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You can lead a horse to water but you cannot make him learn: Smartphone use in higher education

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Abstract

Smartphone technology is penetrating world markets and becoming ubiquitous in most college settings. This study takes a naturalistic approach to explore the use of these devices to support student learning. Students that had never used a smartphone were recruited to participate and reported on their expectations of the value of smartphones to achieve their educational goals. Instrumented iPhones that logged device usage were then distributed to these students to use freely over the course of 1 year. After the study, students again reported on the actual value of their smartphones to support their educational goals. We found that students' reports changed substantially before and after the study; specifically, the utility of the smartphone to help with education was perceived as favorable prior to use, and then, by the end of the study, they viewed their phones as detrimental to their educational goals. Although students used their mobile device for informal learning and access to school resources according to the logged data, they perceived their iPhones as a distraction and a competitor to requisite learning for classroom performance.

Introduction

Smartphone technology is being deployed around the world at a rapid rate. In the year 2013, there were almost as many mobile subscriptions as people in the world (International Telecommunications Union, 2014). These technologies have penetrated most countries and at a rate faster than any other technology in the history of the world (Eagle, 2005). In some countries, smartphones are more prevalent than other technologies, such as personal computers and landline telephones. In contrast to previous-generation mobile phones, current-generation smartphones provide users with easier access to the Web, social networking, games and thousands of other applications. Corresponding to the increased adoption of smartphones around the world, these technologies are also being introduced into teaching and learning environments. In the year 2011, over half of the public universities had fielded a mobile application for their school (Green, 2011), and specific learning applications can be found for a wide range of subjects. Internet-connected mobile devices offer a myriad of possible benefits to students (Rogers, Connelly, Hazlewood & Tedesco, 2010), but paramount to these benefits is the ability to extend the classroom beyond the standard lecture format (Chen, Seow, So, Toh & Looi, 2010; Ryan & Healy, 2007).

Practitioner Notes

What is already known about this topic

- Mobile phones provide unique information acquisition capabilities in learning environments.
- The structured use of mobile phones has been shown to have positive impacts in educational settings.

What this paper adds

- Naturalistic data collection methods can add additional insight into how students use phones in an educational setting.
- Additional evidence shows that in an unstructured setting, educational activities are not widely performed on smartphones.
- Greater awareness that students perceive that smartphones are actually a hindrance to their educational goals in this kind of unstructured setting.

Implications for practice and/or policy

- Access to smartphone technology, by itself, does not necessarily enhance the achievement of educational goals by students.
- Schools should consider using active, proscribed activities with mobile technologies to gain the maximum benefit.
- Use of smartphone technologies on campus in an unstructured form should be the subject of further policy study.

Indeed, this desire to extend beyond traditional education delivery methods is seen in the recent surge in open education efforts like Massive Online Open Courses (MOOCs). MOOCs rely on reaching large numbers of users through nontraditional delivery methods (eg, *not* brick and mortar). Learning anytime and anywhere is one of the stated goals of the MOOC movement (de Waard *et al*, 2011, 2012) and has become the mantra of mobile learning (m-learning) in general, with most research expressing excitement about the benefits to student learning (eg, Hwang & Chang, 2011; Jeng, Wu, Huang, Tan & Yang, 2010; Kim, Mims & Holmes, 2006; Nortcliffe & Middleton, 2013).

This enthusiasm has been tempered by the realization that social and educational smartphone use are different and need to be more fully understood (Merchant, 2012) and that there are also costs associated with the use of mobile technologies for educational purposes (eg, Economides & Nikolaou, 2008; Gupta & Koo, 2010; Masrom & Ismail, 2010). These concerns range from the usability of small devices to the costs associated with deploying and maintaining the technology. Even though most studies would not suggest that smartphones are a silver bullet to improve education, their use within a network of other technologies (ie, ubiquitous computing environments; Weiser, 1991) is generally viewed as a favorable direction by most researchers. Mobile devices, from laptops and tablets to smartphones and personal digital assistants, allow students to enhance, support and improve access to learning in almost any setting (Guy *et al*, 2010).

While research in m-learning has been expanding at a tremendous rate over the last decade (Hwang & Tsai, 2011), much of the published literature has concerned itself with the use and assessment of specific applications that have been developed to deliver content to the students in classroom settings (eg, Morales & Toledano, 2010; Williams, 2010). However, we are unaware of significant research that has been conducted to explore how mobile technology is used more naturalistically across classes, settings and time periods without a specific application to define the usage of the device. Questions regarding what students do with their devices in an academic environment and how they assess the effectiveness of their devices to support their educational goals when such activities are not specifically proscribed by the class or instructor have not been empirically addressed.

This is the goal of the present study. We logged students' iPhone usage over an extended time period to explore how the educational material is accessed on these devices. The recorded data provide the actual usage of education-related materials vis-a-vis all other activity performed on the devices. Previous to this study, the participants that we logged did not own or use a smartphone. Since this was their first experience using a smartphone in an educational setting, we assessed their perception of the potential value of their devices toward their educational goals before they used the instrumented iPhones. Following the year-long data-recording portion of the study, students again answered the same survey questions to ascertain the realized value of their smartphones to support their educational goals. Our primary interest is the change in these perceptions over time.

Methods

We designed a methodology that collected the realistic use data from actual smartphone activity in a group of university students over the course of a year (February 2010 to February 2011). The naturalistic and longitudinal smartphone usage data were recorded with customized logging technology and supplemented with self-reports gathered before and after the study period. This unique methodology has been described elsewhere (see Tossell, Kortum, Shepard, Rahmati & Zhong, 2012).

Participants

The participants in the study were 24 undergraduate students ($M = 19.2$ years old, $SD = 2.48$ years old) that had not previously owned a smartphone. Additionally, none of the students owned a tablet such as an iPad, though all but one owned a laptop. Among the participants, 14 students were male, and 10 were female. Though all students attended the same university, they were diverse in terms of academic majors, ethnicity and socio-economic status, as shown in Table 1.

Table 1: Participant demographics

Gender	58% male 42% female
Class	17% Freshman 29% Sophmores 21% Juniors 33% Seniors
Major	37% Natural sciences 30% Engineering 15% Social sciences 15% Interdisciplinary 3% Humanities
SES	54% Low SES 46% High SES
Ethnicity	67% Asian 25% Caucasian 4% Indian 4% African American

SES, socio-economic status.

This study was not associated with any particular course or course content so students were not intentionally recruited out of a shared course or academic major.

Materials

The university students received iPhones (Apple, Cupertino, CA, USA) in exchange for their participation in the study. These iPhones ran iOS 3.1.3 and were instrumented with a custom-built logger that unobtrusively collected all usage data. Participants also received free voice, text messaging and data service for the entire 1-year study period. The university had just completed a significant wireless network installation before the start of the study, providing nearly 100% coverage in all of the buildings on campus, including the residential colleges, and the phones were 3G enabled to insure ubiquitous connectivity regardless of location. Upon successful completion of the study, participants were allowed to keep their iPhones after the logging technology was removed.

Measuring instruments

Students were not required to do anything for their usage to be recorded. The unobtrusive logging technology collected all participant activities on their devices. Application usage was time stamped, anonymized and recorded in real time. For privacy, the logger obfuscated any personal information including phone numbers, names and message content. A more thorough description of the logger technology can be found in Shepard, Rahmati, Tossell, Kortum and Zhong (2010). In addition to collecting data from every application launch, we logged every uniform resource location (URL) accessed from the Safari web browser.

Two surveys were given to students. The first was given before the smartphones were handed out to assess students' perceptions of the potential use of the iPhone in assisting with their education. The second survey was administered 1 year later after data logging was completed and asked about the student's perceptions of actual use of their devices within an educational setting. All responses were on made on a 5-point scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). The items used in the surveys administered before and after data logging were the same except for verb tense. See Table 4 for the primary survey questions.

Attached to the final survey was a series of open-ended questions to help interpret the logged data. These questions included specific questions regarding the most common locations of usage, why they were using particular applications at these locations and why they used each of the applications on their springboards.

Procedure

Prior to the start of the study, students signed an Institutional Review Board-approved statement of consent and took the initial survey. Once participants received their phones, they were given no instructions about how to use the device, save for their agreement to use their instrumented iPhones as their only mobile phone. The logger automatically started to record data in the background when the smartphone display was turned on and continued to run in the background anytime the device was running. After 1 year, we administered the final surveys and, once completed, removed the logger from their devices. Participants were then allowed to keep their iPhones as compensation for taking part in the study.

Results

Smartphone use patterns

All 24 participants successfully completed the year-long study with their devices. Students' iPhones were actively being used for an average of 1.5 hours per day ($M = 91.04$ minutes, $Median = 86.13$ minutes, $SD = 50.11$ minutes), and applications were launched an average of 68 times per day ($M = 68.49$, $Median = 64.16$, $SD = 37.72$). Figure 1 shows the variability of use across participants.

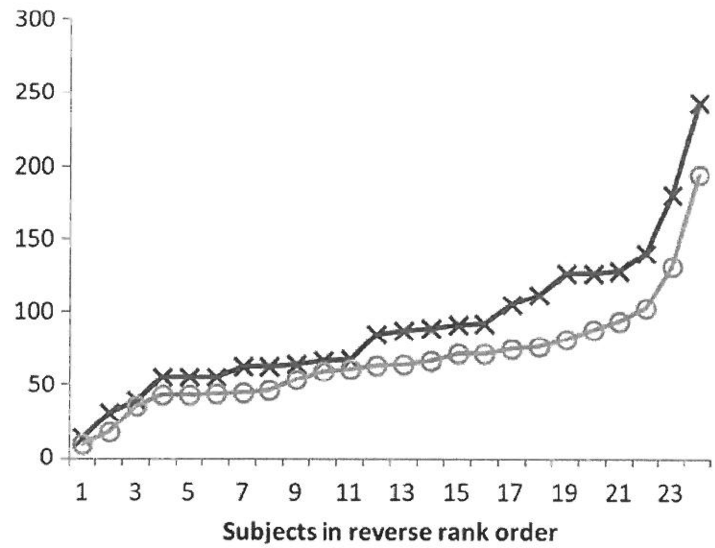

Figure 1: Volume of smartphone use by subjects as recorded by logging technology. —×—, minutes per day; —○—, launches per day

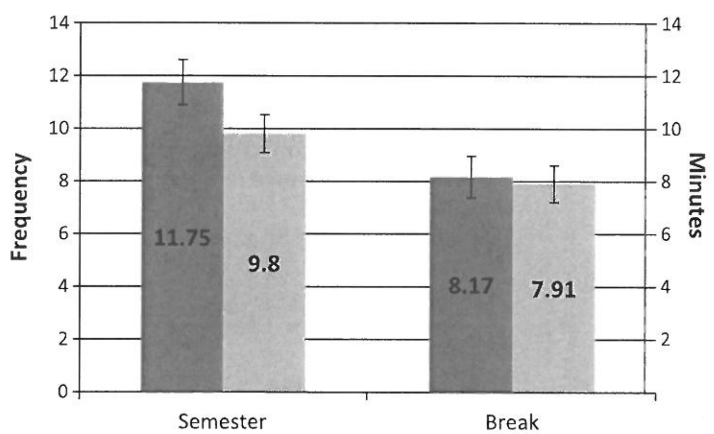

Figure 2: Frequency of launches and minutes spent using the smartphone per user per day (PUPD) separated by semester versus holiday break periods. ■, launches (PUPD); ■, duration (PUPD)

Students used their device more during the academic year versus the summer and winter holiday breaks (Figure 2). Open-ended survey responses provided an additional detail regarding the different ways smartphones were used during these periods. Every user reported that they primarily used their phones away from the classroom (eg, on the shuttle, in the bathroom, etc.). Students also reported that they used their devices to accomplish school-related tasks. A total of 63% of users indicated that their iPhones were useful during this time to complete important tasks such as accessing the course schedule, class announcements and the academic calendar. These students also interacted with other applications not related to school activities. The other 37% of users stated they only filled this dead time with noneducational activities, such as playing games and engaging in personal social networking.

Over 65% of all application launches consisted of opening the top four communication/social applications: text messaging (SMS), voice phone, email and Facebook (Figure 3). Additionally, almost half of this percentage is accounted for by the Messages application. Indeed, the text messaging application (ie, SMS) was by and large used most frequently by participants relative to

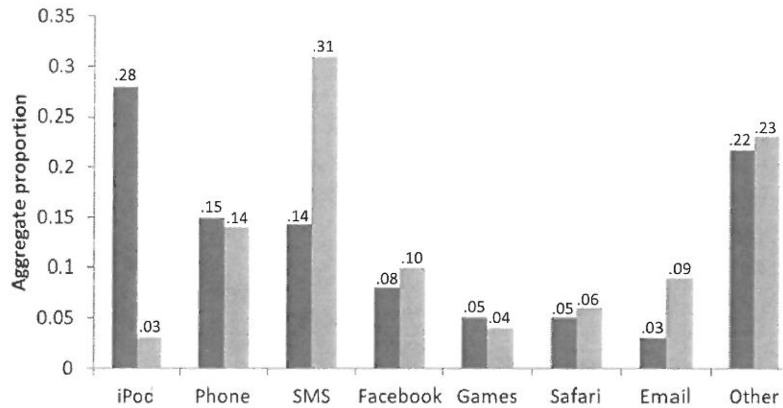

Figure 3: Most popular applications used based on the proportion of launches and duration consumed. ■, *duration;* ■, *launches*

Table 2: Aggregate percentages of applications installed by participants

Category	*Examples*	%
Books	iBooks, Marvel Comics	1
Business	Documents to Go, GoToMeeting	1
Education	Rice, Wikipedia	3
Entertainment	Netflix, YouTube	8
Finance	Bank of America	1
Games	AngryBirds, WordsWithFriends	48
Health	WebMD, Ambiance	2
Lifestyle	eBay, Groupon	4
Media	Pandora Radio, Shazam	5
Medical	Merck Manual, Epocrates	1
Navigation	Google Maps, Spyglass	1
News	New York Times, CNN	1
Photography	iPhoto, Over	1
Productivity	Dropbox, Keynote	4
Reference	Merriam-Webster, Ancestry	4
Social network	Twitter, Facebook	5
Sports	ESPN, Coaches Eye	1
Travel	United, Travelocity	2
Utilities	Flashlight, Calculator	6
Weather	Weather Channel, AccuWeather	1

Categories are based on the Apple scheme as implemented in the AppStore.

all other applications. In terms of the time participants spent on their applications, communication applications also accounted for the highest duration of use (approximately 42%). However, for single application usage, the iPod music player had the longest duration use of any application by far.

Most of the applications that were installed throughout the year by the users were used more for entertainment than learning associated with classroom activities. Games were installed more than any other application across the users in this study, representing approximately 48% of all installed applications (Table 2). By contrast, only 3% of all applications installed were education applications based on the categorization scheme used by Apple in the AppStore. Self-reports on the kinds of applications participants used were consistent with this finding. After being

Table 3: Percentage of URL visits by type and study time periods

Category	*(93 days) Spring*	*(110 days) Summer*	*(112 days) Fall*	*(32 days) Winter break*	*(18 days) Spring 11*	*(365 days) Overall*
Education (Rice.edu, Wikipedia)	27.7	21.4	41.6	30.7	41.8	32
Entertainment (Fandango, Cracked)	15.1	31.9	19.2	21.1	10.1	19
Social/blog (Neoseeker, Facebook)	12.3	11.7	11.6	6.7	13	11
News/sports (ESPN, NYtimes)	14.9	7.8	9.1	13.6	6.4	11
Commerce (Ebay, Amazon)	11.8	8.2	9.6	11.4	8.9	10
Adult (Pornhub, LiveXXX)	4.4	6.7	4.1	2.2	5.7	5
Health (WebMD, Teamhealth)	3.8	6	2.2	4.7	4.4	4
Technology/help (eHow, Apple)	6.8	3.9	1.7	2.1	4.5	4
Religion (Watchtower, Biblegateway)	1.3	1.2	0.6	4.3	3.8	3
Travel/weather (Orbitz, Weather.com)	1.9	1.2	0.3	3.2	1.4	1
Total	100	100	100	100	100	100

The number of days in each time period is given so that relative comparisons can be made.

prompted to look at their device springboards, subjects reported that 75–100% of their installed applications had no learning function but were used exclusively for fun ($M = 90.3\%$, $SD = 3.4\%$). Some applications, however, were specifically installed for learning and education purposes. Every user in the study installed the university's official application, and 83% of the students installed Wikipedia Mobile. Although these applications were almost universally installed, they were not used frequently or for a substantial amount of time relative to other applications.

Subjects largely agreed that the two most frequently used applications to support education were email and Safari. Email was reported to be primarily used to support communication related to school activities, and we did not further analyze with logged data because the content of these messages was not captured. Though web browser usage did not consume much of students' overall usage of their device (roughly 5% of overall launches and duration of use), we analyzed these data more closely to ascertain how the browser was used to help with learning goals. All URLs visited by our users were manually classified into 10 topical categories (Table 3). To enhance the reliability of this classification, four coders who were also students at the university were recruited to categorize the 112 447 URLs visited by the participants. These coders significantly agreed with each other, achieving a high Kappa score of .87 (Landis & Koch, 1977). The disagreements were reconciled by the authors using a "majority rule" approach. Websites associated with education were the highest used category of sites when school was in session. When school was not in session, entertainment sites were the most highly visited.

Similar to email, web pages were visited more frequently in the early part of the study, decreasing as users gained more experience with the device. Corresponding to this overall decrease, the use of web content for education purposes also decreased during the summer holiday break (Figure 4). After this holiday break, students continued to use the Web to gather information throughout the year, albeit with lower frequencies and durations. Clearly, educational URLs comprise the vast majority of web use during the time school is in session, falling to levels observed for other browser activity during school holiday breaks. Before the summer, users visited sites such as Wikipedia, VarsityTutors and other various sites for informal learning in addition to OwlSpace (the university's learning management system). After summer, most of the education-classified web access was comprised of access to OwlSpace with a dramatic reduction to sites that might support informal learning. In fact, Wikipedia was visited 80% more frequently before the summer break.

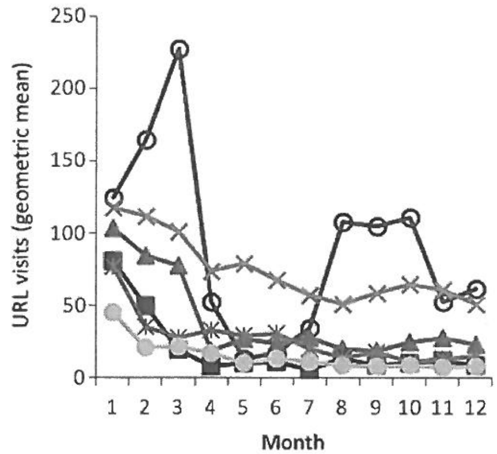

Figure 4: URL visits on the web browser by category over the course of the study. Months 4–6 are during the summer break, and month 11 is the winter break period. Geometric means are used to attenuate the influence of outliers. —o—, education; —×—, entertainment; —▲—, social networking; —■—, news/sports; —✱—, commerce; —●—, other

Table 4: Results of the surveys given at the beginning and end of the study

	Survey 1 (M)	Last survey (M)	Difference	Survey 1 (SD)	Last survey (SD)
My iPhone helped me get better grades.	3.71	1.54	−2.17***	0.37	0.27
My iPhone distracted me from school-related tasks.	1.91	4.03	2.12***	0.36	0.38
I always have to check my phone.	1.36	4.25	2.89***	0.86	0.74
I can control when and where I check my iPhone.	4.41	3.04	−1.37***	0.89	0.83
I used my iPhone for learning in the classroom.	3.1	1.87	−1.23***	1.03	0.91
I used my iPhone for learning outside of the classroom.	4.38	3.22	−1.16**	0.93	0.96
My iPhone helped me more with my studies than distracted me.	3.35	2.14	−1.21***	0.92	0.46
Since getting my iPhone, I have had more time to think deeply.	2.42	2.34	−0.08	1.12	0.8
The iPhone helped me do well on academic tests.	3.88	1.68	−2.2***	1.02	0.31
The iPhone helped me stay updated with academic activities.	4.13	4.18	0.05	0.96	0.43
The iPhone helped me with my homework	3.14	1.49	−1.65***	0.71	0.27
GPA	3.52	3.37	−0.15***	0.37	0.34

**$p < .01$; ***$p < .001$.
Note 1: Future verb tense was used for items in Survey 1.
Note 2: Bonferroni adjustments were made for multiple t-tests.
GPA, grade point average.

Self-reports: distraction and learning value

Table 4 shows the differences in student perceptions at the beginning of the study and following its conclusion. Before they received their device, students generally believed that their iPhones would help them obtain better grades and would not have any negative impact on their education. After use of the iPhone for the entire study period, student perceptions changed dramatically. Independent t-tests with Bonferroni adjustments revealed participants significantly *overestimated* the value of their iPhones for achieving higher grades. Additionally, participants *underestimated* how much the iPhones would distract them from their studies. After the study, participants reported that their iPhones were more of a distraction than a help, and they had noticed large changes in habitual behaviors associated with the need to continuously check their iPhone. Indeed, students indicated at the beginning of the study that they would have a high degree of control of where and when they checked their phone. However, at the end of the study they indicated that they had significantly less control over this checking behavior.

Table 4 also shows several other large changes in students' perceptions that are of note. Students' perceptions of their own learning both in and out of the classroom went down after using a smartphone. Students also reported a significant drop in their perception of how much the iPhone helped with success on academic tests and homework. Of particular note, at the beginning of the study, students reported an average grade point average (GPA) of 3.52 ($SD = 0.36$). This study spanned across two academic semesters, and by the end of the study, student GPAs had dropped significantly ($M = 3.37$, $SD = 0.37$). Of course, because this study did not control for course difficulty or other factors (eg, course load) across semesters, we cannot directly attribute this drop in performance to smartphone use. The only areas where the iPhone did not have a significant change in student perceptions was on the amount of time students believed they would have to perform deep thinking and their ability to keep updated on academic activities.

Discussion and conclusions

This study found some evidence that undirected smartphone use supports student educational goals, though most usage did not appear to be directed toward classroom-related learning. For instance, users often used down time to access the university portal or use the email application for school-related functions. Smartphones afforded students the ability to complete tasks associated with their education.

Still, according to students, smartphones did not facilitate enhanced learning to improve performance in the classroom. Before they regularly used a smartphone, students expected that the technology would help them complete their homework, achieve high marks on academic tests and learn outside of the classroom. Instead, after they used their smartphones, students perceived their smartphones as competitive to achievement in the classroom and learning. At the broadest level, students mostly agreed before the study that their iPhones would help them get better grades and would not be a distraction. By the end of the study, their devices were viewed as a distraction that deterred them from classroom goals. The significant drop in GPA reported above cannot be attributed to the introduction of smartphones but corresponds to user reports.

Although use of the devices for specific educational activities is clearly evident, these education-related activities were sparse relative to other activities and decreased significantly with time. This decreased use asymptotes by the end of the first semester, suggesting that once the novelty of the device has worn off, use patterns are relatively stable in this regard. This may be in part due to the exploration required to identify sites that would be beneficial to the educational experience that occurs early on in the process, and this exploration is what drives that high initial use. It is also possible that students were only able to identify a few resources that were valuable enough to revisit, and so, overall use dropped significantly to reflect the low utility offered by the available resources. This use drop-off has also been seen in the MOOC environment, where estimates of completion rates are around 10% (Rivard, 2013), with some estimates of participation going as low as 1% (Clow, 2013). Clow postulates that MOOC participation is governed by the funnel model (see Barry, 1987 for a review) where there is a decreasing yield as consumers (eg, students) move from awareness of the product, interest in using the product and desire to use that specific product to finally adopting/using/purchasing the product. This model seems to match well with m-learrning on smartphones—much initial interest, with decreasing participation as interest and desire wane over time.

Because of the data collection methodology used in this study, it is unclear how much highly used applications such as email, text messaging and voice phone were used to specifically support learning goals. For these kinds of interpretations, we relied on students' self-reports, which should be viewed with some caution (Podsakoff, MacKenzie, Lee & Podsakoff, 2003).

Indeed, the data collected in this study do not conclusively pinpoint what is driving this change in perception and why students reported their smartphones as detrimental to their learning at the end of the study period. We speculate that it is possible that smartphone use mostly filled idle moments (Matthews, Pierce & Tang, 2009; Tossell, 2012) and that perhaps this idle time was once filled with contemplation or retrieval of notes and readings. Further, the smartphone use that filled this time was likely noneducational in nature, as detrimental habits such as launching social media applications develop in most contexts (Oulasvirta, Rattenbury, Ma & Raita, 2011; Tossell, 2012).

Computing away from the desktop and classroom has been characterized as highly susceptible to interruptions (Abowd, Mynatt & Rodden, 2002), so it is also possible that because smartphones are continuously available, their use could lead to fragmented learning experiences in the real world (Qingyang, 2003). This kind of disjointed activity has been shown to be unfavorable to learning (Junco & Cotten, 2012; Rosen, Lim, Carrier & Cheever, 2011).

Usability could be another factor driving this change in perception. Smartphones provided students with access to the Internet and course resources in a wider variety of settings and at almost any time. This would suggest that preparation for scholastic activities should have been *enhanced* with these technologies. Contrary to our expectations, students felt that their preparation was *impaired* with access to the Internet and other resources through their smartphones. This attenuation could have been driven by usability issues such as small screen space, awkward text entry and long page loading delays. Users may have wanted to use their devices to support educational activities (as indicated by the high volume of usage early in the study), but technology limitations could have hindered this desire to manifest consistently over time.

Clearly, general access to mobile technology by itself appears insufficient to advance the educational performance of the student. While the ubiquitous access to information and communication may prove valuable in specific situations, these situations may be so limited as to be inconsequential compared with the distractive power of the mobile platform. Historically, educational benefits of the early Web were severely limited because of the absence of sites that were specifically designed to provide instructional value. As these sites became available and instructors began requiring their use, the educational value of web instruction became more evident. This may be the case for m-learning at this point as well. Informal learning may turn out to be only a small supporting element in a broader m-learning strategy that is supported and guided by institutions of higher learning. Another possibility is that formal and informal learning are linked—in the absence of formal requirement to use m-learning, opportunities for informal learning may be diminished. This possibility seems to be supported in work by Margaryan, Littlejohn and Vojt (2011) who found that students who reported high use of a technology for formal learning reported high use of that same technology for informal learning and the lower the percentage of formal use, the lower the use in informal learning.

Most provocatively, perhaps the results of this naturalistic study are indicative of a need for updating of the traditional classroom-centric model of education. As the old joke goes, the time traveler from ancient Greece is amazed by what he sees today in transportation, communication and infrastructure, but when he enters a classroom he exclaims "I am home!" The incompatibility between smartphones and higher education may not have to do with the technology per se but might rather be due to the fact the current model of education does not require this type of informal learning. Smartphones support ubiquitous informal learning opportunities, but the educational model being used currently provides limited need for this beneficial activity.

It is important to note that this study did not address the *structured* use of smartphones in an educational setting. There is ample evidence (described earlier) that when smartphones are used with specific learning objectives in mind, then these m-learning platforms can significantly enhance the learning experience. For example, if a specific application is used for demonstrations of a fundamental principle, or the Web is used to find information in class as part of an interactive class exercise, the unique benefits of smartphones in the classroom can add substantial value. However, this study suggests that simply providing access to a smartphone, without specific directed learning activities, may actually be detrimental to the overall learning process.

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