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Unregulated use of laptops over time in large lecture classes

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ABSTRACT

Students often have their own individual laptop computers in university classes, and researchers debate the potential benefits and drawbacks of laptop use. In the presented research, we used a combination of surveys and in-class observations to study how students use their laptops in an unmonitored and unrestricted class setting—a large lecture-based university class with nearly 3000 enrolled students. By analyzing computer use over the duration of long (165 min) classes, we demonstrate how computer use changes over time. The observations and student-reports provided similar descriptions of laptop activities. Note taking was the most common use for the computers, followed by the use of social media web sites. Overall, the data show that students engaged in off-task computer activities for nearly two-thirds of the time. An analysis of the frequency of the various laptop activities over time showed that engagement in individual activities varied significantly over the duration of the class.

1. Introduction

In today's university classrooms, students often have their own individual laptop computers. Many programs even require that students have laptops in the classroom (Brown, Burg, & Dominick, 1998; Campbell & Pargas, 2003; Weaver & Nilson, 2005). It has been suggested that access to online resources and computer-based tools can help students supplement their learning during class through increased engagement and the promotion of active learning (e.g., Brown, et al., 1998; Weaver & Nilson, 2005; Wurst, Smarkola, & Gaffney, 2008). From a constructivist perspective, classroom laptop use provides students the opportunity to take ownership of their learning experiences (Wurst et al., 2008). This ownership carries with it a critical responsibility of remaining on task through use of the laptop for course/topic specific activities, such as note taking, fact checking, information seeking, or additional studying. By this rationale, even without specialized activities and software designed to take advantage of the technology and integrate them into lessons, laptops can be seen as valuable tools with just as much right for a place in students' hands as pens, notepads, and textbooks. Of course, this is assuming that the laptops are used appropriately to supplement learning.

But do university students really use their laptops to aid their educational experiences? From our observations, many students do not even bother using their laptops in class when given the option. And when they are used, it is not uncommon for educators to see laptops as sources of distraction. With computers and wireless Internet connections, students are free to surf the web, keep up with the latest social media, or even play online games. Educators are left with the decision of what to do with laptops, and whether students should have access to Internet-capable devices. Many educators have considered simply banning the use of laptops in the classroom (e.g., Maxwell, 2007; Yamamoto, 2007). Others have argued for disabling or limiting Internet access (e.g., Adams, 2006), and yet another proposed solution has been to separate lecture halls into laptop-approved and laptop-free zones (e.g., Aguilar-Roca, Williams, & O'Dowd, 2012; McCreary, 2009). To better understand the issue, numerous researchers have collected data on how university students use their laptops (e.g.,

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Barak, Lipson, & Lerman, 2006; Demb, Erickson, & Hawkins-Wilding, 2004; Gay, Stefanone, Grace-Martin, & Hembrooke, 2001). Using approaches such as observations (e.g., Barak et al., 2006), surveys (e.g., DeGagne & Wolk, 2007; Demb et al., 2004), and the use of logging software (e.g., Gay, et al., 2001), researchers are learning more about how students use technology in a variety of different class settings.

In this paper, we present the results of a study that contributes additional data on how student use laptops in an unregulated large-lecture class setting, in which the class is too large for the professor to monitor laptop use. In very large university classes, interactions between individual students and the instructor are minimized (Mayer et al., 2009). Consequently, students may easily use computers for distracting or non-educational activities with virtually no risk of being reprimanded. On the other hand, students could also take advantage of wireless Internet technology to actively seek additional information—possibly making up for the lack of personal instructor–students interactions. Additionally, our study investigated laptop use during long class periods (2 h and 50 min), allowing us to collect data on how computer use changes over time.

1.1. Students' use of computers in lecture classes

Several prior studies have investigated how university students use computers in the classroom. For instance, DeGagne and Wolk (2007) surveyed approximately 10,000 students at an undergraduate university. The researchers found that many (nearly half of the sample) students owning laptops reported that they never brought them to classes. Of those that did, many students (48.7%) reported always using laptops for note taking during class, while 27.3% reporting sometimes using their computers to take notes. Students also reported a large amount of off-task activities in class, including communicating with friends, reading and writing emails, and doing school work for other classes. These results demonstrate how laptops are commonly used both as course tools and distracters. However, the data consisted of only student-reported responses and only describes general use tendencies, rather than providing specific data about certain types of courses.

In a similar study, Gay et al. (2001) studied laptop use through a combination of surveys and the use of software tools to track how students used their computers. The researchers studied computer use in a communications course and in a computer science course, finding general class differences in how students found and shared information. Additionally, students in the communications class made significantly more use of communications tools and applications than those in the computer science class. This study demonstrates the importance of considering class specifics when studying computer use.

In another study using the survey approach, Lauricella and Kay (2010) found that students commonly use laptops for a mix of on-task and off-task purposes during class. While many students reported using laptops for academic purposes for large percentages of class time, results also included other non-academic uses, such as communication, movie watching, and game playing. Students in this study reported off-task uses to be unhelpful or distracting during class.

1.2. Effects of computer use in lecture classes

In addition to studying how students use laptops, researchers have investigated whether laptop use affects education. Despite the potential benefits and widespread adoption of laptops in university classes, many educators believe that laptop use can have negative effects on learning (e.g., Adams, 2006; Maxwell, 2007). Unrestricted computer access provides students with an unlimited source of distractions, including activities such as web browsing, game-playing, and text-messaging. Several studies have provided evidence backing these concerns, showing that students often use computers for purposes unrelated to the class lessons (e.g., Fried, 2008; Gay et al., 2001; Wurst et al., 2008). Grace-Martin and Gay (2001) tracked Internet usage through a semester (not just during class time) for computer science and communications courses. They found a significant correlation between the length of Internet browsing sessions and class performance. That is, longer browsing sessions were related to lower performance scores. In a university psychology course, Fried (2008) found a similar result. In this study, students completed weekly surveys that included questions about laptop use and class attendance. Results indicated a significant negative correlation between class performance and laptop use, showing that students who used their laptops more in class demonstrated inferior academic performance. Further, Fried's results show laptop use by other students as the most commonly reported in-class distractor.

A study by Kraushaar and Novak (2010) collected data about in-class laptop use and class performance in an information systems course through surveys and spyware monitoring software for volunteers. The study found more off-task than course-relevant computer use, and showed a negative correlation between class performance measures and the amount of off-task computer use. Additionally, Burak (2012) surveyed university students from a variety of disciplines and found a significant relationship between multitasking with laptops or phones during classes. Survey results about class behaviors showed that student GPAs suffered with increased in-class laptop multitasking. This collection of findings provides knowledge of the general relationship between laptop use and academic performance.

In addition to laptop use being detrimental to personal performance, a study by Sana, Weston, and Cepeda (2013) found that students performed worse on tests after sitting near students using laptops during an introductory psychology class. This finding suggests that the laptop use can be distracting even for those in the class who are not themselves using the technology.

Researchers have also investigated the effects of laptop use on factors besides academic performance. For example, Wurst et al. (2008) compared student satisfaction and the general level of activity level among different business honors courses with or without laptops. Based on the results of student reports, students expressed significantly less satisfaction with their education with laptops as compared to those without computer access during class. This study found no differences in academic performance or level of overall class activity due to laptop use. The results did, however, show that students with laptops were significantly more likely to find answers to an instructor's questions. Of course, honors courses generally are relatively small in size—especially when compared to a large, lecture-type course.

1.3. Computer use in large lecture classes

Few researchers have explicitly targeted large classrooms for investigation. Barak et al. (2006) examined the use of wireless laptops for promoting active learning in large lecture halls, basing their investigation within an introductory undergraduate computer engineering class with 374 students. Course sessions mixed short lectures, lab assignments, and specialized laptop activities. Using an online survey, the researchers collected data about attitudes and perceptions regarding the use of laptops in the classroom. In-class observations were also conducted to examine student operations and behaviors while using laptops in the classroom. According to Barak et al. (2006), "Class observations showed that the use of wireless laptops enhances student-centered, hands-on, and exploratory learning, as well as meaningful student-to-student and student-to-instructor interactions" (p. 1). However, the authors also reported that "wireless laptops can become a source of distraction, if used for non-learning purposes" (p. 1). While this study provides useful information about the use of laptops in large classes, the studio format of the class makes it quite different from pure traditional lecture sessions.

Also looking at large classes, Aguilar-Roca, Williams, and O'Dowd (2012) studied the use of laptops in biology lectures with over 400 students in an auditorium. The researchers compared laptop use in a control group, in which students were free to use laptops anywhere in the auditorium, and in a *zoned* group, in which students who wanted to use their laptops during class were encouraged to sit in a designated "laptops-allowed" portion of the auditorium. Through in-class observations of 50-min class sessions, the researchers found significantly higher off-task laptop use in the zoned group (with approximately 24%) than in the control group (with approximately 16%). In our study, we consider how longer class times influence the amount of off-task laptop behavior.

1.4. Research questions

In a large, lecture-formatted class, the central questions under investigation were: (a) Why do students not bring laptops to class?; (b) For those students who do bring their laptops to class, how do they use their laptops during class?; and (c) For those students who do bring their laptops to class, how does students' laptop use change over the duration of the class?

2. Methods

The examination of students' use of computers in a large lecture-based class was pursued using two methods: a laptop-use survey and laptop-use classroom observations. The participants for these two methods were in the same class and participants who completed the laptop use survey may also have been observed for computer use. No attempt was made to align participants who completed the survey with participants who were observed.

2.1. Participants

Laptop-use survey participants were recruited from a large face-to-face, lecture-based university class with 2724 enrolled students. All participants were enrolled in an introductory world geography class (i.e., the course had no prerequisite courses, and students from any grade/year were permitted to enroll). Participants received no course credit for participation in the study.

For the survey portion of the study, a general request to participate in research (non-incentivized, anonymous, and voluntary) was sent to all students. Ultimately, 212 students (104 male; 94 female; 4 other; 10 unreported) with a mean age of 19.3 years ($SD = 2.9$; range 17–29) participated in the survey portion of the study. The survey results showed that the majority of responders (54%) were first-year university students, while 23% were second-year, 11% were third-year, and 9% were fourth-year (the remaining 3% classified themselves at other year levels).

For the classroom-observation portion of the study, 92 participants (46 male; 46 female) were observed from the class. Because observations were done without student awareness, the researchers were not able to determine participant ages or grade level. Observations were made from different locations around the classroom. The student sample is assumed to be representative of the class's laptop users, though students were selected based on visibility of laptop screens.

2.2. Materials and procedure

2.2.1. Laptop use survey

The laptop-use survey was administered as an online survey in week 13 of a 16-week course. The survey consisted of three sections: demographics, reasons for not using a laptop during class, and reasons for using a laptop during class. First, students were asked if they normally brought a laptop to class and if they did not, why not (i.e., no need, distracting, too heavy, take notes by hand, other/specify). Second, students who indicated that they did bring a laptop to class were asked how much time they spent on their computer engaging in various tasks (i.e., taking notes, clarifying information, emailing, Facebooking, blogging, tweeting, searching, gaming, watching sports, watching videos, browsing).

2.2.2. Laptop use observation

With the instructor's permission, three observers entered the 3000-seat auditorium/classroom with the students and selected seats that would allow them to observe several students' use of their computers simultaneously. The number of observed students for each observation period varied between six and eleven students, as observations depended on the number of screens visible to the observer and the amount of time needed to discern laptop use. Students were unaware of the ongoing study and unaware of the observers' presence. The observers selected and observed a group of computer-using students for a segment of approximately 50 min, then moved to another location in the classroom and observed a second set of computer-using students for a segment of approximately 50 min, and then finally moved to a third location and observed a third set of computer-using students for the final segment of approximately 50 min. The observers sat at different locations for different observation periods, observing different groups of students.

Upon selecting the group of six to eleven students to watch for each 50-min period, the observer would first note the observed students' gender and location within the classroom. Then, the observer would record the students' computer use (e.g., note taking, tweeting, gaming) on a datasheet once every 3 min. The observers used timers to keep track of the appropriate time to next record an observation for each of the observed students in the current group of students. Rather than monitoring continuous usage time over the 50 min, observers recorded usage for the moment of observation at regular 3-min intervals. That is, observations were spot checks of computer usage at the time of the observation.

The 3-min observation protocol resulted in 18 observations per 50-min (approximate) segment and 54 observations per 165-min class. All observations were completed across five classroom visits. By recording and referencing the locations and times of observations, the observers balanced the times and locations of observations across the auditorium. All data collection forms and techniques were first tested in a pilot study the previous semester; in addition, the observers were trained the previous semester during the pilot study in the same auditorium classroom.

2.2.3. Class design

The introductory geography class was conducted one evening per week for 2 h and 45 min. The class was facilitated in a lecture-based format with online supplemental materials. The class was held in a large auditorium capable of accommodating up to 3000 students. Class attendance was not enforced, although typical class attendance was estimated to be 70–80% each day, and students were not required to bring a laptop to the class. Wireless access to the Internet was available.

The instructional approach was consistent across all observed classes—fast-paced, energetic lectures accompanied with text, pictures, and graphic-based slides projected on dual screens, with occasional video clips. Student engagement and class participation were actively solicited throughout the session's entirety. Microphones were located throughout the auditorium so that everyone could hear both the student's random shout-out responses to the instructor's queries and any questions/comments related to structured engagement activities.

3. Results

3.1. Why do students not bring laptops to class (survey)?

Within the survey, all students ($n = 212$) were first asked if they "normally bring a laptop to class" and while 59% of students indicated that they did bring a laptop to class, a significant minority (41%) indicated they did not. Those who *did not* bring laptops to class were then asked why not. Over half of these students (51%) indicated that they either preferred to take notes by hand or that they had no need for a laptop during class. These responses indicate that for those who do not bring a laptop to class the main impetus is simple necessity, or a lack thereof. From a strictly practical perspective, 30% of students indicated that they did not bring a laptop to class because there were no power outlets for the computers available in class, there was insufficient Internet availability in class, or the computers were heavy. Finally, beyond necessity and practicality, 18% of these students indicated that they found having a laptop distracting, having a negative impact on their learning. Collectively, these results indicate that many students do not see significant value in bringing a laptop to class.

3.2. How do students use their laptops during class (survey)?

Within the survey, students who did bring laptops to class ($n = 114$) were asked how long they spent on a series of computer-based activities during class (i.e., in minutes: 0, 15, 30, 45, 60, or 60+). The results (see Table 1) indicated that students spent significantly more time using their computers to take notes than any other *single activity*. In addition, the results also indicated that of non-note taking activities, students engaged in significantly more social networking (e.g., Facebook), web browsing, and web searching, and less blogging than any other single activities. These results clearly indicated that for those students who brought their computers to class, the most common single use was taking notes. That said, when the computer-based activities were categorized as either on-task (i.e., note taking or viewing related course websites) or off-task (i.e., everything else), students were on task 39% of the time (7155 min) and off task 61% of the time (11,080 min). Thus, while the most common single activity for which computers were used was note taking, overall the computers were used mostly for off-task activities.

Table 1
Self-reported time engaged in specific computer-based activities during class.

During class, how long did you spend on each of the following computer-based activities? ($n = 114$)	Mean time %	Mean minutes[a] b	Minutes						Time spent
			00	15	0	45	60	60+	
Note Taking	32.05	52.89_c	019	13	15	17	8	46	6030
Social Media	14.91	24.61_d	036	30	24	15	7	06	2805
Web Browsing	9.10	$23.68_{d,e}$	043	26	26	09	4	10	2715
Web Searching	9.57	15.79_e	053	32	18	12	1	02	1800
Clarifying Information	5.98	9.87_f	064	39	12	02	0	01	1125
Emailing	5.10	8.42_f	065	42	11	00	0	00	1000
Tweeting	4.39	7.24_f	095	09	06	04	1	03	0825
Gaming	3.75	6.18_f	093	11	10	02	1	01	0705
Sports	3.19	5.26_f	090	20	06	00	2	00	0600
Videos	2.71	$4.47_{f,g}$	099	11	04	01	3	00	0510
Blogging	.64	1.05_g	111	06	01	00	0	00	0120

Note. Mean Times are in percentages. Mean Minutes and Time Spent columns are in minutes. All other columns are in response counts for the given number of minutes. Time Spent is $\sum(\text{count} \times \text{time})$ for each row, for example $(19 \times 0) + (13 \times 15) + (15 \times 30) + (17 \times 45) + (8 \times 60) + (46 \times 90) = 6030$ min. The value of 60+ is interpreted as 90 min for calculating purposes.

[b] – Means with similar subscripts are statistically similar, means with dissimilar superscripts are statistically different, $F(10,1130) = 77.7$, $\eta_p^2 = .40$, $p < .01$.

[a] Mean = $\sum(\text{time spent})/n$.

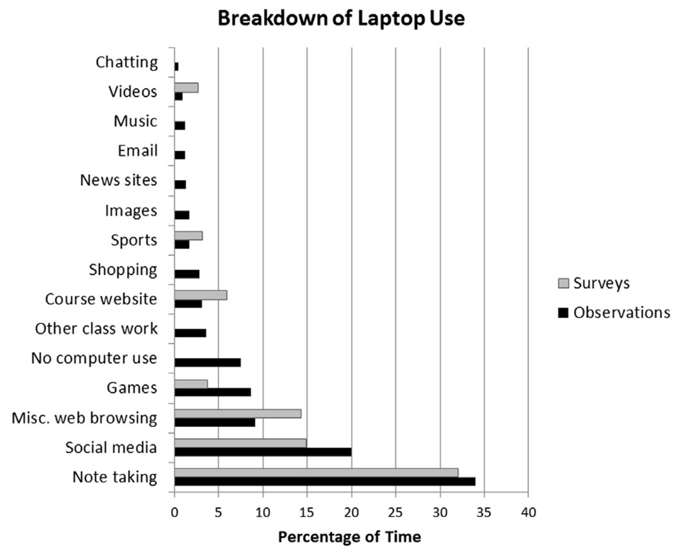

Fig. 1. Breakdown of frequency of computer activities for observed activities along with the frequencies calculated from survey results. Note that the presented percentage of time for observations is estimated from the percentage of observation instances, rather than from exact timing.

3.3. How do students use their laptops during class (observation)?

Within the laptop use classroom observations, each participant ($n = 92$) was observed an average of 18 times over approximately 50 min, examining laptop use behavior. Fig. 1 shows the percentages of observed activities graphically along with the corresponding results from the survey responses. The observations determined that students with laptops spent 34% of their time taking notes and 20% of their time engaged with social media websites (e.g., Facebook, Twitter). Students also spent between 7 and 10% of their time browsing the web (9.1%) or playing games (8.7%). For 7.5% of observations, participants were not using their computers. Activities between 2 and 4% of observations included doing work for another class (3.6%), visiting the course website (3.1%), or shopping online (2.8%). Finally, students spent less than 2% of their time looking at sports content (1.7%), looking at images/photographs (1.7%), reading the news (1.3%), emailing (1.2%), listening to music (1.2%), watching videos (.9%), or chatting (.5%). Overall, when the observations were categorized as either on-task (i.e., note taking or working on the course website) or off-task (i.e., everything else), students were on task for 37% of the time and off task 63% of the time.

Though off-task laptop use was clearly higher than on-task use overall, note taking was still the single most common observed use of laptops (34% of all observations). With regard for the individual note-taking behavior, 37% of participants took notes for at least half of their observed activities, and 66% of participants were observed using a laptop to take notes at least once.

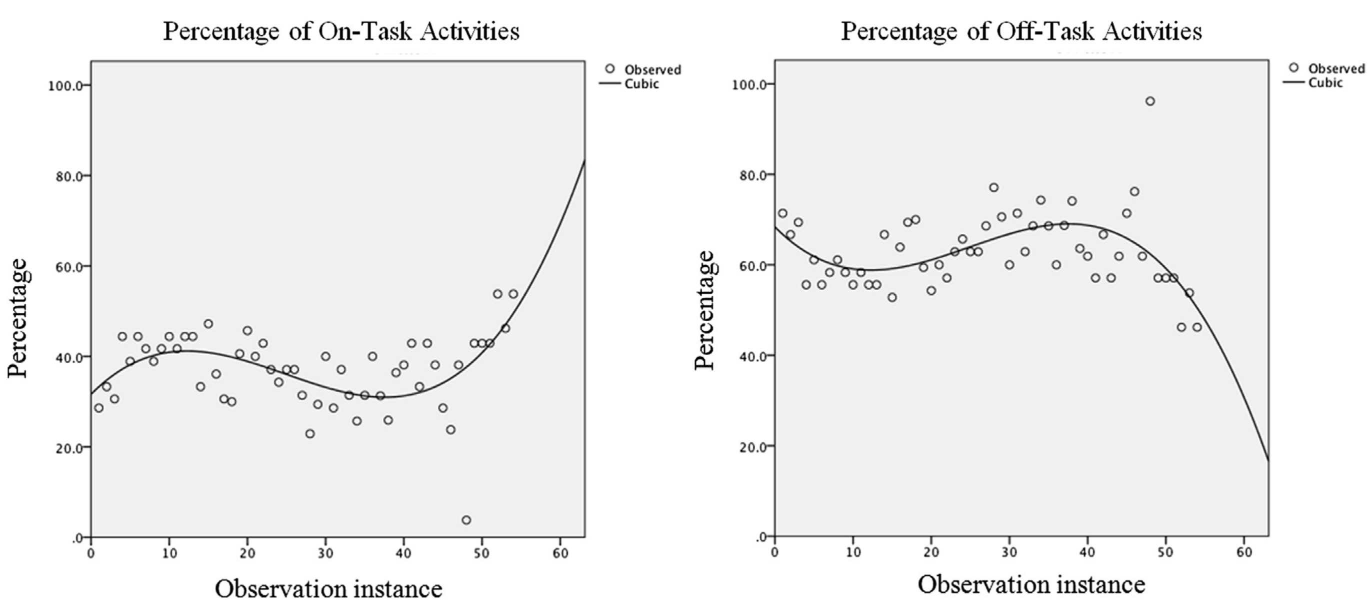

Fig. 2. Percentage of students on-task and off-task at any given observation time across class period, with cubic regression lines.

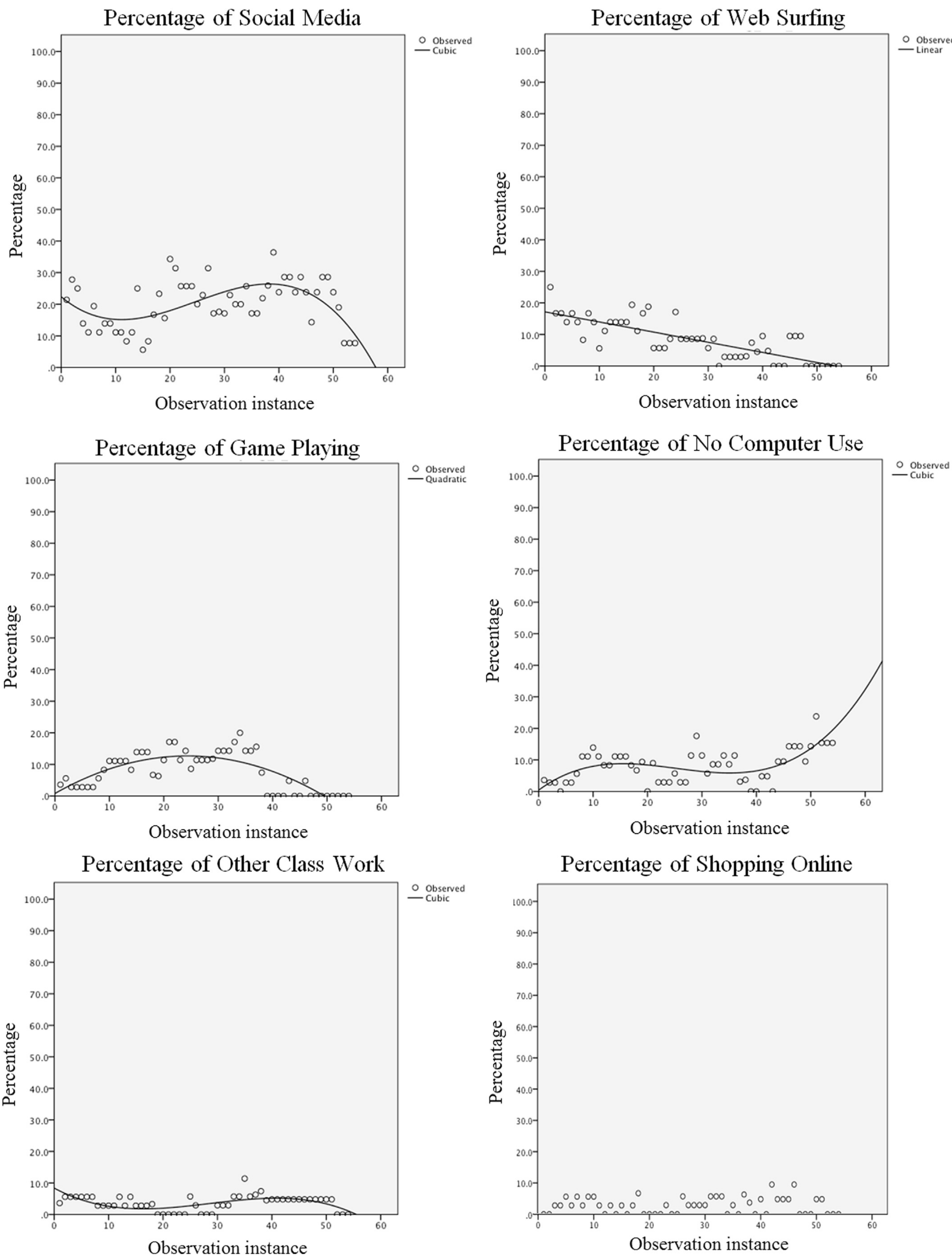

Fig. 3. Percentage of students off-task engaging in specific behaviors at any given observation time across class period, with the "best fit" regression lines.

3.4. How does students' laptop use change over the time of the class?

Students' laptop use across the class time was examined using regression analysis. The rationale for using regression analysis was that of description, not prediction; that is, regression was used to describe the relationship (if any) between students' on-task/off-task behavior and time during class (i.e., the 54 observation times), not to predict who is likely to be on-task or off-task at any given moment. In addition, a visual examination of the data revealed the potential presence of curvilinearity. Given the potential of curvilinearity in the data and a desire to establish the best fitting model to the data, the regression analysis involved two phases. First, data were fit to linear, quadratic, and cubic models to determine which model fit the data, using an ANOVA (regression) for each model as the determining factor (i.e., where the dependent and independent variables are determined to be related). Second, for models with significant ANOVA results, the R^2 (coefficient of determination) for those significant models were compared (ANOVA) to determine which model yielded the highest R^2 with the lowest higher-order term.

In order to examine the overall relationship between on-task student laptop use across the span of the class, three regressions were computed, linear ($R^2 = .003$, $F = .146$, $p = .70$), quadratic ($R^2 = .068$, $F = 1.87$, $p = .16$), and cubic ($R^2 = .272$, $F = 6.21$, $p < .01$). Given that only the cubic model yielded a significant relationship, the cubic model provided the best fit to the overall on-task data (see Fig. 2); thus, no subsequent R^2 analyses were conducted. The analysis indicated that students' on-task behavior increased during the first part of the class, then dipped during the middle of the class, and rose again at the very end of class. It should be noted that the off-task relationship was simply a mirror image of the on-task relationship, with the same statistical results ($R^2 = .272$, $F = 6.21$, $p < .01$; see Fig. 2).

In order to examine the relationship between specific off-task behaviors and class time, linear, quadratic, and cubic regressions were conducted on those specific behaviors. That said, only those behaviors that accounted for at least 2% of the off-task behaviors were analyzed (i.e., social networking, surfing the web, playing a game, doing nothing, working on a different class, and shopping). Behaviors accounting for less than 2% of the off-task behaviors (i.e., watching sports, looking at pictures, reading the news, emailing, listening to music, watching a video, chatting, and texting) contained too many observations with no one engaging in that behavior (0%), resulting in meaningless regression interpretations.

Analysis of the social networking data yielded linear ($R^2 = .043$, $F = 2.34$, $p = .13$), quadratic ($R^2 = .124$, $F = 3.59$, $p = .03$), and cubic ($R^2 = .326$, $F = 8.07$, $p < .01$) regressions. Analysis of the changed R^2 between the linear and quadratic models was significant ($F = 4.71$, $p < .05$), as was the changed R^2 between the quadratic and cubic models ($F = 14.9$, $p < .05$), indicating that the cubic model provided the best fit to the social networking data (see Fig. 3). The regression line indicates that the degree of social networking decreased during the first third of the class, increased through the middle third, and decreased again at the end of the class.

Analysis of the web surfing data yielded linear ($R^2 = .628$, $F = 87.6$, $p < .01$), quadratic ($R^2 = .631$, $F = 43.6$, $p < .01$), and cubic ($R^2 = .632$, $F = 28.5$, $p < .01$) regressions. Analysis of the changed R^2 between the linear and quadratic models was not significant ($F = .41$, $p > .05$) and neither was the changed R^2 between the quadratic and cubic models ($F = .13$, $p > .05$), indicating that the linear model provided the best fit to the web surfing data (see Fig. 3). The regression line indicates that the degree of web surfing decreased from the beginning of the class to the end of the class.

Analysis of the game playing data yielded linear ($R^2 = .105$, $F = 6.12$, $p = .01$), quadratic ($R^2 = .621$, $F = 41.7$, $p < .01$), and cubic ($R^2 = .634$, $F = 28.8$, $p < .01$) regressions. Analysis of the changed R^2 between the linear and quadratic models was significant ($F = 69.4$, $p < .05$), however, the changed R^2 between the quadratic and cubic models was not significant ($F = 1.77$, $p > .05$), indicating that the quadratic model provided the best fit to the game playing data (see Fig. 3). The regression line indicates that the degree of game playing increased from the beginning of class to the middle of class, and then decreased to the end of class.

Analysis of the data where students were not doing anything, neither taking notes nor interacting with the laptop, yielded linear ($R^2 = .148$, $F = 9.05$, $p < .01$), quadratic ($R^2 = .197$, $F = 6.23$, $p < .01$), and cubic ($R^2 = .394$, $F = 10.8$, $p < .01$) regressions. Analysis of the changed R^2 between the linear and quadratic models was not significant ($F = 3.11$, $p > .05$), however, the changed R^2 between the quadratic and cubic models was significant ($F = 20.29$, $p < .05$), indicating that the cubic model provided the best fit to the "no computer use" data (see Fig. 3). The regression line indicates that the degree of doing nothing increased during the first third of the class, decreased marginally through the middle third, and increased again at the end of the class.

Analysis of the data where students were working on material from a different course yielded linear ($R^2 = .000$, $F = .20$, $p = .88$), quadratic ($R^2 = .019$, $F = .48$, $p = .61$), and cubic ($R^2 = .343$, $F = 8.72$, $p < .01$) regressions. Analysis of the changed R^2 between the linear and quadratic models was not significant ($F = .98$, $p > .05$), however, the changed R^2 between the quadratic and cubic models was significant ($F = 26.1$, $p < .05$), indicating that the cubic model provided the best fit to the data related to students working on material from a different class (see Fig. 3). The regression line indicates that the degree of working on a different class decreased during the first third of the class, increased through the middle third, and decreased again at the end of the class.

Analysis of the online shopping data yielded linear ($R^2 = .003$, $F = .13$, $p = .71$), quadratic ($R^2 = .010$, $F = .25$, $p = .77$), and cubic ($R^2 = .061$, $F = 1.08$, $p = .36$) regressions. Analysis of the changed R^2 between the linear and quadratic models was not significant ($F = .35$, $p > .05$), nor was the changed R^2 between the quadratic and cubic models ($F = 2.71$, $p > .05$), indicating that none of the three models fit the data and that even the best fitting model (cubic) only resulted in explaining 6.1% of the variance in online shopping due to the time during class (see Fig. 3).

Overall, the results indicate that while the proportion of students who are on-task/off-task remains fairly constant over the duration of the class, what the students are actually doing with their laptops during class does vary significantly.

4. Discussion

This research indicates that students in a large class who chose to bring laptops to class tended to be off-task in using their laptop almost two-thirds of the time. This finding was corroborated using both survey data (off-task 61%; on-task 39%) and observational data (off-task 63%; on-task 37%). The concept that students in lecture-oriented classes who choose to use laptops have a tendency to be off-task is not new. This finding has been reported several times, with variations in off-task percentages ranging from 16% (Aguilar-Roca et al., 2012) to 23% (Fried, 2008) to 50% (Hembrooke & Gay, 2003) to 90% (Borbone, 2009). These large variations may be due to differences in the methods used to collect the data (e.g., survey, direct observation), format of reporting the data (e.g., overall percentage, moment-by-moment percentage), criteria for determining on-task/off-task (e.g., at any given moment, never off-task), class size (e.g., small, large), or student year (e.g., first year, upper class). The current study used both aggregated data (survey) and raw data (observations), and in both cases yielded similar results (see Fig. 1), providing a level of confidence in both the overall finding that almost two-thirds of students with laptops in a large were off-task at any given time and the validity of the survey data.

It is also important to recall the significant portion of students (37%) who used their laptops for taking notes for at least half of their observations. Thus, although laptops are often used for off-task purposes, these results show that it is clear that many individuals opt to use technology to support class activities. This is relevant for discussions of banning all laptop use, which could negatively affect those students who have legitimate uses of their devices. But the fact that even the students who did considerable on-tasking also did a large amount of off-tasking suggests that students do a large amount of multitasking or change their laptop use over time. This behavior is in alignment with perspectives of digital natives as ardent multitaskers (Palfrey & Gasser, 2013). Previous multitasking research has shown disadvantages of off-task multitasking during class (Kraushaar & Novak, 2010), but questions remain about how multitasking behavior changes over the duration of the class.

Subsequent examination of the observational data revealed that while students were overall off-task 63% of the time, this percentage varied across the class time such that students' off-task behavior dropped to 55% a third of the way through the class and then rose to 71% two-thirds of the way through the class (see Fig. 2). In fact, at least 50% of the students were off-task until the very end of class. This change in off-task behavior was reflected in students' use of social media, which accounted for 20% of the off-task behavior and followed the same undulating pattern as the overall results, and students' surfing of the web, which accounted for 9.1% of the off-task behavior and which decreased from 17% at the start of class to 0% by the end of class. These changes in student behavior across the class time indicate that simple overall statistics of how many students are on-task/off-task may not be sufficiently nuanced to accurately describe student behavior.

Our current hypothesis for the high frequency of overall off-task behavior is that the class periods were atypically long (165 min). To help explain the curve seen in Fig. 2, perhaps students begin engaging in off-task behavior early as a means of "settling in" for the long duration of class, but they may still attempt to focus and stay on task during the first quarter of the class session. After this period, off-task behavior was seen to increase, as might be expected when students lose interest or look for activities to help stay awake. Even with the energetic lectures and engaging class format offered in the course studied in this research, a period of almost 3 h is a long time to maintain attention. The significant drop in off-task behaviors towards the later portion of class also supports this interpretation of off-tasking as a coping mechanism for the long class. If students were primarily interested in the off-task behavior itself, they might be expected to continue those activities with more constant frequencies throughout the class period—but this is not observed result. Students ceased off-tasking and increased on-task activities towards the end of the class. Perhaps knowing that the class will be concluding in the short-term is enough to motivate students to focus their attention for remaining time. The observation data also shows that many laptop users stopped using their laptops towards the end of the class, suggesting that the students were more anxious to finish the session than to continue either the on-task or off-task activities. Additionally, laptop use would be expected to decrease over time as a result of drained batteries, as students mentioned the lack of power outlets in the auditorium. Analysis of technology use within classes of varying lengths would be needed to further investigate these hypotheses and to provide additional insight of the observed behavior.

5. Conclusions

We studied laptop use in a large lecture-based university class with 2724 enrolled students. Students completed surveys to self-report on how they used their laptops during class time, and researchers observed student laptop use during class sessions. The observations and student reports provided similar descriptions of laptop activities (see Fig. 1). Note taking was the most common use for computers, followed by visiting social media web sites. By categorizing computer usage into on-task or off-task activities, the survey data showed that students were off task for 61% of the time, and the observations showed students to be off-task for 63% of the time. An analysis of the frequency of the various laptop activities over time showed that engagement in individual activities varied significantly over the duration of the class. We suspect that this effect may have been a consequence of the long (165 min) class periods, which could have influenced students' choices of how to use the available technology.

The majority (88%) of observed students used their laptops for multiple activities during the class periods. As might be expected during such a long period, most students engaged in both on-task and off-task activities. Though many of the students used their laptops to take notes during class at least occasionally, fact-finding and other on-task activities were rare. The high overall proportion of off-task observations clearly demonstrates that students were not using laptops for class-relevant purposes. Attendance was not taken in class and participation was not enforced, so why would students choose to attend the class but engage in unrelated laptop activities? A possible explanation is that students turn to superfluous laptop use in a way similar to how students traditionally doodle in notebooks, perhaps as a means of maintaining attention (Andrade, 2010). But studies suggest that off-task laptop use is more likely to be harmful to learning (Fried, 2008; Grace-Martin & Gay, 2001; Kraushaar & Novak, 2010). Follow-up studies of laptop use over time in classes of varying lengths could help to investigate possible relationships between course length and choices for laptop use.

It would also be interesting to compare technology usage behaviors with non-technology behaviors over time—particularly in large lecture classes where students have more autonomy and anonymity in the classroom. Such a comparison could inform whether the observed laptop usage behavior is really an outcome of technology use, or if it might be more strongly influenced by student engagement or length of class time. A study of behaviors with and without technology could also be useful for better understanding the nature of multitasking in the classroom and its relationship to technology.

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References

Adams, D. (2006). Wireless laptops in the classroom (and the Sesame Street syndrome). *Communications of the ACM, 49*(9).
Aguilar-Roca, N. M., Williams, A. E., & O'Dowd, D. K. (2012). The impact of laptop-free zones on student performance and attitudes in large lectures. *Computers & Education, 59*(4), 1300–1308.
Andrade, J. (2010). What does doodling do? *Applied Cognitive Psychology, 24*(1), 100–106.
Barak, M., Lipson, A., & Lerman, S. (2006). Wireless laptops as means for promoting active learning In large lecture halls. *Journal of Research on Technology in Education, 38*(3).
Borbone, M. (2009). *From doodle to Google: exacerbating old problems or causing new ones? The relationship between laptop usage and in-class student behavior.* Master's Thesis. Chapel Hill, North Carolina: University of North Carolina at Chapel Hill.
Brown, D. G., Burg, J. J., & Dominick, J. L. (1998). A strategic plan for ubiquitous laptop computing. *Communications of the ACM, 41*(1), 26–35.
Burak, L. (2012). Multitasking in the university classroom. *International Journal for the Scholarship of Teaching and Learning, 6*(2).
Campbell, A. B., & Pargas, R. P. (2003). Laptops in the classroom. In *, Vol. 35(1). Proceedings of the 34th SIGCSE Technical Symposium on Computer Science Education – SIGCSE '03*.
DeGagne, M., & Wolk, R. M. (2007). Unwired: student use of technology in the ubiquitous computing world. *Information Systems Education Journal, 5*(13).
Demb, A., Erickson, D., & Hawkins-Wilding, S. (2004). The laptop alternative: student reactions and strategic implications. *Computers & Education, 43*(4), 383–401.
Fried, C. B. (2008). In-class laptop use and its effects on student learning. *Computers & Education, 50*(3), 906–914.
Gay, G., Stefanone, M., Grace-Martin, M., & Hembrooke, H. (2001). The effects of wireless computing in collaborative learning environments. *International Journal of Human-computer Interaction, 13*(2), 257–276.
Grace-Martin, M., & Gay, G. (2001). Web browsing, mobile computing and academic performance. *Educational Technology & Society, 4*(3), 95–107.
Hembrooke, H., & Gay, G. (2003). The laptop and the lecture: the effects of multitasking in learning environments. *Journal of Computing in Higher Education, 15*(1), 46–64.
Kraushaar, J. M., & Novak, D. C. (2010). Examining the affects of student multitasking with laptops during the lecture. *Journal of Information Systems Education, 21*(2), 11.
Lauricella, S., & Kay, R. (2010). Assessing laptop use in higher education classrooms: the laptop effectiveness scale (LES). *Australasian Journal of Educational Technology, 26*(2), 151–163.
Maxwell, N. G. (2007). From facebook to Folsom Prison Blues: how banning laptops in the classroom made me a better law school teacher. *Richmond Journal of Law and Technology, 14*(2).
Mayer, R. E., Stull, A., DeLeeuw, K., Almeroth, K., Bimber, B., Chun, D., et al. (2009). Clickers in college classrooms: fostering learning with questioning methods in large lecture classes. *Contemporary Educational Psychology, 34*(1), 51–57.
McCreary, J. R. (2009). The laptop-free zone. *Valparaiso University Law Review, 43*(3), 989–1044.
Palfrey, J. G., & Gasser, U. (2013). *Born digital: Understanding the first generation of digital natives*. Basic Books.
Sana, F., Weston, T., & Cepeda, N. J. (2013). Laptop multitasking hinders classroom learning for both users and nearby peers. *Computers & Education, 62*(0), 24–31.
Weaver, B. E., & Nilson, L. B. (2005). Laptops in class: what are they good for? What can you do with them? *New Directions for Teaching and Learning, 2005*(101), 3–13.
Wurst, C., Smarkola, C., & Gaffney, M. A. (2008). Ubiquitous laptop usage in higher education: effects on student achievement, student satisfaction, and constructivist measures in honors and traditional classrooms. *Computers & Education, 51*(4), 1766–1783.
Yamamoto, K. (2007). Banning laptops in the classroom: Is it worth the hassles. *Journal of Legal Education, 57*, 477.