appear to benefit more from receiving free computers than non-minority students, but there are some educational outcomes where non-minority students also improve from treatment. The statistically significance for the various measures of educational outcomes vary somewhat, but the point estimates are consistently positive (with the results for the course success rate, course completion rate, and credit vs. non-credit rate being the strongest for minority students).

4.4. Degree receipt

In addition to the effects on grades, receiving a free computer may affect longer term outcomes such as graduation.

Table 8
Additional educational outcome regressions.

	Completion rate (1)	Take for grade rate (2)	GPA (3)	Credit vs. no credit (4)
Minority treatment	0.1058*	0.0227	0.3151	0.3377***
	(0.0556)	(0.0211)	(0.2037)	(0.1147)
Non-minority treatment	0.0089	0.0323*	0.0159	0.2148**
	(0.0371)	(0.0169)	(0.1366)	(0.1001)
Minority	−0.0420	−0.0084	−0.2302	0.1490
	(0.0469)	(0.0219)	(0.1814)	(0.1163)
Quarter and course department fixed effects	No	Yes	Yes	Yes
Campus and job activity	No	No	Yes	Yes
Assessments and English language (administrative data)	No	No	No	Yes
Mean of dependent variable	0.7486	0.9297	2.7173	0.8333
Sample size	1953	1792	1666	126

Notes: (1) The dependent variable is whether the grade was a C, CR or better including withdrawals in Specification 1, taking a course for a grade in Specification 2, grade point average in Specification 3, and credit vs. no credit among non-graded classes in Specification 4. (2) Robust standard errors are reported and adjusted for multiple courses taken by study participants. (3) All reported specifications 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.

* Denotes statistical significance at 0.10 level.
** Denotes statistical significance at 0.05 level.
*** Denotes statistical significance at 0.01 level.

Table 9
Graduation rate regressions.

	(1)	(2)	(3)	(4)	(5)	(6)
Minority treatment	0.0746	0.0814	0.0831	0.0584		
	(0.0584)	(0.0589)	(0.0602)	(0.0621)		
Non-minority treatment	0.0030	−0.0123	−0.0110	−0.0111		−0.0122
	(0.0607)	(0.0595)	(0.0602)	(0.0603)		(0.0606)
Minority	−0.1505***	−0.1189**	−0.1170**	−0.1248**	−0.0919*	
	(0.0540)	(0.0553)	(0.0555)	(0.0575)	(0.0481)	
Latino treatment						0.0141
						(0.0875)
Asian treatment						0.1091
						(0.1464)
Other minority treatment						0.1202
						(0.1067)
Latino						−0.0806
						(0.0685)
Asian						−0.0592
(0.1125)						
Other minority						−0.2400***
						(0.0639)
Treatment					0.0139	
					(0.0446)	
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	0.1713	0.1713	0.1713	0.1713
Sample size	286	286	286	286	286	286

Notes: (1) The dependent variable is whether the student received an associates degree, vocational degree or vocational certificate. (2) Robust standard errors are reported. (3) All reported specifications include gender, 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.

* Denotes statistical significance at 0.10 level.
** Denotes statistical significance at 0.05 level.
*** Denotes statistical significance at 0.01 level.

The college provided information on whether students received a degree by Summer 2008. Students may have received an associates degree, vocational degree or vocational certificate. For minorities, 13.5% of students receiving computers graduated with a degree or certificate compared to 6.0% of students not receiving computers. In contrast, among non-minority students 21% of both the treatment and control groups graduated.

Table 9 reports regression estimates for the probability of graduating. The regression estimates indicate that for minorities the treatment group is more likely to graduate than the control group. The minority treatment coefficient estimate ranges from 6 to 8 percentage points, although it is not significant at conventional levels (the lowest p-value is 0.17 for a two-tailed test). The inclusion of all entering students also provides similar estimates of the treatment effect (see Table 7). For non-minorities, there is no evidence of a positive treatment effect – all of the point estimates are very close to zero. The combination of the two treatment effects results in an overall treatment effect point estimate that is modest and insignificant. The estimate is reported in Specification 5 and a more detailed analysis can be found in Fairlie and London (2012). Minority students have substantially lower rates of graduating from the community college than non-minorities even after controlling for other factors. The coefficient on the main minority variable is large and negative.

In Specification 6, I also report estimates of the treatment effect interacted with specific minority groups. The point estimates on the treatment effect for Asians and other minorities are positive and large, whereas the Latino treatment estimate is positive and smaller. For all groups, the estimates are imprecisely measured. Similar to what I find in the course success rate regressions, there is some variation in the magnitudes of treatment estimates across the three main minority groups, but for all groups the point estimates indicate positive results that are larger than the non-minority estimates. Additionally, I find larger graduation treatment effects for Asians, but larger grade treatment effects for Latinos. Although much larger sample sizes would be needed to verify if there are important differences across minority groups, it does not appear as though combining separate minority groups provides misleading results.

4.5. Treatment compliance

The estimates presented thus far capture the "intent-to-treat" from the experiment and do not adjust for noncompliance in the treatment and control groups. Some of the students in the treatment group did not pick up their free computers, and some of the students in the control group purchased their own computers during the study period. Although the intent-to-treat estimate is often a parameter of interest in evaluating policies to address the consequences of disparities in access to technology, the "treatment-on-the-treated," or more general, local average treatment effect (LATE) estimates are also of interest. They

Table 10
Course success and graduation rate IV regressions.

	Course success rate			Graduation rate		
	OLS (1)	IV lower bound (2)	IV upper bound (3)	OLS (4)	IV lower bound (5)	IV upper bound (6)
Minority treatment	0.1100**	0.1148**	0.1311*	0.0584	0.0644	0.1222
	(0.0497)	(0.0547)	(0.0721)	(0.0621)	(0.0674)	(0.1156)
Non-minority treatment	−0.0022	0.0014	0.0119	−0.0111	−0.0120	−0.0180
	(0.0340)	(0.0366)	(0.0431)	(0.0603)	(0.0657)	(0.0772)
Minority	−0.0696	−0.0653	−0.0998*	−0.1248**	−0.1243**	−0.1868*
	(0.0443)	(0.0435)	(0.0589)	(0.0575)	(0.0575)	(0.0968)
Quarter and course department fixed effects	Yes	Yes	Yes	No	No	No
Campus and job activity	Yes	Yes	Yes	Yes	Yes	Yes
Assessments and English language (administrative data)	Yes	Yes	Yes	Yes	Yes	Yes
Mean of dependent variable	0.8159	0.8159	0.8159	0.1713	0.1713	0.1713
Sample size	1792	1792	1792	286	286	286

Notes: (1) The dependent variable is whether the grade was a C, CR or better in Specifications 1–3 and whether the student received an associates degree, vocational degree or vocational certificate in Specifications 4–6. (2) Robust standard errors are reported and adjusted for multiple courses taken by study participants when needed. (3) All reported specifications include gender, 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. The lower (upper) bound estimate assumes that all control group noncompliers obtained computers at the end (beginning) of the survey period. Course success rate.

* Denotes statistical significance at 0.10 level.
** Denotes statistical significance at 0.05 level.
*** Denotes statistical significance at 0.01 level.

provide estimates of the effects of having a home computer on educational outcomes.

Of the 141 students in the study that were eligible to receive a free computer, 129 students (or 92%) actually picked them up from Computers for Classrooms. Similarly high percentages of minority and non-minority students picked up their computers. Among minority students, 47 out of 52 students (90.4%) winning free computers picked them up from the warehouse. Ninety-two percent (82 out of 89) of non-minority students in the treatment group picked up their computers. These high rates of compliance in the treatment group suggest that adjusting for noncompliance in the treatment groups will not change the results much. To confirm that the "treatment-on-the-treated" estimate does not differ substantially from the previous "intent-to-treat" estimate, an instrumental variables regression is estimated. Computer eligibility (winning a free computer) is used as an instrumental variable for whether the student picked up the free computer. The first-stage regression for the probability of computer receipt is:

$$C_i = \omega + \varphi M_i + \pi^M T_i M_i + \pi^N T_i(1 - M_i) + \gamma X_i + \lambda_t + \lambda_d + u_i + \varepsilon_{ij}, \quad (4.2)$$

The second-stage regression is:

$$y_{ij} = \alpha_2 + \theta_2 M_i + \Delta^M \hat{C}_i M_i + \Delta^N \hat{C}_i(1 - M_i) + \beta_2 X_i + \lambda_t + \lambda_d + u_i + \varepsilon_{ij}, \quad (4.3)$$

where $\hat{C}_i$ is the predicted value of computer ownership from (4.2). In this case, Δ^M and Δ^N provide estimates of the "treatment-on-the-treated" effects for minority and non-minority students, respectively. The IV estimates for the course success are reported in Specification 1 of Table 10. Given the high compliance rate for minority students in the treatment group, the estimates are only slightly larger than the intent-to-treat estimate and approximate the simple OLS coefficient divided the pick-up rate of 90.4%. The non-minority estimate remains small and indistinguishable from zero.

The control group cannot be prevented from purchasing a computer on their own during the study period. This problem of the control group receiving an intervention that potentially has the same effect as the treatment intervention is a similar problem in most social experiments. Results from the follow-up survey taken at the end of the study period indicate that 28% of the control group reports getting a new computer, although no information is available on when they purchased the computer. For minority students, 46.7% of the control group reported getting a new computer on the follow-up survey. For non-minority students, 18.2% of the control group reported getting a new computer. Although students in the control group who purchased their computers near the end of the study period are not likely to have a large effect on the estimates, students in the control group purchasing computers at the beginning of the study period may dampen estimated differences between the treatment and control groups.

The more general local average treatment effect (LATE) estimator is used to expand on the "treatment-on-the treated" estimates. Specification 1 reports estimates that implicitly assume that all students in the control group received a computer at the end of the study period, and Specification 2 reports estimates that 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 Specification 2, control group students obtaining computers contribute to the estimation of (4.2) with $C_i = 1$. This new "upper bound" estimate of the LATE is 13 percentage points for minority students. For non-minority students, I continue to find small and negligible estimates.

I also estimate IV regressions for the graduation rate and report estimates in Specifications 3 and 4 of Table 10. For minority students, the point estimates indicate that having a home computer increases graduation rates by 6.4–12.2 percentage points. These estimates, however, are not statistically significant at conventional levels. Non-minority students show no effect from having home computers.

5. Potential explanations for differential effects of home computers

Estimates from the random experiment indicate that the receipt of free computers increased educational outcomes among minority students, but the evidence of positive effects of receiving free computers for non-minority students is limited to only a few outcomes. What are some potential explanations for these differential results? Although the experiment is not designed to examine the causes of these differences explicitly, I present some suggestive evidence on the question.

One possibility is that race is correlated with another factor such as income, parental education, or test scores that has differential treatment effects. Examining the baseline characteristics of the sample of financial aid students participating in the study, the largest differences are that minority students have lower parental education and are more likely to live with their parents (see Table 3). These differences may be partly responsible for why minority students appear to benefit more from home computers than non-minority students. In other words, the effects of home computers may be larger for students with more limited family educational backgrounds instead of there being a large minority effect for example. To investigate this question, I estimate separate regressions that add a treatment interaction with each factor. If the factor is driving part of the minority effect then the minority treatment estimate would become smaller or possibly disappear.

Table 11 reports estimates for grade regressions. Specification 1 reports estimates after including a treatment interaction for whether the parents have less than a college education. In our sample, nearly 60% of minority students do not have a college-educated parent whereas only 30% of non-minority students have parents with less than a college education. Although minority students have lower levels of parental education, this does not explain the large, positive treatment effect. The coefficient estimate on the minority treatment variable is 0.112 which

Table 11
Course success rate regressions with treatment interactions.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Minority treatment	0.1121*	0.1284**	0.0963*	0.0516	0.0928	0.1170*	0.1211*
	(0.0614)	(0.0558)	(0.0577)	(0.0655)	(0.0655)	(0.0613)	(0.0678)
Non-minority treatment	−0.0012	0.0127	−0.0168	−0.0427	−0.0084	0.0234	0.0297
	(0.0370)	(0.0382)	(0.0503)	(0.0487)	(0.0468)	(0.0467)	(0.0716)
Minority	−0.0698	−0.0724	−0.0730	−0.0653	−0.0686	−0.0669	−0.0654
	(0.0448)	(0.0447)	(0.0454)	(0.0440)	(0.0492)	(0.0496)	(0.0507)
No college-educated parent treatment	−0.0034						
	(0.0586)						
Live with parents treatment		−0.0445					
		(0.0601)					
Has job treatment			0.0301				
			(0.0590)				
Live far from campus (more than 15 miles) treatment				0.0792			
				(0.0570)			
Math assessment treatment					0.0366		
					(0.0581)		
English assessment treatment						−0.0374	
						(0.0688)	
Reading assessment treatment							−0.0301
							(0.0738)
Quarter and course department fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Campus and job activity	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Assessments and English language (administrative data)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean of dependent variable	0.8159	0.8159	0.8159	0.8159	0.8111	0.8111	0.8111
Sample size	1792	1792	1792	1792	1313	1313	1313

Notes: (1) The dependent variable is whether the grade was a C, CR or better. (2) Robust standard errors are reported and adjusted for multiple courses taken by study participants. (3) All reported specifications include gender, 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.

* Denotes statistical significance at 0.10 level.
** Denotes statistical significance at 0.05 level.
*** Denotes statistical significance at 0.01 level.

is very similar to the original estimate of 0.110. There is also no evidence suggesting that the treatment effect differs by parental education. Another large difference is that minority students are more likely to live with their parents than non-minority students (42% compared with 30%, respectively). Including a live with parents treatment interaction, however, has little effect on the minority treatment estimate. Although not reported, I also try including interactions with other baseline characteristics and find similar results. The large, positive treatment effect for minority students cannot be explained away by differential treatment effects in these baseline characteristics.

Using the full sample of study participants, Fairlie and London (2012) find some evidence that students who had a job at baseline benefitted more from receiving free computers than students who did not have a job at baseline. They also find evidence that students living farther from campus benefitted more from the computers than those living closer to campus. Home computers are likely to provide more flexibility in computing access times which is likely to represent a larger improvement for students who have a job (less flexibility in using computers at non-work times) and students living farther from campus (more difficult to get to on-campus computer labs). I include treatment interactions with having a job in Specification 3 and living far from campus (more than 15 miles, which is the median distance) in Specification 4. Controlling for the interaction with having a job does not affect the minority treatment interaction: it remains similar to the original estimate. The interaction with distance from campus appears to have more of an effect on the minority-treatment estimate: the coefficient is now roughly half of the original magnitude. Minorities are 15 percentage points more likely to live far from campus than are non-minorities, which could imply that part of the larger minority treatment effect is due to minority students living farther from campus. But, some caution is warranted here as the estimates are not very precise, and I cannot rule out that the coefficient estimate on the minority-treatment effect is the same as the original estimate.

A major difference between minority and non-minority students noted above was their overall performance in courses. If students with lower achievement levels are the ones that benefit the most from receiving free computers then it could explain the race effect. Lower achievement students may have more room for improvement in educational outcomes which in turn could lead to larger estimated effects. To investigate this question, I examine administration information on assessment tests given to most entering students (75% of study participants). Assessments in math, English and reading are available and are used for student placement in courses. Although math assessments are roughly similar, minority students tend to perform much lower than non-minority students on the reading and English tests. On the English assessment test, minority students have an average score that is one half standard deviation lower than the average non-minority score, and on the reading assessment test, minority students have average scores that are 0.7 standard deviations lower. Do the lower assessment scores explain the minority effects?

Table 11 reports estimates from separate regressions that include each of the assessment scores and their interactions with treatment status. Specification 3 reports estimates for the math assessment score interaction. The minority treatment interaction coefficient remains large and positive. The coefficient is similar to the baseline minority treatment estimate of 0.1086 resulting from the 25% smaller sample size. Specifications 4 and 5 report estimates for the English and reading assessments, respectively. In both cases, the minority treatment effect remains large and positive.[8] For all three assessments, the interactions with treatment status have yielded small and insignificant estimates.

5.1. Alternative access to computers

Another potential explanation for the larger minority treatment effect is that minority students may have fewer alternatives outside the home for using computers to conduct schoolwork than non-minority students. In particular, lower rates of computer ownership among family, friends, and relatives may provide fewer alternatives for places to access computers for minority students. If this is the case, minority students will benefit more than non-minority students from receiving a free computer to use at home. I find, based on the follow-up survey conducted in Spring 2008, that minority students receiving free computers increase the total time they use computers by more than non-minority students relative to the control group. Minority students increase their time by 4.6 h per week compared with 1.6 h for non-minority students. Further evidence from the follow-up survey indicates that minority students may rely more heavily on campus computers than non-minority students. I find that 32% of the minority control group reports experiencing wait times to use computers at Butte College compared with 13% of non-minority control group.

Published estimates from the October 2007 Current Population Survey (CPS), Computer and Internet Supplement indicate that rates of home computer Internet access are substantially lower for minorities than non-minorities (U.S. Department of Commerce, 2008). Two-thirds of white households have access to computers with the Internet at home compared with 48% of minority households. Estimates from the 1997 to 2007 CPS indicate that these disparities have been persistent over the past decade and provide no clear indication of a downward trend (Fig. 3). These results are consistent with previous research indicating large racial disparities in access to computers, the Internet and broadband at home (Fairlie, 2004; Goldfarb & Prince, 2008; Ono & Zavodny, 2003, 2008; U.S. Department of Commerce, 2008; Warschauer, 2003).

Large racial differences in access to home computers exist for all age groups including youth. In Table 12, I report estimates of minority and non-minority home access rates by age groups calculated from 2007 CPS microdata. For

[8] I also examine whether differential treatment effects by whether the student reports having a computer at baseline and find very similar minority treatment effects.

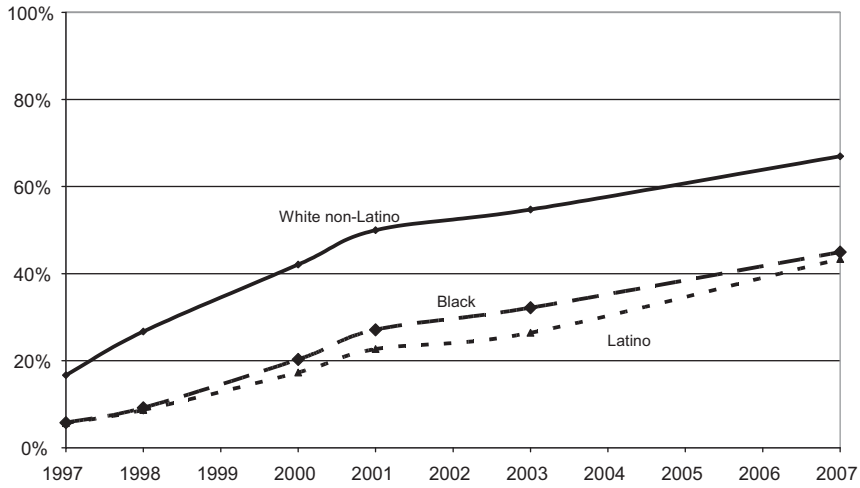

Fig. 3. Percent of the population (ages 18+) with access to a home computer by race/ethnicity Current Population Survey (1997–2007).

all age groups, minorities are substantially less likely to have home computers with Internet access than non-minorities. These differences also do not disappear after controlling for income, region, age and other observable characteristics. Specifications 1 and 2 of Table 13 report estimates of regressions for access to home computers with the Internet. Minorities are 19 percentage points less likely than non-minorities to have access to home computers.

One method of examining whether minority students have fewer alternatives for using computers to complete schoolwork, such as those at family, friends', and relatives' houses, is to examine computer use among individuals who do not have home computers. The 2007 CPS provides information on Internet use outside the home in addition to information on home access. If minorities have fewer convenient access points outside the home then they should have lower rates of use conditional on not having

Table 12
Access to home computers with internet and internet use outside home Current Population Survey, 2007.

	Minorities		Non-minorities	
	Percent	*N*	Percent	*N*
Access to home computers with Internet				
All individuals	53.6%	39,651	73.8%	94,311
Children (ages under 18)	52.9%	12,839	81.6%	20,410
Young adults (ages 18–30)	53.9%	7612	77.1%	14,251
Older adults (ages 31 and over)	53.9%	19,200	70.2%	59,650
Internet use conditioning on no home access				
All individuals	14.8%	17,954	19.5%	24,202
Children (ages under 18)	15.2%	5549	22.3%	3335
Young adults (ages 18–30)	21.3%	3497	38.2%	3246
Older adults (ages 31 and over)	11.6%	8908	15.1%	17,621

Note: All estimates use sample weights provided by the CPS.

Table 13
Internet use and home computer with internet access regressions Current Population Survey, 2007.

	Home computer with internet		Internet use outside home	
	(1)	(2)	(3)	(4)
Minority	−0.2316***	−0.1879***	−0.1688***	−0.1422***
	(0.0075)	(0.0074)	(0.0123)	(0.0133)
Demographic controls	No	Yes	No	Yes
Mean of dependent variable	0.6795	0.6795	0.2863	0.2863
Sample size	21,648	21,648	6743	6743

Notes: (1) The sample includes all individuals ages 18–30 in Specifications 1 and 2, and individuals ages 18–30 who do not have access to a home computer with the Internet in Specifications 3 and 4. (2) Robust standard errors are reported. (3) The controls include gender, age, family income, home ownership, region, and urbanicity.

* Denotes statistical significance at 0.10 level.
** Denotes statistical significance at 0.05 level.
*** Denotes statistical significance at 0.01 level.

a computer with Internet at home. Conditioning on not having access to a home computer with Internet, I find that minorities are less likely to use the Internet anywhere (Table 12). For young adults, the difference is large. Twenty-one percent of minorities without home access do not use the Internet anywhere compared with 38% of non-minorities without home access. The difference in Internet use outside the home between minorities and non-minorities is not due to other observable factors, although it could be related to unobservable differences in preferences. Minorities have a substantially lower rate of Internet use outside the home than non-minorities even after controlling for family income, home ownership, region, and other factors (Specifications 3 and 4 of Table 12). Minorities without home access are 14 percentage points less likely to use the Internet elsewhere than are non-minorities without home access.

All of these estimates are consistent with minorities having fewer alternatives for using computers outside the home. More limited opportunities for non-home computer use among minorities may result in larger impacts of the computer giveaway on educational outcomes for minority students.

6. Conclusions

One contributing factor to the achievement gap between minority and non-minority students is the disparity in access to technology. Minorities have substantially less access to home computers than non-minorities potentially placing them at a disadvantage in completing their schoolwork. Evidence from the first-ever field experiment that randomly provided free computers to students indicates large educational benefits of home computers for minority students. The randomly selected treatment group of financial-aid students enrolled in community college achieved better educational outcomes than the control group that did not receive free computers. I find that the percentage of courses completed successfully by minority students participating in the study increases by 8–11 percentage points by winning a free computer through the giveaway program. Estimates of the effects of having a home computer on course success among complying minority students are 4–20% higher. I also find some evidence that the treatment group of minority students is more likely to graduate from community college, defined as receiving an Associate's degree, vocational degree, or vocational certificate, than the control group. For several additional educational outcomes, I find evidence of higher levels of success among minority students in the treatment group than in the control group. The statistically significance of these results for educational outcomes vary somewhat, with the results for the course success rate, course completion rate, and credit vs. non-credit rate being the strongest.

In contrast to the finding of large, positive effects of home computers on the educational outcomes of minority students, I find less evidence of positive effects for non-minority students. This finding combined with the minority results is consistent with the finding of modest-sized overall treatment effects shown in more detail in Fairlie and London (2012). Minority students may benefit more from receiving free computers because of fewer alternatives for accessing home computers due to lower rates of computer ownership among family, friends, and relatives. Using microdata from the 2007 CPS, I find that conditioning on not having access to a home computer with the Internet, minorities are half as likely to use computers for the Internet outside the home than are non-minorities. I also do not find evidence that the positive treatment effects for minorities are due to correlations with differences in treatment effects for other characteristics such as income, parental education, having a job and test scores. The one exception is that minorities living farther away from campus might contribute to the larger benefits of home computers for minority students. Another possibility, which I cannot test with the data, is that in the sample of financial-aid students wishing to receive free computers minority and non-minority students may differ in the reasons for not previously having a home computer. For example, minority students participating in the study may be more likely than nonminority students to want a computer because they could not previously afford one. Although minority and nonminority students do not differ in terms of current family income they might differ in permanent income and wealth.

The finding of large, positive returns to home computers among minority students is especially important because of the large returns to education among minority students and the contribution of educational disparities to earnings gaps (Altonji & Blank, 1999; Card, 1999). The achievement gap and resulting earnings gap may be partly caused by the underinvestment of minorities in educational technology. Many minority students and their families may not be purchasing personal computers even when otherwise optimal because of financial, informational and technical constraints. Although financial constraints may cause a major hindrance for low-income minority students, technical and informational constraints resulting from having less previous experience with computers may also be important.

Estimates from the field experiment suggest that these constraints may have non-negligible effects on educational outcomes. The LATE estimates indicate that having a home computer results in a 1.1–1.3 percentage point higher likelihood of successfully completing courses among minority students. Improving home computer access among minority students by 20 percentage points, which is equivalent to the total minority/non-minority gap in home computer rates, would thus result in an increase in the course success rate of 2.2–2.6 percentage points. This is a large contribution as the difference in course success rates between minority and non-minority students on financial aid at Butte College is roughly 6 percentage points (74.5% compared with 80.3%). The large estimated contribution also corroborates extensive qualitative evidence of the educational disadvantage created by limited access to home computers among minority students (Warschauer & Matuchniak, 2010).

Policies that address these constraints, such as tax breaks or special loans for educational computer purchases, an expansion of computer refurbishing programs,

and laptop computers for home use may be needed.[9] Improving minority access to computers may become increasingly important as schools, professors and financial aid sources are rapidly expanding their use of technology to provide information and course content to students.

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[9] Several colleges have programs in which students can check out laptops, but these programs are not universal and are usually limited to a day or only a few days of use.