Research Article

Following Along or Falling Behind? An Analysis of Internet Access During Lab-Based University Classes

Timothy Delbridge[a], and Xiaowei Cai[a]
[a]*California Polytechnic State University*

JEL Codes: A2
Keywords: Computer labs, distraction, undergraduate teaching

Abstract
Most undergraduate programs in agribusiness and applied economics include courses on data analysis, spreadsheet modeling, and other topics that are inherently computer-based. It is typical in these courses for students to have access to computers either during lecture or in lab sessions. In fact, students in some agribusiness and applied economics programs may spend a majority of their total in-class time with access to their own laptop or a desktop computer in a university lab. In this context it becomes crucially important for educators to understand how students consume and interact with course materials, including spoken lectures, while they simultaneously engage with technology. Previous research on the use of computers in the classroom show that there exists the potential for technology access to help students follow along and strengthen their understanding of course concepts during a lecture, but also that there is a risk that students are distracted by the available technology and end up falling behind. This study analyzes the effect of restricted internet access during lab-based class meetings on student learning outcomes, and provides guidance on instructor policies around technology use in the classroom.

1 Introduction

University instructors that teach in computer labs with fixed computers for student use are often unsure how to manage student computer access. The tradeoffs center around a desire to maximize student engagement with the instructor and material being presented, while avoiding restrictions that reduce student ability to follow along, take digital notes, and practice with their own machines. The instructor's computer management decision in a classroom with fixed computers is different than the issue faced regarding laptops in a typical lecture hall, as even students that do not typically use laptops to take notes have a potentially distracting screen at their desk. Some instructors choose to restrict all computer access, shutting down lab computers during lecture portions of the class, and prohibiting the use of student laptops and cell phones to prevent students from texting, emailing, web surfing, or conducting any noncourse-related activities. Other instructors take a more hands-off approach and do not limit technology access in anyway. Despite a robust literature on the use of laptops during lecture-based classes, and their impact on student performance, it is not clear which instructional approach results in the better student learning outcomes in computer lab settings with fixed student computers.

Several previous studies have explored the relationships between internet access (and computer access more broadly), distractedness, and educational outcomes. Downs et al. (2015) found, in a controlled experimental setting, that when distracted by social media sites, students performed worse on a multiple-choice exam. Similarly, Sana, Weston, and Cepeda (2013) found that multitasking on personal laptops during lectures resulted in lower test scores for the multitasking individuals, but also for those students that were sitting nearby the multitasking peers. However, not all research in this area has found internet access to be detrimental to student learning outcomes. Elliott-Dorans (2018) randomly assigned students to different sections of a large lecture course, and implemented a laptop ban in half of the sections and allowed unrestricted computer use in the other half. The author found no difference in

student grade outcomes and no difference in student satisfaction as expressed on course evaluations. Despite these mixed findings, it remains unclear under which conditions the potentially detrimental distraction effects could outweigh the potentially productive uses of student computers.

In contrast to other studies that have focused on personal laptop use in the classroom or lecture hall, the present study explores whether restriction of student access to fixed lab computers during lectures improves or detracts from student learning outcomes. Using the lab management software on the instructor computer, we carry out an experiment over multiple course terms in which some course sections are granted unrestricted access to internet browsing, while others are only permitted to access relevant software and the course website. We collect student performance data, in the form of exam scores and overall course grades, in six course sections of an introductory agricultural finance course and estimate the relationship between this experimental treatment and course outcomes. We also discuss the impact of restricted web access on student comments and course ratings in end-of-term course evaluations.

This paper adds to this literature by exploring whether and how student internet access impacts student performance and satisfaction in an agricultural finance course that meets in a computer lab. Previous studies have focused primarily on the use of student-owned laptops during lecture-based courses, but it is not clear that these findings generalize to internet access in a computer lab with computer management software. As a greater number of courses in agribusiness curricula incorporate data literacy and hands-on practice during class meetings, it might be the case that more flexible policies around computer use are more helpful than harmful for student learning outcomes. This study contributes an additional point of reference that may be more useful for instructors that teach in computer labs, and more relevant for courses in which computer use is a normal and necessary component.

2 Background

Over the past twenty years, as the use of computers in university classrooms has gone from exceptional to typical, there have been many studies that have explored the ways in which computers have altered the classroom learning ecosystem. The major focus of this work has been on the ways in which access to computers has impacted student performance and how students perceive the use of technology for learning and its impact on the learning environment.

2.1 Student Performance

Since laptop computers were first introduced to university classrooms, instructors have been concerned with whether these tools were helping or hindering student learning. In a relatively early study, Hembrooke and Gay (2003) found that the retention of material presented decreased when students were able to keep laptops open during a lecture, and that this result did not depend on the way in which the student used the computer (i.e., productive vs. distractive use). Furthermore, Kraushaar and Novak (2006) examined laptop use in a lecture-style classroom with spyware installed on student computers and found a negative relationship between distractive use of the computers and academic performance. A more recent study by Zhang (2015) also showed that the use of laptop during lecture time negatively impacted student course grades.

Not all studies have found that computer access has detrimental effects on student performance in classrooms. Wurst, Smarkola, and Gaffney (2008) found that business school cohorts with access to laptops did not perform any differently (in terms of GPA) than the cohorts that were not provided laptops. In a study of the efficacy of laptop bans in an introductory politics lecture, Elliott-Dorans (2018) found that performance on both exams and writing assignments was worse than when laptop use was permitted.

2.2 Students' Perceptions and Impact on Learning Environment

Studies have come to different conclusions about the ways in which students themselves feel about access to computers in the classroom. Several authors have found that students are keenly aware that their access to technology is a distraction that is not always productive. Fried (2008) showed, in a study in which student views on classroom environment were elicited, that both one's own computer use and the computer use of nearby students were seen as detriments to a student's ability to learn the material. Vahedi, Zannella, and Want (2019) found that although a majority of students acknowledged that their own use of technology distracted them from the course material, and nearly half of students reported that use of technology by nearby students was distracting, a large majority of students were against any restriction of computer use in the classroom.

Studies that include analysis of course evaluations have not found that computer access policies have much effect on end-of-term course evaluations or other modes of assessing student satisfaction. In addition to their analysis of academic performance, Wurst et al. (2008) discovered that students that were given laptops for use in their undergraduate business program found them useful and productive tools for communication, but did not rank their overall education experience higher than those that did not have access to laptops. Similarly, Elliott-Dorans (2018) concluded that while students may prefer to have access to laptops during lecture, they did not rate courses or instructors lower on course evaluations when they were prohibited from using them.

While making decisions about technology use in the classroom, instructors are often left to speculate on the applicability of past studies to their specific teaching assignment and student cohorts. For example, there may be different considerations in an agribusiness or business program than in lectures focused on liberal arts or humanities, as much of the material in modern agribusiness curriculum is engaged with electronically. These are often practical rather than theoretical courses, and the balance between productive and distractive use may not be consistent with previous studies on laptops in different subject areas. That is, in reviewing existing literature on computer use in university classrooms, we should keep in mind that the interaction between the mode of instruction and the course topic may fundamentally alter the dynamics around technology use.

3 Methods

Over the course of three academic quarters, data on student performance were collected in a total of six sections of an introductory agricultural finance class. The course was taught in a computer lab with either 28 or 40 student computers. In each 10-week quarter, two sections were taught by the same instructor, with identical materials, lectures, and in-class activities. Students in one section each quarter had open access to all websites on the lab computers, while the students in the treatment section were restricted from visiting websites other than the university's website and course management (i.e., Moodle) page. Background information on the students in all course sections was gathered through their university profile, including GPA prior to enrollment in the course, academic progress (i.e., number of course units completed), chosen major, and the level of prerequisite accounting course that had been completed. Descriptive statistics of student information is included in table 1.

Table 1 shows that a total of 76 students were enrolled in the treatment sections and 110 in the control sections. The Fall 2018 and Fall 2019 groups had a lower percentage of female students, higher degree progress percentages, and lower average GPAs than the Winter 2019 group. This can be attributed to the fact that the Winter 2019 sections are restricted mostly to students majoring in agribusiness and tend to take the course earlier in their undergraduate careers so that they can proceed to more advanced finance and management courses. The fall sections are made up of students primarily in other majors within the College of Agriculture, Food, and Environmental Sciences. These students do not typically concentrate in finance or advance to more complex business management courses.

Table 1. Descriptive Statistics for Students in Treatment (i.e., Restricted Web Access) and Control (i.e., Unrestricted Web Access) Groups

Characteristic	Fall 2018		Winter 2019		Fall 2019	
	Treatment	Control	Treatment	Control	Treatment	Control
Number of students	27	40	21	35	28	35
Gender (female = 1)	0.48	0.40	0.62	0.51	0.32	0.49
Degree progress (%)	64%	65%	55%	52%	68%	81%
GPA prior to course	2.60	2.86	3.07	3.04	2.82	2.89
Exam avg. (max = 1)	0.80	0.80	0.89	0.87	0.77	0.80
Final grade (max = 1)	0.79	0.84	0.72	0.73	0.82	0.84

3.1 Controlling Internet Access

The course in question covers finance principles including analysis of financial statements, time value of money, the relationships between risk, return, and diversification, and capital budgeting techniques. In typical class meetings, new content is presented in a lecture format, with examples or calculations projected by the instructor from their computer or demonstrated on the white board. The second half of the class meeting is typically devoted to an in-class activity in which the students use their computers to practice the new concepts and techniques, usually using Microsoft Excel. The distinction between the internet-restricted treatment group and the control group is primarily in the lecture portion of the class meeting. CrossTec SchoolVue computer lab management software, which can remotely control the lab computers, is used to restrict browser access to approved websites for the treatment group.

3.2 Performance Metrics and Model

The goal of this study is to analyze the relationship between students' internet access and their learning outcomes and satisfaction with the course. We measure learning outcomes using the average exam score and final course grade. We estimate the impact of the no-internet treatment using a simple linear regression model (OLS), in which performance is a function of the student's assignment to treatment or control, along with the students' previous success (i.e., GPA), degree progress, grade in accounting (pre-requisite course), and binary variables for course instructor.

We estimate the OLS models using two different measures of student learning outcomes. First, we use the total course grade, as a percentage of the total number of points possible. We also estimate the same models with the performance metric as the average of two exam scores, where the score is the percentage of total points possible on each exam. This measure ignores any homework or other grades in the course. We estimate models with both measures of performance because it might be the case that the exams are a more accurate reflection of learning than total course grades, or that restricted web access has an impact on retention but not on ability to complete homework assignments in an untimed setting.

A linear model risks generating biased coefficient estimates if the data set is censored. Data censoring could happen in the context of student performance, using either overall course grades or exam score averages as a dependent variable, if the true performance of students at either the top or bottom of the distribution is obscured by the limits of the grading scale. For example, if there is a cluster of students that all achieve perfect scores on their exams, the grade data do not reflect how well the best of these students would have scored if the exams were more difficult or there were more points possible. In this study, data censoring is not a concern because there were no students that achieved perfect exam scores or perfect overall course averages.

3.3 Student Satisfaction

In addition to student performance on course assessments, we compare the outcomes of voluntary course evaluations for treatment and control sections of this course to assess whether or not the

restriction of internet access to lab computers was considered offensive or annoying by students in the class. This is often a key faculty concern with more restrictive computer management strategies, particularly among untenured and adjunct faculty. With only 6 course sections (3 treatments and 3 controls), we do not attempt to identify statistical relationships between experimental treatment and evaluation outcomes. Instead, we compare scores informally and search for written comments that address the computer restrictions in either a positive or negative light.

4 Results

Our regression results for the four estimated models are presented in table 2. The variable of interest, which takes the value of 1 if students had unrestricted access to the internet on lab computers, is not found to have a significant effect on student performance in any model. Unsurprisingly, a student's prior success, in terms of GPA before enrolling in the course in question, has a strong and statistically significant impact on exam and final course grades. Two independent variables indicating the strength of a student's accounting preparation and the percentage of their course program that had been completed at the start of the course are not found to impact the performance metrics. These variables are removed from models 2 and 4. The course instructor also appears to have a strong impact on student scores, likely because of differences in grading habits. Comparing models 1 and 2 to models 3 and 4 suggests that one instructor tends to award lower course grades and higher exam grades than the other instructor. It should be noted that it is not clear whether either of these performance metrics more accurately measures student learning of the finance concepts presented in the course.

Although it appears that granting full student access to the internet during class lectures has no net-effect on exam or overall course scores, it might still be the case that the policy of restricting internet access reduces student satisfaction in the course or instructor. Although student satisfaction is not necessarily reflective of learning, it can be an important consideration, particularly for untenured faculty

Table 2. Estimates from the OLS Models of Student Performance Measures

	Final Course Score				Exam Average (%)			
Independent Variables	**Model 1**		**Model 2**		**Model 3**		**Model 4**	
Web access	0.012		0.012		-0.011		-0.009	
	(0.96)		(0.97)		(-0.91)		(-0.73)	
GPA	0.113	***	0.112	***	0.096	***	0.099	***
	(7.12)		(7.26)		(7.40)		(7.99)	
Gender (female = 1)	-0.027	*	-0.028	*	-0.036	**	-0.034	**
	(-2.17)		(-2.22)		(-3.13)		(-2.93)	
Financial accounting	0.003				0.016			
	(0.24)				(0.94)			
Degree progress percent	-0.021				0.015			
	(-0.54)				(0.36)			
Instructor binary	-0.128	***	-0.124	***	0.061	***	0.064	***
	(-8.08)		(-8.39)		(4.08)		(5.51)	
Constant	0.524	***	0.516	***	0.527	***	0.535	***
	(11.2)		(11.9)		(13.8)		(15.5)	
N	184		184		184		184	
Adjusted R-squared	0.411		0.416		0.324		0.326	

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; *t* statistics are in parentheses; *p* values were calculated using the heteroskedasticity-robust standard errors.

that are often assessed based on student course evaluations. An analysis of course evaluations for these six course sections shows that there is no evidence that students are bothered by restrictions to their computer usage during lectures. No students in any of the treatment sections commented on being frustrated that they could not search for complementary material as the lecture was proceeding, or expressed that they felt overly controlled by the restrictive web access policy. Nobody in the control sections commented on distraction caused by off-topic use of computers by those nearby. The numerical ratings for the course and instructor were higher for the treatment section in two of the three course terms for which data was collected. While this is far too few observations for any statistical claims at the section level, it does not appear that faculty face much risk of alienating students by restricting internet access in this course format.

5 Conclusions

Although there has been significant research focused on the impacts of computer access in university classrooms, much of this work has been specific to a particular content area or classroom format. Many instructors still struggle with the best way to manage their classrooms with respect to student access to computers and internet connection. This study explores this issue in an agricultural finance course that meets in relatively small groups in a computer lab setting. We conduct an experiment in which two sections of the same course are taught in a single term by the same instructor. Results indicate that student internet access has no discernable net impact on the exam scores or course grades that the students earn. Furthermore, students make no mention of the restrictions in course evaluations and rate overall class quality similarly as the control group. The general recommendation based on these results is that faculty should think twice before spending valuable time or mental energy in restricting student access to fixed computers in a lab setting, at least if the goal of such restriction is to improve student learning outcomes or satisfaction with the course.

There are a couple of issues to keep in mind when interpreting the results of this analysis. First, literature on student access to computers in the classroom has found both positive and negative effects on student performance measures. In some cases, technology access serves a productive role and allows students to either practice in real time or supplement the instructor-provided material with additional contextual information. Perhaps more frequently, technology access acts as a distraction from course content and may detract from student learning outcomes. It is not clear if the results from this experiment indicate that these effects offset one another, or if neither is significant in this context. A study that more carefully monitors how students use their computers in these computer lab–based courses is necessary to learn more about the underlying drivers of these results.

Second, in this experiment, the instructors restricted access to the internet using computer lab management software in which student computers can be controlled remotely. Students are likely aware that their computers are not as private as their laptops or phones would be, and may behave differently than they would with laptops in a lecture hall. Instructors in these computer labs do not actively monitor what students are doing on their computers during a lecture, but the students may not know this. We acknowledge that the results of this study are less relevant for different classroom formats, but this point highlights a key risk with moving to a “bring-your-own-computer” system that some universities are considering.

Third, the lack of statistical association between internet access and student performance in our models could be attributed to the fact what we don’t have an accurate measurement of student’s attention level. Farley, Risco, and Kingston (2013) indicated that college students’ minds wander frequently during lectures regardless of computer use. The frequency of mind wandering could largely depend on individual student’s learning motivation and self-regulation (May and Elder 2018; Zhang 2015). This could partially explain why students’ GPAs prior to taking the agricultural finance course have a significantly positive impact on their exam grade and overall course grade in the course. Future research focused on tracking the time students actually spend on task in the control and treatment

groups could help instructors better understand the impact of computer/internet use on student attentiveness during lectures and its relationship with subsequent learning outcomes.

Fourth, we make no attempt to formally analyze the more subjective considerations that may lead instructors to choose different technology policies. Some instructors may find that classroom policies requiring that computers be locked or turned off results in more attentive and engaged students, even if this is not reflected in student scores or success on assessments. Others may decide that the hassle of managing student computers or restricting use is not worth the potential benefits in classroom environment. A more robust study design that elicits student opinions on these specific issues would be helpful for instructors that are weighing these issues.

Finally, the culture of a classroom, program, and university can have significant impacts on the way that students interact with technology during lectures. In some classes, the student use of technology for distractive purposes may be excessive and cause serious difficulty for instructors. Other classes or departments may not have a culture of laptop use and distractive use is less of a problem. This culture can be influenced and shaped by instructors to some degree, by walking the room to the extent possible, engaging students more actively, or avoiding a long lecture format. This study does not take into consideration the degree to which these techniques might alter the impact of web access on student performance, and different results might be found in other situations.

About the Authors: Timothy A. Delbridge is an Assistant Professor in the Agribusiness Department at California Polytechnic State University (Corresponding Author: tdelbrid@calpoly.edu). Xiaowei Cai is a Professor in the Agribusiness Department at California Polytechnic State University.

Approval for this research was provided by the California Polytechnic State University IRB (Protocol Number 2020-092).

References

Downs, E., A. Tran, R. McMenemy, and N. Abegaze. 2015. "Exam Performance and Attitudes Toward Multitasking in Six, Multimedia-Multitasking Classrooms Environments." *Computers and Education* 86:250–259. https://doi.org/10.1016/j.compedu.2015.08.008

Elliott-Dorans, L.R. 2018. "To Ban or Not to Ban? The Effect of Permissive versus Restrictive Laptop Policies on Student Outcomes and Teaching Evaluations." *Computers and Education* 126(July):183–200. https://doi.org/10.1016/j.compedu.2018.07.008

Farley, J., E.F. Risco, and A. Kingston. 2013. "Everyday Attention and Lecture Retention: The Effects of Time, Fidgeting, and Mind Wandering." *Frontiers in Psychology* 18. https://doi.org/10.3389/fpsyg.2013.00619

Fried, C.B. 2008. "In-class Laptop Use and Its Effects on Student Learning." *Computers and Education* 50(3):906–914. https://doi.org/10.1016/j.compedu.2006.09.006

Hembrooke, H., and G. Gay. 2003. "The Laptop and the Lecture: The Effects of Multitasking in Learning Environments." *Journal of Computing in Higher Education 15*(1):46–64. https://doi.org/10.1007/BF02940852

Kraushaar, J. M., and D.C. Novak. 2006. "Examining the Affects of Student Multitasking with Laptops During the Lecture." *Journal of Information Systems Education 21*(2):241–252.

May, K.E., and A.D. Elder. 2018. "Efficient, Helpful, or Distracting? A Literature Review of Media Multitasking in Relation to Academic Performance." *International Journal of Educational Technology in Higher Education* 15(13). https://doi.org/10.1186/s41239-018-0096-z

Sana, F., T. Weston, and N.J. Cepeda. 2013. "Laptop Multitasking Hinders Classroom Learning for Both Users and Nearby Peers." *Computers and Education 62*:24–31. https://doi.org/10.1016/j.compedu.2012.10.003

Vahedi, Z., L. Zannella, and S.C. Want. 2019. "Students' Use of Information and Communication Technologies in the Classroom: Uses, Restriction, and Integration." *Active Learning in Higher Education*:1–14. https://doi.org/10.1177/1469787419861926

Wurst, C., C. Smarkola, and M.A. Gaffney. 2008. "Ubiquitous Laptop Usage in Higher Education: Effects on Student Achievement, Student Satisfaction, and Constructivist Measures in Honors and Traditional Classrooms." *Computers and Education 51*(4):1766–1783. https://doi.org/10.1016/j.compedu.2008.05.006

Zhang, W. 2015. "Learning Variables, In-Class Laptop Multitasking and Academic Performance: A Path Analysis." *Computer and Education* 81:82–88. https://doi.org/10.1016/j.compedu.2014.09.012

2(4) doi: 10.22004/ag.econ.307145