



## USING AFFORDABLE TECHNOLOGY TO DECREASE DIGITAL INEQUALITY

Shelia R. Cotten , Timothy M. Hale , Michael Howell Moroney , LaToya O'Neal & Casey Borch

**To cite this article:** Shelia R. Cotten , Timothy M. Hale , Michael Howell Moroney , LaToya O'Neal & Casey Borch (2011) USING AFFORDABLE TECHNOLOGY TO DECREASE DIGITAL INEQUALITY, *Information, Communication & Society*, 14:4, 424-444, DOI: [10.1080/1369118X.2011.559266](https://doi.org/10.1080/1369118X.2011.559266)

**To link to this article:** <http://dx.doi.org/10.1080/1369118X.2011.559266>



Published online: 12 Apr 2011.



Submit your article to this journal [↗](#)



Article views: 744



View related articles [↗](#)



Citing articles: 13 View citing articles [↗](#)

# Shelia R. Cotten, Timothy M. Hale, Michael Howell Moroney, LaToya O'Neal & Casey Borch

## USING AFFORDABLE TECHNOLOGY TO DECREASE DIGITAL INEQUALITY Results from Birmingham's One Laptop Per Child XO laptop project

*School systems in the United States are increasingly integrating computers into the classroom. Yet, we know little about the factors that determine successful adoption, use, and attitudes toward the computers. The City Council of Birmingham, Alabama is the first in the United States to provide One Laptop Per Child XO laptops to all students in first-fifth grades in the Birmingham City School System. The purpose of this study is to present the survey results examining factors that are related to XO laptop usage and attitudes among fourth- and fifth-grade students in Birmingham City schools. The results indicate that factors vary depending upon the type of use or attitudes being examined. Teachers' use of the XO laptop in the classroom is a primary factor that is related to the frequency of XO activity use and students' attitudes toward the XOs, while teachers' ability is related to the hours of XO usage in school. These results highlight the importance of having well-trained teachers who embrace using the XO laptop in the classroom in order to facilitate positive attitudes toward technology and its use among students.*

**Keywords** digital inequality; One Laptop Per Child; XO laptops; computer use

*(Received 14 January 2011; final version received 27 January 2011)*

## Introduction

K-12 school systems are increasingly integrating 1-to-1 computing programs (e.g. each student has a computer) into their curricula (The Metiri Group 2006; Apple Computer 2007). These initiatives can enhance students' academic performance and standardized test scores; increase levels of students' collaboration, engagement, and participation; and lower rates of absenteeism and dropping out of school (Lemke & Martin 2003; Silvernail & Lane 2004; Gulek & Demirtas 2005; Apple Computer 2007; Suhr *et al.* 2010). The impacts of these programs depend upon a variety of organization- and individual-level factors, including teachers' and students' digital literacy skills, teachers' preparedness, how much students use the technology in the classroom, and attitudes toward technology. Few researchers have examined the factors that affect students' usage and attitudes toward computers in large-scale 1-to-1 computing programs; yet, this is critical for understanding the impacts of interventions such as these. Furthermore, this paper is among the first to examine a large-scale dissemination of XO laptops, in particular.

In early 2008, the Mayor of Birmingham, Alabama, contracted with the One Laptop Per Child (OLPC) organization to distribute an XO laptop to every student in grades 1–5 in Birmingham City schools. XO laptops were originally developed to be distributed to children in the third world countries. This was the *first XO laptop dissemination project in the US schools*. The Mayor's goal was to provide students in this high-poverty, minority school system with the technological skills to compete in the increasingly technologically dependent social world, and to eliminate digital inequality in Birmingham, Alabama.

The XO laptop is unique compared with many laptops, as it is based on theories of constructionism, the idea being that students learn best by doing, creating, and experimenting in collaboration. All of the XO software, including the operating system, is open source, thus providing individuals with the ability to customize the XO in ways that better fit their own learning and teaching styles.

The purpose of this study is to examine how individual- and teacher-level characteristics affect both XO laptop usage and attitudes toward XOs in this large-scale 1-to-1 computing initiative in a low-income minority school district in Alabama. Determining factors at the individual and teacher levels that facilitate or constrain XO laptop usage may provide instrumental information for this school system and others as they attempt to implement 1-to-1 computing programs.

## Determinants of computer and Internet usage

Researchers often refer to youth as digital natives, as they were born when computers and the Internet were present and increasing in use (Palfrey & Gasser 2008). Children aged 8–10 years are exposed to high levels of technology/media per day

(close to eight hours per day, on average) (Rideout *et al.* 2010). These high levels of usage may be explained by increased access to technology and the development of appealing new technology targeted toward younger aged children. Children aged 8–10 years, compared with older age groups, spend the least amount of time with computers. With regard to time spent online, 70 percent of 8–18-year olds go online in a typical day. Youth are more likely to go online at home (57 percent) than at school (20 percent) or another location (14 percent).

Although considered digital natives, research illustrates that persistent differences in computer and Internet use remain among certain groups of youth in the US society (Eamon 2004; Pinkard 2005; Cooper 2006; Hargittai 2010; Rideout *et al.* 2010). To explain these differences, research has focused on two interrelated concepts: the digital divide and digital inequality. Most early researches focused on the concept of the digital divide, drawing on socio-demographic factors to explain the 'haves' versus the 'have nots' in computer ownership and Internet access (DiMaggio *et al.* 2004; van Dijk 2005; Hargittai 2008). More recently, researchers have begun to examine how initial digital divides contribute to digital inequalities in technological skills, attitudes, behaviors, and activities (DiMaggio *et al.* 2004; van Dijk 2005; Livingstone & Helsper 2007; Hargittai 2008). Digital divides in computer ownership and Internet access continue to be important primary factors; but understanding how differences in technology use contribute to social mobility requires a closer examination of digital inequalities in skills, attitudes, and uses (Hargittai 2008).

Despite the diffusion of technology across social groups, variations still exist in levels and types of technology ownership, access, and usage (Cotten & Jelenewicz 2006; Hargittai 2008, 2010; Cotten *et al.* 2009; Davison & Cotten 2009; Rideout *et al.* 2010; Smith 2010). Eamon (2004) found that white youth reported the highest levels of home computer ownership, followed by Latinos, then African-Americans. Warschauer and Matuchniak (2010) reported the mean number of computers per household for students in a California school district to be lowest among Hispanics and African-Americans. Although racial-group gaps in physical access to computers and the Internet may be shrinking, African American, Latina, and Native American individuals are still being left behind, while Asians and Whites are benefiting the most from technology due to differences in technology socialization preparation in relation to the diversity of usage contexts (Gorski 2005; Smith 2010; Warschauer & Matuchniak 2010).

Students from poor, urban areas have lower levels of technology usage than those from more affluent areas (Eamon 2004; Morse 2004; Shelley *et al.* 2004; Martin & Robinson, 2007). Existing inequalities in Internet usage among Black and Hispanic children have been linked to the availability of computing resources in the home (Cleary *et al.* 2006). These include whether there is a computer in the home and the presence of adult(s) who use the Internet at home or outside of the home. As Warschauer and Matuchniak (2010, p. 188) note, 'Influence from family members and friends can be critical in deciding whether and how to make

use of computers and the Internet'. Lee *et al.* (2009) found that for children aged 10–13, being Black or Hispanic, age, neighborhood quality, and family income to needs ratio are each associated with time spent using a computer. Minority and low-income youth are less likely to have friends and relatives who are 'sophisticated users of digital media' (Warschauer & Matuchniak 2010, p. 189). Having parents who limit children's time in particular activities was associated with less computer use among older youth (Lee *et al.* 2009).

Wilson *et al.* (2003) found that low-income people and African-American individuals at all income levels were less likely to have home computers or be connected to the Internet. African-Americans' and Hispanics' Internet access rates, particularly home broadband access, still lag behind those of Whites (Crews & Feinberg 2002; Eamon 2004; Whitacre & Mills 2007; Rideout *et al.* 2010; Smith 2010). In addition to Internet access, ethnic disparities in 'Internet connectedness' impact usage (Kim *et al.* 2007; Jung 2008). Internet connectedness reflects patterns or relationships that people have developed with the Internet based on their history of computer use and ownership and sites of Internet access, their Internet related goals, and how central the Internet is to their lives.

Age of first computer use and ownership of computers affect how youth think about and use computers. Having a computer before 10 years of age may impact whether children value computer skills and see the importance of them for their future (Ching *et al.* 2005). Livingstone and Helsper (2007) found that youth who have been online longer and use the Internet more often tend to use a wider variety of online activities, and that perceived online skills and self-efficacy correlate with a wider variety of online activities. Computer use at home may help youth acquire more sophisticated technological skills, which ultimately affects their behaviors, attitudes, and responses to computers. However, Livingstone and Helsper (2007) point out that providing home access to computers and the Internet will not overcome the disadvantage of existing in a low-socioeconomic status household in terms of breadth of Internet usage. Similarly, Gorski (2005) adds that just providing computers will not eliminate the existing patterns of inequalities in our society.

Attitudes toward using technology and computer anxiety may influence students' acceptance of new technology and how they use it (Selwyn 1997). Stanley (2003) found that psychosocial factors, such as perceptions of lack of computer ability, belief that computers are difficult to use, and computer anxiety posed significant barriers to acquiring digital literacy skills among low-income adults. Torkzadeh *et al.* (2006) found that individuals with less computer anxiety had significantly higher gains in computer and Internet self-efficacy as they matriculated through a computer course than those with higher levels of computer anxiety. They also found that computer anxiety exerts more influence than user attitudes. Students may experience greater self-confidence and reduced anxiety through access to and exposure to computers while at school (Poynton 2005). However, exposure is not a panacea for eliminating anxiety.

Computer anxiety may prove challenging for the students who use them and the educators who are integrating them into their curriculum (Chang 2005).

The ways that technology is used by others also impacts students' use of technology. Students develop specific beliefs about technology as well as patterns of use and skills as a result of the way computers are used by classroom teachers (Morse 2004). Before teachers can teach students how to use technology and integrate it into their curriculum, they must have adequate training in using the technology (Morse 2004). However, some researches suggest that even when teachers are appropriately trained, teachers in lower socioeconomic status (SES) schools will find it harder to integrate technology due to the 'complexity of their instructional environments', such as higher numbers of at-risk students, limited students' technology experience, and concerns about standardized testing (Warschauer & Matuchniak 2010, p. 191).

The Birmingham XO project provides an interesting natural experiment on the effectiveness of the XO laptop as a means to decrease digital inequality in a low-income, minority school district. Our study advances prior work by focusing on factors associated with computer usage (specifically, XO laptop usage) and attitudes toward the XO laptop among elementary school students. Although some researchers have examined computer usage in general, no one has examined XO laptop usage in the United States in a large-scale study of this type. This is also one of the few studies examining computer usage in a largely minority school system.

## Methods

The dissemination of XO laptops in Birmingham City elementary schools provided the opportunity for a natural, longitudinally designed experiment. We surveyed fourth and fifth graders at two time points, just before they received the XOs and then about 4.5 months later, to examine the factors associated with three outcomes measured in the posttest survey: (1) attitudes toward the XO laptop, measured as students' assessment of the impact of the XO on their academic achievement and XO usage, measured by (2) hours using the XO and (3) the number of XO activities used at school. This study examines the effects of a wide range of predictors including students' demographics, digital use and literacy, and students' assessment of teachers' technology usage and ability. A series of ordinary least squares (OLS) models were used to examine the effects of these predictors.

### *Sample*

There were 39 elementary schools in the Birmingham City school district, 27 of which participated in the study. Data were collected from fourth- and fifth-grade students at two different time periods. The pretest surveys (T1) were administered

about the time the XO laptops were distributed, and the posttest surveys (T2) were given three to five months following the XO dissemination. Surveying occurred between October 2008 and May 2009. Participation was voluntary, and a small incentive was provided for those electing to participate. Surveys were read aloud to students, but in a small number of cases, the surveys were self-administered. Researchers were available for students requiring assistance.

The student enrollment at participating schools was 2,915. This study had a 52 percent response rate ( $N = 1,583$ ) for the pretest survey. Students were only eligible for the posttest if they had participated in the pretest survey. A total of 1,202 student surveys were matched from both the pretest and posttest surveys. We restricted our analytic samples to cases with no missing data on our three dependent variables and independent variables. Thus, the analytic sample varied by dependent variable: XO attitude  $N = 1,075$ , missing 10.6 percent; XO hours  $N = 1,066$ , missing 11.3 percent; and XO application use  $N = 1,030$ , missing 14.3 percent. No single variable used in our analyses was missing data on more than 3.7 percent of cases.

Students in this school system are primarily African-American (>90 percent) and 82 percent of the students qualify for free/reduced price lunch. The characteristics of the analytic sample are similar to the population of Birmingham City school students.

## Outcome measures

We examined the factors associated with three outcomes measured in the posttest survey. Our first outcome variable is a scale of students' attitudes toward the XO laptop at school (Cronbach's  $\alpha = 0.730$ ). Four questions assessed whether using the XO laptops at school had a positive impact on students' academic experience (get better grades, get more out-of-class assignments, helps to learn, and get more homework completed on time). Responses for each item were coded 0 = disagree, 1 = not sure, and 2 = agree. The scale was constructed using a minimum of three items with missing values imputed to the mean for seven cases. The scale ranged from 0 to 8, with higher scores representing students' perception that the XO laptops had a positive impact upon their academic experience.

Our next two outcome variables measure two different dimensions of XO laptop usage. The first measure is an ordinal measure of hours per day using the XO, which ranges from 0 to 5 (0 = I do not use this at all, 1 = one to two hours, 2 = three to four hours, 3 = five to six hours, 4 = seven to eight hours, and 5 = more than eight hours). Our last outcome is a count variable measuring the number of 'activities' used on the XO laptop while at school. (In XO parlance, activities are the equivalent of what most would call applications.) Though there are many activities on the XO, there are a few core activities which have the greatest frequency of use. After examining our

survey data and experimenting with several scales, we arrived at a scale that consisted of five activities: write; chat; record audio, pictures, or video; memorize (a memory game); and journal. Responses for each item were recoded from the frequency of use at school (0 = never to 3 = almost every day or every day) to a binary measure of use versus non-use at school. The scale was created only for cases with no missing data on the five items ( $N = 1,142$ ), and excluded 60 cases. The scale ranged from 0 to 5, with a higher value representing a greater number of XO activities used (Cronbach's  $\alpha = 0.769$ ).

## Independent variables

### *Students' computer ability, use, and ownership*

To assess the impact of early experiences with technology, we included factors that measure students' computer ability, use, and ownership in the pretest survey prior to receiving the XO computers. Computer ability is an ordinal-level variable measured by asking students how good they are at using a computer (0 = not good at all, 1 = okay, 2 = pretty good, and 3 = very good). Hours using a computer is an ordinal-level variable that measures how many hours a day they use a computer (0 = I do not use this at all, 1 = one to two hours, 2 = three to four hours, 3 = five to six hours, 4 = seven to eight hours, and 5 = more than eight hours). Computer use was measured by two variables: computer use for entertainment and homework. Computer use for entertainment is a scale constructed from four items asking students how often they use a computer to play games on the Internet, watch videos on the Internet, listen to music on the Internet, and create and upload video to sites such as YouTube (Cronbach's  $\alpha = 0.759$ ). The ordinal-level responses (coded 0 = never, 1 = less than once a week, 2 = at least once a week, 3 = several times a week, and 4 = every day) were summed to create a scale with values ranging from 0 to 16. Higher scores represent more frequent use of computers for entertainment. The scale was created for observations with at least three of four items. Values for missing items were imputed to the mean of the other scale items in 25 cases. Computer use for homework was measured by a single item with ordinal-level responses (coded 0 = never, 1 = less than once a week, 2 = at least once a week, 3 = several times a week, and 4 = every day). Computer ownership was coded as 1 = own a computer and 0 = do not own this.

### *Students' assessment of teachers' technology ability and use*

A set of classroom-level variables measured students' assessment of teachers' ability and use of technology prior to the XO dissemination and teachers' ability and use of the XO. Teachers' ability using computers and the Internet, assessed at the pretest, was measured by students' assessment of their teacher's

ability and coded as 0 = not good at all, 1 = okay, 2 = pretty good, and 3 = very good. How much a teacher uses technology, assessed at the pretest, was measured by students' assessment of their teacher's technology use and coded as 0 = none, 1 = a little, and 2 = a lot. Two variables measured at the posttest were used to assess teachers' ability using the XO and how much teachers use the XO in class. Teachers' ability using the XO was coded as 0 = not good at all to 3 = very good. How much teacher uses the XO was coded as 0 = none, 1 = a little, and 2 = a lot.

### *Demographics*

Our models include gender (0 = male and 1 = female) and grade (0 = fourth grade and 1 = fifth grade) for each of the students. We chose not to include variables measuring age and race in the multivariate models for several reasons. First, we considered age to be too similar to grade level as a measure of physical and cognitive maturation. Second, the sample was overwhelmingly (97.5 percent) of minority racial status, predominantly African-American (84.5 percent), with few students reporting being White (1.5 percent), Hispanic (1.4 percent), American-Indian (3.3 percent), or Asian (0.84 percent). Therefore, we suspected that these variables would not add to the predictive power of our models. Preliminary analysis confirmed that age and race are not significant predictors of our outcomes, and we chose to omit them from the final models to be parsimonious. While we had measures of parents' education level, approximately 50 percent of the students reported not knowing their parents' education level during the survey.

### *Computer anxiety*

Computer anxiety was measured using two items from the affective component of Selwyn's (1997) computer attitude scale. Students were asked if they disagreed or agreed with the statements 'computers make me uncomfortable' and 'using a computer does not scare me at all' (reverse coded). Responses were recoded from the original (0 = disagree, 1 = not sure, and 2 = agree) to a binary coding (0 = disagree and not sure, 1 = agree).

## **Analytic design**

Our study focused on the factors associated with attitudes toward the XO laptop and XO usage. Our empirical model specifies that these outcomes are a function of four sets of factors: (1) students' computer ability, use, and ownership prior to receiving the XO; (2) classroom-level variables measuring students' assessment of their teacher's technology ability and use prior to receiving the XOs and

specific to the XOs; (3) students' demographics; and (4) students' computer anxiety. As noted earlier in the literature review, computing attitudes also affect usage. Thus, we included our measure of XO attitudes as a factor predicting XO use. We did not include measures of SES (i.e. parents' level of education, occupation, and household income) in our models. Although these factors are potentially important, it was noted during survey administration that many students did not know their parents' levels of education and occupation. Missing values on parents' levels of education showed that about 50 percent of the students marked 'I don't know'. Data on household income were not included in the survey, and are not available.

For each of our dependent variables (XO attitudes, hours of XO usage, and XO activities usage), we estimated a regression model adding blocks of variables that follow this general specification. Although each of the three outcome variables is a different level of measurement, the results and substantive conclusions did not differ between the use of OLS regression and other regression methods. Therefore, we present the results using OLS for all three outcome variables, as this is the most parsimonious method. We used the 'cluster' command in Stata 10 to compute robust standard errors to adjust for the non-random distribution of students, grouped by classes.

## Results

Table 1 presents descriptive statistics for all variables. The mean age of the participants was 10.4. The sample was 52.6 percent female and 84.5 percent Black. Fifth graders made up 51 percent of the sample. The XO attitude scale had a mean of 3.69 (range = 0–8, with higher scores indicating more favorable views toward XO). The mean hours of XO usage per day was 1.73. This indicates that, on average, students use the XOs closer to three to four hours per day (coded as 2) versus one to two hours per day (coded as 1). The XO activities scale had a mean of 3.97 activities.

Students' characteristics include measures of computer anxiety and computer ability, use, and ownership. Teachers' characteristics include classroom-level variables such as students' assessment of their teachers' technology ability and use. Our sample is fairly computer savvy, with a mean computer ability at the pretest of 2.4 out of 3. The means of the two computer anxiety items were both very low, suggesting low computer anxiety.

*What determines students' perceptions that the XO laptop has a positive impact on academic experiences?*

The results given in Table 2 illustrate the factors associated with XO attitudes, which measure the degree to which the XO has had a positive impact on the

**TABLE 1** Descriptives, students' matched pretest to posttest.

	N	Mean	SD	Min	Max
<i>Demographics</i>					
Female	1,202	0.526	0.500	0	1
Age	1,202	10.409	0.683	8	13.1
Black race/ethnicity	1,184	0.845	0.362	0	1
Grade 5	1,202	0.510	0.500	0	1
<i>XO attitude and use</i>					
XO attitude scale	1,195	3.690	2.422	0	8
XO hours	1,189	1.733	1.515	0	5
XO activity use scale	1,142	3.973	1.452	0	5
<i>Students' computer ability, use, and ownership</i>					
Computer ability T1	1,178	2.400	0.815	0	3
Hours using computer T1	1,153	1.512	1.383	0	5
Computer use, entertainment T1	1,193	10.549	4.414	0	16
Computer use, homework T1	1,183	2.281	1.651	0	4
Own computer T1	1,147	0.639	0.480	0	1
<i>Students' assessment of teachers' technology ability and use</i>					
How good teacher is at using computers T1	1,202	1.517	0.399	0	2
How much teacher uses technology T1	1,202	1.053	0.365	0	2
How good teacher is at using XO	1,202	1.642	0.532	0	3
How much teacher uses XO	1,202	0.394	0.277	0	1.4
<i>Students' computer anxiety</i>					
Uncomfortable with computers T1	1,185	0.053	0.224	0	1
Scared of using computers T1	1,189	0.183	0.387	0	1

academic experience of the students. Model 1 regresses students' computer ability, use, and ownership on the XO attitude scale. Model 2 adds classroom-level variables and students' assessment of their teacher's technology ability and use. Model 3 includes controls for gender and grade in school. Model 4 adds the computer anxiety items.

In Model 1, only computer use for homework (at pretest) had any effect on XO attitudes. Turning to Model 2, computer use for homework was still significant, as was students' report of teachers' XO usage. Model 3 included controls for females and grade 5; the effect of the students' use of the computer for homework increased and the effect of the students' report of teachers' use of the XO was attenuated slightly. Of the controls, only the effect of the measure of grade 5 was significantly different from zero. The results suggest that fifth graders feel significantly less positively about the XO than the fourth graders, all else being equal. Finally, Model 4 includes the measures of computer anxiety, of which, neither were significant.

*What factors are associated with XO laptop usage?*

*XO hours models.* The results from the five models are presented in Table 3. The first four models include predictors that are the same as those in the models discussed above (Table 2). The fifth model introduces the XO attitude scale as an independent variable. The rationale behind doing this is straightforward – if students feel more positively toward the XO, it is reasonable to assume that they will use it more. By including a measure of XO attitudes as a predictor, it also underscores the common belief that attitudes precede behavior change (Fazio 1990).

The items indicating computer use for entertainment and homework were positively associated with XO usage and significant in most models, but dropped from significance in Model 5. An interesting result was the significant and negative relationship between prior computer ownership and XO usage. It appears that the XO and home computers may be substitutes for students at home.

Among classroom-level factors, students' assessment of their teacher's ability of using computers was highly significant in determining the frequency of students' XO usage. However, the results indicate that classrooms in which the teacher is 'good at computers' have students who use the XO less frequently. This is an unexpected result; but may be due to the teacher being reluctant to learn a new technology, and so the students continue to use more traditional computer systems.

Student-reported teachers' usage of the XO had a positive association with students' XO usage. This suggests that if the students perceive that their teachers use the XO frequently, then they will follow suit. This is straightforward enough, given that the example of the teachers will almost certainly impact students' usage proficiency and frequency. However, teachers' use dropped from statistical significance in Model 5.

Another somewhat unexpected result was the positive and statistically significant association between students' discomfort with using computers and XO usage. One possible explanation is that students who were uncomfortable using computers previously had not had much exposure to computers. When they received the XO, they started using it more than other students who already had home computers.

Model 5 includes the XO attitude scale variable. The results show that the posttest attitudes indeed had a highly significant and positive effect on XO usage. Moreover, adding this factor nearly doubled the explanatory power of our model.

*XO activity use model.* Our last set of analyses examines the factors associated with the frequency of XO activity usage (Table 4). Among individual characteristics, prior computer usage for homework was positively associated with activity

**TABLE 2** XO attitude scale regressed on students' computer ability, use, and ownership; students' assessment of teachers' technology use and ability; demographics; and students' computer anxiety.

	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>	<i>Model 4</i>
<i>Students' computer ability, use, and ownership</i>				
Computer ability T1	0.178 (0.092)	0.170 (0.094)	0.172 (0.096)	0.169 (0.096)
Hours using computer T1	0.053 (0.059)	0.060 (0.061)	0.056 (0.059)	0.048 (0.060)
Computer use, entertainment T1	0.020 (0.017)	0.020 (0.017)	0.014 (0.017)	0.012 (0.017)
Computer use, homework T1	0.173** (0.052)	0.173*** (0.051)	0.182*** (0.051)	0.178*** (0.051)
Own computer T1	-0.019 (0.144)	-0.026 (0.150)	0.064 (0.147)	0.095 (0.148)
<i>Students' assessment of teachers' technology ability and use</i>				
How good teacher is at using computers T1		-0.167 (0.299)	-0.264 (0.317)	-0.270 (0.314)
How much teachers use technology T1		-0.254 (0.306)	-0.331 (0.298)	-0.345 (0.298)
How good teacher is at using XO		0.092 (0.216)	0.086 (0.204)	0.074 (0.201)
How much teacher uses XO		1.020** (0.386)	0.971* (0.398)	0.967* (0.396)
<i>Demographics</i>				
Female			-0.207 (0.160)	-0.219 (0.159)
Grade 5			-0.725*** (0.202)	-0.701*** (0.202)
<i>Students' computer anxiety</i>				
Uncomfortable with computers T1				0.584 (0.376)
Scared of using computers T1				0.233 (0.191)
Intercept	2.523*** (0.286)	2.515*** (0.552)	3.243*** (0.550)	3.241*** (0.545)
<i>N</i>	1075	1075	1075	1075
Adjusted $R^2$	0.020	0.032	0.054	0.056

Note: Robust standard errors in parentheses.

\* $p < 0.05$ ; \*\* $p < 0.01$ ; \*\*\* $p < 0.001$ .

**TABLE 3** XO hours regressed on students' computer ability, use, and ownership; students' assessment of teachers' technology use and ability; demographics; students' computer anxiety; and XO attitude

	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>	<i>Model 4</i>	<i>Model 5</i>
<i>Students' computer ability, use, and ownership</i>					
Computer ability T1	0.075 (0.062)	0.073 (0.062)	0.066 (0.062)	0.062 (0.062)	0.035 (0.062)
Hours using computer T1	0.079 (0.040)	0.083* (0.040)	0.081* (0.040)	0.076 (0.040)	0.070 (0.038)
Computer use, entertainment T1	0.026* (0.011)	0.024* (0.011)	0.021* (0.010)	0.019 (0.011)	0.017 (0.011)
Computer use, homework T1	0.065* (0.029)	0.067* (0.029)	0.070* (0.029)	0.067* (0.029)	0.042 (0.027)
Own computer T1	−0.355*** (0.097)	−0.350*** (0.100)	−0.306** (0.100)	−0.277** (0.096)	−0.287** (0.094)
<i>Students' assessment of teachers' technology ability and use</i>					
How good teacher is at using computers T1		−0.292 (0.158)	−0.341* (0.144)	−0.347* (0.142)	−0.308* (0.145)
How much teachers use technology T1		0.112 (0.145)	0.076 (0.143)	0.065 (0.139)	0.112 (0.125)
How good teacher is at using XO		0.192 (0.119)	0.191 (0.117)	0.178 (0.116)	0.169 (0.105)
How much teacher uses XO		0.536** (0.200)	0.515** (0.187)	0.510** (0.184)	0.362 (0.193)
<i>Demographics</i>					
Female			−0.012 (0.095)	−0.023 (0.094)	0.006 (0.090)
Grade 5			−0.401*** (0.103)	−0.383*** (0.102)	−0.279** (0.096)
<i>Students' computer anxiety</i>					
Uncomfortable with computers T1				0.629** (0.232)	0.549* (0.212)
Scared of using computers T1				0.115 (0.122)	0.083 (0.119)
<i>Students' XO attitude</i>					
XO attitude scale					0.149*** (0.023)
Intercept	1.201*** (0.167)	1.020** (0.316)	1.365*** (0.316)	1.382*** (0.307)	0.907** (0.296)
<i>N</i>	1066	1066	1066	1066	1066
Adjusted <i>R</i> <sup>2</sup>	0.028	0.048	0.064	0.072	0.127

Note: Robust standard errors in parentheses.

\**p* < 0.05; \*\**p* < 0.01; \*\*\**p* < 0.001.

**TABLE 4** XO activities regressed on students' computer ability, use, and ownership; students' assessment of teachers' technology use and ability; demographics; students' computer anxiety; and XO attitude.

	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>	<i>Model 4</i>	<i>Model 5</i>
<i>Students' computer ability, use and ownership</i>					
Computer ability T1	0.110 (0.058)	0.100 (0.060)	0.093 (0.060)	0.093 (0.060)	0.081 (0.061)
Hours using computer T1	0.018 (0.032)	0.026 (0.032)	0.025 (0.032)	0.026 (0.032)	0.022 (0.032)
Computer use, entertainment T1	-0.012 (0.011)	-0.013 (0.010)	-0.013 (0.010)	-0.013 (0.010)	-0.014 (0.010)
Computer use, homework T1	0.130** (0.039)	0.130*** (0.033)	0.129*** (0.033)	0.130*** (0.033)	0.112** (0.034)
Own computer T1	0.107 (0.106)	0.120 (0.097)	0.124 (0.093)	0.124 (0.092)	0.120 (0.092)
<i>Students' assessment of teachers' technology ability and use</i>					
How good teacher is at using computers T1		-0.001 (0.178)	-0.008 (0.178)	-0.008 (0.178)	0.020 (0.174)
How much teachers use technology T1		-0.214 (0.343)	-0.214 (0.339)	-0.214 (0.340)	-0.188 (0.333)
How good teacher is at using XO		0.023 (0.171)	0.026 (0.173)	0.026 (0.174)	0.023 (0.170)
How much teacher uses XO		1.151*** (0.328)	1.151*** (0.329)	1.151*** (0.330)	1.069*** (0.311)
<i>Demographics</i>					
Female			0.084 (0.110)	0.084 (0.110)	0.103 (0.107)
Grade 5			-0.082 (0.159)	-0.082 (0.161)	-0.019 (0.156)
<i>Students' computer anxiety</i>					
Uncomfortable with computers T1				-0.009 (0.171)	-0.063 (0.172)
Scared of using computers T1				-0.003 (0.124)	-0.022 (0.118)
<i>Students' XO attitude</i>					
XO attitude scale					0.088*** (0.024)

*Continued*

**TABLE 4** Continued

	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>	<i>Model 4</i>	<i>Model 5</i>
Intercept	3.412*** (0.240)	3.179*** (0.511)	3.196*** (0.476)	3.196*** (0.477)	2.896*** (0.479)
<i>N</i>	1030	1030	1030	1030	1030
Adjusted <i>R</i> <sup>2</sup>	0.021	0.067	0.066	0.064	0.084

Note: Robust standard errors in parentheses.

\**p* < 0.05; \*\**p* < 0.01; \*\*\**p* < 0.001.

usage across all specifications. This may suggest that children who are more familiar with using computers for educational purposes have a broader range of abilities when it comes to using a variety of activities.

Among classroom-level factors, students' assessment of the frequency with which teachers use the XO in the classroom was the only significant factor. This could indicate that more in-class usage by teachers creates a greater familiarity with the range of XO activities. Our posttest measure of XO attitudes was also significant, suggesting that a positive educational experience with the XO is associated with wider activity usage.

### Summary and discussion

The results presented here are from the largest study examining XO laptops in the United States, a study of a low-income, minority school district-wide dissemination of XO laptops. Our models showed some patterns of divergence and convergence in terms of factors associated with hours of XO usage, frequency of XO activity usage, and positive attitudes about the impact of XO laptops on students' academic experience.

Across almost all models, only two factors were consistent predictors. First, computer usage for homework (at the pretest) was a fairly consistent factor, though it did become non-significant in some of the fuller models. This suggests that students with more experience using computers in academic pursuits used more of the XO activities, and had more positive attitudes toward the XO impact on their education. Second, students' assessment of their teachers' XO usage also had an almost unanimously significant and positive effect on XO attitudes, usage, and activity use. In classes where students reported that XOs were used with greater frequency by teachers, there was an increase in usage and familiarity with the XOs by the students.

From a policy perspective, these results have some important implications. In particular, our models show that the frequency with which students perceive that teachers use XOs in the classroom has a significant impact on XO usage and

students' perceived XO educational impacts. This suggests that measures to improve teachers' knowledge and ability of employing the XO in the classroom would likely improve students' experiences with this technology. This conclusion is echoed by others who noted that effective implementation of laptops in the classroom requires revising curricula, training, and technical support for teachers and staff (Gibbs *et al.* 2009; Zucker & Light 2009). Gibbs *et al.* (2009) found that teachers who attended training workshops rated themselves as having higher ability of using technology applications and greater ability of working with general technology. They were also more likely to use computers more frequently in the classroom and to integrate technology into classroom lessons. Students' increase in technology use was associated with students' perception of teachers' skill increase and usage.

Having more than a basic understanding of computers, knowing how to implement technology appropriate to the students and ongoing teachers' professional development is crucial for providing students with the technological skills that they need (Swain & Pearson 2003; Gorski 2005; Judge *et al.* 2006; Valadez & Duran 2007; Gibbs *et al.* 2009). As Natriello (2001) pointed out 10 years ago, having technology without proper training, funding, and associated equipment may adversely affect the overall effort to introduce the technology into the educational system. Additionally, adoption efforts may be impacted by 'geo-ethnicity' and connectedness (Kim *et al.* 2007; Jung 2008). The incorporation of new technology into minority communities may be challenged by individual and group attitudes toward and interactions with technology as well as structural factors of the environment in which they live.

This research is not without some important limitations. First, many of our measures are based upon self-reporting by fourth- and fifth-grade students and are subject to measurement errors and other potential biases. Examples include our dependent variable measures (XO usage and activity frequency) and students' perceptions of teachers' usage and ability. In future work, we would like to obtain some objective measures in addition to self-reported ones to attenuate possible self-reporting bias. Second, the time between the pretest and posttest was, on average, only about 4.5 months. Though some effects might begin to emerge over such a short time, it is likely that they would be larger if the interval between pretest and posttest was longer. For example, Suhr *et al.* (2010) found that positive effects for a 1-to-1 program did not show up until year 2 of the program. Future work would benefit from a longer time interval between the pretest and posttest. Third, our study focuses on the XO laptop specifically. This is both a strength and a limitation. It is a strength because our work extends the 1-to-1 literature to the specific effects of the XO laptop. But it also poses a limitation in terms of external validity. That is, because of the XO's uniqueness, it may be unwise to draw direct inference from our results to other 1-to-1 researches studying windows-based PCs, for example. Finally, we do not have adequate data to measure parental

education, income, and occupation, or other family and parental variables. Even though all the schools in the school system have high levels of students receiving free or reduced price lunch, an indicator of poverty, there is likely important variation in these factors that may impact students' access to, usage of, and attitudes toward XO laptops and other technologies more generally. As others have reported, families that have higher incomes may be able to acquire new technology and related media that may be more appealing to youth (Lee *et al.* 2009), which might potentially affect XO usage and attitudes.

In sum, our results illustrate that a fairly narrow range of factors affect whether students use and how they perceive computers in this 1-to-1 OLPC computing initiative. This research illustrates the importance of teachers' preparation and usage of the XO laptop in the classroom. From a policy perspective, our findings are consistent with calls for better integration of computers into the curriculum and adequate training for teachers to make use of them. It is our hope that our work will inform future 1-to-1 computing initiatives in other urban school districts so that these initiatives will succeed in decreasing digital inequalities.

## Acknowledgements

This research was supported by a grant from the National Science Foundation (DRL-0819063; Shelia Cotten, PI). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

## References

- Apple Computer (2007) *Research on 1 to 1 Learning Programs, A Review*, Apple Computer, Cupertino, CA, [Online] Available at: <http://images.apple.com/ca/education/k12/onetoone/pdf/ResearchLearningPrograms.pdf> (3 January 2008).
- Chang, S. E. (2005) 'Computer anxiety and perception of task complexity in learning programming-related skills', *Computers in Human Behavior*, vol. 21, no. 5, pp. 713–728.
- Ching, C. C., Basham, J. D. & Jang, E. (2005) 'The legacy of the digital divide: gender, socioeconomic status, and early exposure as predictors of full-spectrum technology use among young adults', *Urban Education*, vol. 40, no. 4, pp. 394–411.
- Cleary, P. F., Pierce, G. & Trauth, E. M. (2006) 'Closing the digital divide: understanding racial, ethnic, social class, gender and geographic disparities in Internet use among school age children in the United States', *Universal Access in the Information Society*, vol. 4, no. 4, pp. 354–373.
- Cooper, J. (2006) 'The digital divide: the special case of gender', *Journal of Computer Assisted Learning*, vol. 22, no. 5, pp. 320–334.

- Cotten, S. R. & Jelenewicz, S. M. (2006) 'A disappearing digital divide among college students? Peeling away the layers of the digital divide', *Social Science Computer Review*, vol. 24, no. 4, pp. 497–506.
- Cotten, S. R., Anderson, W. & Tufekci, Z. (2009) 'Old wine in a new technology or a different type of digital divide?' *New Media & Society*, vol. 11, no. 7, pp. 1163–1186.
- Crews, M. & Feinberg, M. (2002) 'Perceptions of university students regarding the digital divide', *Social Science Computer Review*, vol. 20, no. 2, pp. 116–123.
- Davison, E. L. & Cotten, S. R. (2009) 'Connection disparities: the importance of broadband connection in understanding today's digital divide', in *Handbook of Research on Overcoming Digital Divides: Constructing an Equitable and Competitive Information Society*, eds E. Ferro, Y. Dwivedi, J. Gil-Garcia & M. D. Williams, Information Science Reference, Hershey, PA, pp. 346–358.
- van Dijk, J. A. G. M. (2005) *The Deepening Divide: Inequality in the Information Society*, Sage Publications, Inc, Thousand Oaks, CA.
- Dimaggio, P., Hargittai, E., Celeste, C. & Shafer, S. (2004) 'Digital inequality: from unequal access to differentiated use', in *Social Inequality*, ed. K. M. Neckerman, Russell Sage Foundation, New York, pp. 355–400.
- Eamon, M. K. (2004) 'Digital divide in computer access and use between poor and non-poor youth', *Journal of Sociology and Social Welfare*, vol. 31, no. 2, pp. 91–112.
- Fazio, R. H. (1990) 'Multiple process by which attitudes guide behavior: the mode model as an integrative framework', in *Advances in Experimental Social Psychology*, ed. M. P. Zanna, Academic Press, San Diego, CA, pp. 75–110.
- Gibbs, M. G., Dosen, A. J. & Guerrero, R. B. (2009) 'Bridging the digital divide: changing the technological landscape of inner-city Catholic schools', *Urban Education*, vol. 44, no. 1, pp. 11–29.
- Gorski, P. (2005) 'Education equity and the digital divide', *Association for the Advancement of Computing in Education Journal*, vol. 13, no. 1, pp. 3–45.
- Gulek, J. C. & Demirtas, H. (2005) 'Learning with technology: the impact of laptop use on student achievement', *The Journal of Technology, Learning, and Assessment*, vol. 3, no. 2, pp. 1–39.
- Hargittai, E. (2008) 'The digital reproduction of inequality', in *Social Stratification*, ed. D. Grusky, Westview Press, Boulder, CO, pp. 936–944.
- Hargittai, E. (2010) 'Digital na(t)ives? Variation in internet skills and uses among members of the "net generation"', *Sociological Inquiry*, vol. 80, no. 1, pp. 92–113.
- Judge, S., Puckett, K. & Bell, S. M. (2006) 'Closing the digital divide: update from the early childhood longitudinal study', *The Journal of Educational Research*, vol. 100, no. 1, pp. 52–60.
- Jung, J.-Y. (2008) 'Internet connectedness and its social origins: an ecological approach to postaccess digital divides', *Communication Studies*, vol. 59, no. 4, pp. 322–339.

- Kim, Y.-C., Jung, J.-Y. & Ball-Rokeach, S. J. (2007) 'Ethnicity, place, and communication technology: effects of ethnicity on multi-dimensional internet connectedness', *Information Technology and People*, vol. 20, no. 3, pp. 282–303.
- Lee, S.-J., Bartolic, S. & Vandewater, E. A. (2009) 'Predicting children's media use in the USA: differences in cross-sectional and longitudinal analysis', *British Journal of Developmental Psychology*, vol. 27, no. 1, pp. 123–143.
- Lemke, C. & Martin, C. (2003) *One-to-One Computing in Maine, A State Profile*, National Science Foundation Policy Report, Metiri Group, Culver City, CA, [Online] Available at: <http://www.metiri.com/NSF-Study/ME-Profile.pdf#search=%22A%20State%20Profile%20One-to-One%20Computing%20in%20Maine%20December%2015%2C%202003%22.pdf> (13 September 2010).
- Livingstone, S. & Helsper, E. (2007) 'Gradations in digital inclusion: children, young people, and the digital divide', *New Media & Society*, vol. 9, no. 4, pp. 671–696.
- Martin, S. & Robinson, J. (2007) 'The income digital divide: trends and predictions for levels of Internet use', *Social Problems*, vol. 54, no. 1, pp. 1–22.
- Morse, T. E. (2004) 'Ensuring equality of educational opportunity in the digital age', *Education and Urban Society*, vol. 36, no. 3, pp. 266–279.
- Natriello, G. (2001) 'Bridging the second digital divide: what can sociologists of education contribute?', *Sociology of Education*, vol. 74, no. 3, pp. 260–265.
- Palfrey, J. & Gasser, U. (2008) *Born Digital: Understanding the First Generation of Digital Natives*, Basic Books, New York.
- Pinkard, N. (2005) 'How the perceived masculinity and/or femininity of software applications influence students' software preferences', *Journal of Educational Computing Research*, vol. 32, no. 1, pp. 57–78.
- Poynton, T. (2005) 'Computer literacy across the lifespan: a review with implications for educators', *Computers in Human Behavior*, vol. 21, no. 6, pp. 861–872.
- Rideout, V., Foehr, U. G. & Roberts, D. F. (2010) *Generation M2, Media in the Lives of 8- to 18-Year Olds*, Kaiser Family Foundation, Menlo Park, CA, [Online] Available at: [www.kff.org/entmedia/upload/8010.pdf](http://www.kff.org/entmedia/upload/8010.pdf) (30 January 2010).
- Selwyn, N. (1997) 'Students' attitudes toward computers: validation of a computer attitude scale for 16-19 education', *Computers & Education*, vol. 28, no. 1, pp. 35–41.
- Shelley, M., Thrane, L., Shulman, S., Lang, E., Beisser, S., Larson, T. & Mutiti, J. (2004) 'Digital citizenship – parameters of the digital divide', *Social Science Computer Review*, vol. 22, no. 2, pp. 256–269.
- Silvernail, D. L. & Lane, D. M. (2004) *The Impact of Maine's One to One Laptop Program on Middle School Teachers and Students*, Maine Education Policy Research Institute, Portland, ME, [Online] Available at: <http://www.usm.maine.edu/cepare/pdf/mlti/MLTI%20One%20Evaluation%20Report%201.pdf> (10 May 2005).
- Smith, A. (ed.) (2010) 'Technology trends among people of color', *Pew Internet & American Life Project*, Commentary, [Online] Available at: <http://pewinternet.org/Commentary/2010/September/Technology-Trends-Among-People-of-Color.aspx> (11 January 2011).

- Stanley, L. D. (2003) 'Beyond access: psychosocial barriers to computer literacy', *The Information Society*, vol. 19, no. 5, pp. 407–416.
- Suhr, K. A., Hernandez, D. A., Grimes, D. & Warschauer, M. (2010) 'Laptops and fourth-grade literacy: assisting the jump over the fourth-grade slump', *Journal of Technology, Learning, and Assessment*, vol. 9, no. 5, [Online] Available at: <http://www.jtla.org> (11 January 2011).
- Swain, C. & Pearson, T. (2003) 'Educators and technology standards: influencing the digital divide', *Journal of Research and Technology in Education*, vol. 34, no. 3, pp. 326–335.
- The Metiri Group (2006) *1 to 1 Learning, A Review and Analysis by the Metiri Group*, Culver City, CA, [Online] Available at: [http://images.apple.com/education/k12/onetoone/pdf/1\\_to\\_1\\_white\\_paper.pdf](http://images.apple.com/education/k12/onetoone/pdf/1_to_1_white_paper.pdf) (3 January 2008).
- Torkzadeh, G., Chang, J. C. & Demirhan, D. (2006) 'A contingency model of computer and Internet self-efficacy', *Information and Management*, vol. 43, no. 4, pp. 541–550.
- Valadez, J. R. & Duran, R. (2007) 'Redefining the digital divide: beyond access to computers and the internet', *The High School Journal*, vol. 90, no. 3, pp. 31–44.
- Warschauer, M. & Matuchniak, T. (2010) 'New technology and digital worlds: analyzing evidence of equity in access, use, and outcomes', *Review of Research in Education*, vol. 34, no. 1, pp. 179–225.
- Whitacre, B. E. & Mills, B. F. (2007) 'Infrastructure and the rural-urban divide in high-speed residential Internet access', *International Regional Science Review*, vol. 30, no. 3, pp. 249–273.
- Wilson, K. R., Wallin, J. S. & Reiser, C. (2003) 'Social stratification and the digital divide', *Social Science Computer Review*, vol. 21, no. 2, pp. 133–143.
- Zucker, A. A. & Light, D. (2009) 'Laptop programs for students', *Science*, vol. 323, no. 5919, pp. 82–85.

---

**Shelia R. Cotten** is Associate Professor of Sociology at the University of Alabama at Birmingham. Her research examines technology use across the life course and the social, educational, and health impacts of this usage. Her work has been funded by the National Science Foundation and the National Institutes of Health. *Address:* Department of Sociology, University of Alabama – Birmingham, HHB 460, 1530 3rd Avenue South, Birmingham, AL 35294, USA. [email: [cotten@uab.edu](mailto:cotten@uab.edu)]

**Timothy M. Hale** is a doctoral student in the Department of Sociology at the University of Alabama at Birmingham. His work examines the impact of information and communication technology (ICT) on physical health and mental well-being. He is currently studying the relationship between offline health lifestyles and online health activities. *Address:* Department of Sociology, University of Alabama – Birmingham, Birmingham, AL, USA. [email: [timhale@uab.edu](mailto:timhale@uab.edu)]

**Michael Howell Moroney** is Associate Professor of Public Administration and Director of Graduate Studies in Public Administration at the University of Alabama at Birmingham. His research interests include urban policy, equity issues related to technology and child welfare policy. *Address:* Department of Government, University of Alabama – Birmingham, Birmingham, AL, USA. [email: mhowellm@uab.edu]

**LaToya O'Neal** is a PhD student in Medical Sociology at the University of Alabama at Birmingham. Her research interests include human ecology, social stratification, and mental health. *Address:* Department of Sociology, University of Alabama – Birmingham, Birmingham, AL, USA. [email: ljoneal@uab.edu]

**Casey Borch** is Assistant Professor of Sociology at the University of Alabama at Birmingham. His recent work examines patterns of exchange in economic exchange networks, the effects of military spending on social welfare, and the self-segregation of adolescent social networks. *Address:* Department of Sociology, University of Alabama – Birmingham, Birmingham, AL, USA. [email: caborch@uab.edu]

---