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# No A 4 U: The relationship between multitasking and academic performance

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ABSTRACT

The proliferation and ease of access to information and communication technologies (ICTs) such as Facebook, text messaging, and instant messaging has resulted in ICT users being presented with more real-time streaming data than ever before. Unfortunately, this has also resulted in individuals increasingly engaging in multitasking as an information management strategy. The purpose of this study was to examine how college students multitask with ICTs and to determine the impacts of this multitasking on their college grade point average (GPA). Using web survey data from a large sample of college students at one university ($N = 1839$), we found that students reported spending a large amount of time using ICTs on a daily basis. Students reported frequently searching for content not related to courses, using Facebook, emailing, talking on their cell phones, and texting while doing schoolwork. Hierarchical (blocked) linear regression analyses revealed that using Facebook and texting while doing schoolwork were negatively associated with overall college GPA. Engaging in Facebook use or texting while trying to complete schoolwork may tax students' capacity for cognitive processing and preclude deeper learning. Our research indicates that the type and purpose of ICT use matters in terms of the educational impacts of multitasking.



## 1. Introduction

The last decade has seen the advent of new technologies used by individuals to share and communicate with each other. These social technologies, such as Facebook and text messaging, have seen growth in adoption rates over the last ten years. A decade ago, Facebook did not yet exist having been first introduced in 2004 and becoming widely available to everyone in 2006. Pew Internet and American Life data show that teen cell phone ownership has increased from 45% in 2004 to 75% in 2010 (Lenhart, Ling, Campbell, & Purcell, 2010) and that 51% of teens reported text messaging in 2006 which increased to 72% in 2009. The latest Pew report focusing on college students found that 96% of all undergraduates owned cell phones (Smith, Rainie, & Zickuhr, 2011). The popularity of text messaging has also increased exponentially. Data from Nielsen show that the average number of text messages sent each month grew from 65 in the first quarter of 2006 to 357 in the second quarter of 2008 (Nielsen, 2008).

Compared to ten years ago, Internet users are presented with more data (in the form of news stories, friend requests, wall posts, tweets, etc.) than ever. Unfortunately, humans are unable to take in and process all of this information and turn to engaging in multitasking as an information management strategy (Chun, Golomb, & Turk-Browne, 2011). Add to that the ubiquitous nature of cell phones and text messaging and you have a society of people that are surrounded by real-time digital information that is constantly placing demands on their attention. A necessary byproduct of the fast pace of our digital lives is the ability to filter data in order to manage our attention—we must be particular about what we pay attention to, for if we try to pay attention to every byte crossing out monitors, we would most surely fail. As Chun et al. (2011) aptly state, "people attend to all kinds of information every day, but they do not encode or remember all the things that they have attended." (p. 84).

For the purposes of this paper, we use the term multitasking with the understanding that it is often used in the vernacular to describe the phenomena of divided attention or task switching, concepts from the cognitive psychology literature that are more representative of how humans attend to and process information (Chun et al., 2011). Therefore, we define multitasking as divided attention and non-sequential

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task switching for ill-defined tasks as they are performed in learning situations; for example, when a student is text messaging a friend while studying for an examination.

The last decade of research on multitasking has uncovered clear evidence that human information processing is insufficient for attending to multiple input streams and for performing simultaneous tasks (Chun et al., 2011; Koch, Lawo, Fels, & Vorländer, 2011; Marois & Ivanoff, 2005; Rosen, Lim, Carrier, & Cheever, 2011; Tombu et al., 2011; Wood & Cowan, 1995; Wood et al., 2012). Almost all of the research on multitasking is conducted in the cognitive sciences and focuses on simple tasks such as attending to a stream of words presented to one ear while a distractor stream is presented to the other. However, it is clear that the information processing difficulties humans experience when attempting to focus on simple stimuli transfers to more complex tasks. For instance, research shows that driving while talking and/or texting on a cell phone is associated with increased reaction times and higher rates of accidents (Drews, Pasupathi, & Strayer, 2008; Drews, Yazdani, Godfrey, Cooper, & Strayer, 2009; Strayer & Drews, 2004). Recent studies also show that talking on the phone is associated with worse pedestrian safety among college students (Stavrinos, Byington, & Schwebel, 2011).

Researchers are beginning to examine how today's college students multitask and how this affects their ability to learn material and engage in the learning process (Junco & Cotten, 2011; Mayer & Moreno, 2003; Rosen et al., 2011; and Wood et al., 2012). The purpose of this paper is to expand the research focusing on the effects of multitasking on educational outcomes among a large sample of college students.

### 1.1. College student technology use and the potential for multitasking

Nowhere is the penetration of social technologies and potential for multitasking more apparent than on college campuses. College students are part of a digital generation, born during a time when information and communication technologies (ICTs) were pervasive in our society; they have never known a time when it was not normal to use ICTs to perform daily activities (Cotten, McCullough, & Adams, 2011). They use ICTs at extremely high rates and also have to juggle classes, homework, work, and recreational activities.

A large EDUCAUSE Center for Applied Research (ECAR) study of college student ownership and use of technology ($N = 36{,}950$ students and 127 universities) found that over 73% text message daily, 99% own a computer (with 84% owning laptops), and 90% use social networking websites. The most popular social networking website is Facebook, with 97% of students saying they use the site (Smith & Caruso, 2010). Junco (2012) found that 92% of undergraduates used Facebook and spent an average of over 1 h and 40 min on the site per day. Ninety-six percent of young adult Internet users use search engines to find information and search engine use is the most popular Internet activity after email (Fallows, 2008; Purcell, 2011). Cell phones are also very popular with college students. A higher proportion of undergraduate college students own cell phones compared to same-aged non-students (Smith, Rainie, & Zickuhr, 2011). Eighty-eight percent of teenage cell phone owners send text messages, with those 14–17 years old typically sending 123 text messages a day (Lenhart et al., 2010).

Other technologies have decreased in popularity with college students. Data from 2007 (Junco & Mastrodicasa, 2007) show that students who used instant messaging (IM) typically spent over 1 h and 20 min actively chatting each day; more recent data using a younger sample (Rideout, Foehr, & Roberts 2010) found a steep decline with 15–18 year olds reporting using IM only 14 min per day. College students have shifted from using email for communicating with friends to using email for communicating with their professors (Carnevale, 2006; Lenhart, Madden, & Hitlin, 2005) and prefer it for official university communications (Salaway, Caruso, & Nelson, 2007).

### 1.2. Digital inequalities

While research shows that there is a high adoption rate of social technologies among college students, digital inequalities still persist. Technological ownership, adoption and use within the overall population and within the population of college students vary according to gender, race, and socioeconomic status (Cooper & Weaver, 2003; DiMaggo, Hargittai, Celeste, & Shafer, 2004; Hargittai, 2008a; Junco, Merson, & Salter, 2010; Kaiser Family Foundation, 2004; Rideout et al., 2010). Junco et al. (2010) found that female and white college students were over twice as likely to own a cell phone as male and African American students and more affluent students were over three times as likely to own a cell phone. African American students were more likely to send text messages than Whites (Horrigan, 2009), send more text messages and spend more time talking on cell phones than others (Junco et al., 2010). Women typically send more text messages than men (Junco et al., 2010; Rideout et al., 2010). Hargittai (2010) found that women, students from lower socioeconomic backgrounds, and African American and Latino students reported knowing less about the Internet even when controlling for online experience. She also found that Latino students were less likely to use Facebook than Caucasians, and that students whose parents had a college degree were more likely to use Facebook than students whose parents did not have a college degree (Hargittai, 2008b).

### 1.3. Multitasking and educational outcomes

Much research has examined the effects of multitasking on human information processing. Koch et al. (2011) found that there were significant performance costs (in both accuracy and reaction time) when switching between two auditory stimuli and that these costs were not reduced by advance preparation of participant's attention. Tombu et al. (2011) found that participants responded more slowly on dual task trials than on single task trials (for both auditory-vocal and visual-manual tasks) and had poorer accuracy. Additionally, using time-resolved fMRI, they found that an information processing bottleneck seems to be located in the prefrontal regions of the brain (Tombu et al., 2011). Attempting to either attend to or process more than one task at a time overloads the capacity of the human information processing system (Koch et al., 2011; Marois & Ivanoff, 2005; Strayer & Drews, 2004; Tombu et al., 2011; Wood & Cowan, 1995), which results in real-world consequences due to the costs of task switching (Koch et al., 2011; Tombu et al., 2011). The consequences of task switching extend to more complex tasks like driving and learning.

Research on distracted driving shows that drivers who talked on a hands-free cell phone had 18% slower brake onset times, took 17% longer to recover the speed that was lost after braking, and were involved in twice as many rear-end collision as those not talking on a phone (Strayer & Drews, 2004). Talking on a hands-free cell phone caused drivers to make more driving errors than when talking to a passenger (Drews, Pasupathi, & Strayer, 2008). Drivers who engaged in text messaging had longer brake onset times, longer following

distances, more instances of inadvertent lane departures, and were involved in more crashes than drivers not engaged in text messaging (Drews et al., 2009).

Some researchers have wondered how the costs of multitasking affect educational outcomes (Junco & Cotten, 2011; Mayer & Moreno, 2003; Rosen et al., 2011; Wood et al., 2012). A study conducted by Junco and Cotten (2011) found that students who spent more time instant messaging and who reported engaging in schoolwork while IMing reported that IM had a detrimental effect on their schoolwork. Two recent studies have used experimental designs to evaluate the effect of multitasking on learning. Wood et al. (2012) found that students who used Facebook while attending to a lecture, scored significantly lower on tests of lecture material than those who were only allowed to take notes using paper-and-pencil. Across the experimental and control groups, students who did not use technology outperformed students who did use technology during lectures. In addition, students who were classified as non-multitaskers scored better than multitaskers, regardless of the level of multitasking they reported. In another study, Rosen et al. (2011) found that students who received more text message interruptions during a lecture performed worse on an information posttest.

Mayer and Moreno's (2003) research-based cognitive theory of learning and information overload provides a framework to understand how multitasking can affect the learning process. There are four assumptions based on the evidence of how we process information: 1. That the human information processing system has two channels—auditory and verbal; 2. That each channel has a limited capacity for cognitive processing; 3. This capacity is used when selecting and then modulating (how the selected item is processed) presented stimuli; and 4. Meaningful learning requires that a substantial amount of cognitive processing occur either in the visual or auditory channels (Chun et al., 2011; Mayer & Moreno, 2003). Cognitive overload occurs when processing demands evoked by a learning task exceed the processing capacity of the cognitive system (Mayer & Moreno, 2003). Mayer and Moreno (2003) distinguish between three types of cognitive demands during the learning process:

1. *Essential processing* refers to the basic cognitive processes required for making sense of presented material, including tasks such as selecting and organizing words and images from presented materials and integration of those words and images.
2. *Incidental processing* refers to cognitive processes that are not required for making sense of the presented materials. For instance, adding music to a presentation—the music is an extraneous stimulus that engages incidental processing.
3. *Representational holding* refers to processes that hold mental representations in working memory. An example would be providing questions about a video on a web page separate from that video—the viewer must use representational holding to remember the questions about the video while watching it.

### 1.4. Research questions and hypothesis

Few published studies have examined the effect of multitasking on educational outcomes. The notable exceptions are the studies by Junco and Cotten (2011), Rosen et al. (2011), and Wood et al. (2012). The data from Junco and Cotten (2011) were collected between 2006 and 2007, a time when IM was a popular online activity for college students. However, in the intervening years other technologies have increased in popularity while IM use has declined (Pew Internet and American Life Project, 2009). Furthermore, the studies by Rosen et al. (2011) and Wood et al. (2012) examined the impact of multitasking on immediate recall of information. These studies support the notion that meaningful learning requires sustained attention to material over time (Chun et al., 2011; Mayer & Moreno, 2003). In this study, we will extend previous research by evaluating the impact of engaging in a number of popular ICT activities (searching for content, using Facebook, email, IM, talking, and texting) while studying on overall college GPA. Furthermore, it is possible that Internet skills played a role in the relationship between multitasking and academic impairment in the Junco and Cotten (2011) and the Wood et al. (2012) studies; therefore, we will include an established measure of Internet skills as a control variable (Hargittai & Hsieh, 2012). We will also use an actual measure of student academic performance, actual grade point average (GPA) collected from the university registrar.

The research questions examined for the current study are:

*Question 1: How frequently do college students use ICT's and how frequently do they use these technologies at the same time they are doing schoolwork?*

*Question 2: Controlling for demographic variables, high school grade point average, time spent preparing for class, and Internet skills, how does frequency of using technology while conducting schoolwork relate to academic performance as measured by overall college GPA?*

Given the high levels of technology use among college students, the research on multitasking, Mayer and Moreno's (2003) theory of learning, and the research in this area, we hypothesize that the use of ICT's in conjunction with attempting to complete schoolwork will result in detrimental educational outcomes.

## 2. Methods

### 2.1. Participants

All students surveyed were U.S. residents admitted through the regular admissions process at a 4-year, public, primarily residential institution in the Northeastern United States ($N = 3866$). The university's Institutional Review Board for human subjects approved the research protocol. The students were sent a link to a survey hosted on SurveyMonkey.com, a survey-hosting website, through their university-sponsored email accounts. For the students who did not participate immediately, two additional reminders were sent, one week apart. Participants were offered a chance to enter a drawing to win one of 90 $10 Amazon.com gift cards as incentive. A total of 1839 surveys were submitted for an overall response rate of 48%. The data were downloaded as an SPSS file directly from SurveyMonkey, screened for anomalies and analyzed using PASW (formally SPSS) Statistics 18.0. Initial screening showed that 65 survey responses were unusable because they were not completed; therefore, the final sample size was 1774.

### 2.2. Instrument/measures

#### 2.2.1. Key independent variables

ICT usage was measured through two main questions, each of which included various ICT types. To provide multiple measures for accuracy checks in reporting, students were asked to estimate their average time spent searching for information online, on Facebook, email, IM, and talking on their cell phones as well as the amount of time they spent "yesterday" on each activity. These were evaluated by asking students: "On average, about how much time per day do you spend on the following activities?" and "How much time did you spend on each of these activities yesterday?" with a prompt for each of the activities. Students used a pull-down menu to select the hours and minutes spent using each ICT. Students were also asked "On average, how many text messages do you send in a day?" and "How many text messages did you send yesterday?" Respondents were permitted to input a number of their choosing in a blank field. Because multitasking while doing schoolwork outside of class was the variable of interest, overall time spent studying was included in the analyses to control for the possibility that time spent multitasking was related to time spent studying (for example, it is possible that students who multitasked more increased their amount of study time to compensate). Students were asked: "About how many hours do you spend in a typical 7-day week doing each of the following?" with a prompt for "preparing for class." Hours and minutes for all variables were converted to minutes for this study.

Frequency of multitasking was evaluated by asking students "How often do you do schoolwork at the same time that you are doing the following activities?" with prompts for searching for information online that is not part of schoolwork, Facebook, email, IM, talking, and texting on their cell phones. The possible choices for multitasking frequencies were worded: "Very Frequently (close to 100% of the time);" "Somewhat Frequently (75%);" "Sometimes (50%);" "Rarely (25%); " and "Never." For the analyses, these items were coded using a five-point Likert scale with "Never" coded as 1 and "Very Frequently (close to 100% of the time)" coded as 5. To remove the proportion of the variance attributable to time spent using ICTs in ways that did not involve multitasking with schoolwork, aggregate variables were created that multiplied the percentage estimate of frequency of multitasking using an ICT by overall time spent using that ICT. The aggregate variables give an estimate of the time students spent multitasking while using each ICT. For instance, if a student reported doing schoolwork 50% of the time that they used Facebook and reported spending 100 min on the site overall, the value of the aggregate variable would be 50.

Internet skills were measured using a 27-item scale developed by Hargittai (2005). The original scale was created based on research that compared people's actual online abilities with their responses to survey questions about knowledge of Internet activities (Hargittai, 2005; Hargittai & Hsieh, 2012). Students were asked "How familiar are you with the following computer and Internet-related items?" with prompts for 27 items focusing on Internet activities and technologies. Internet skills items were coded using a five-point Likert scale ranging from "Full" to "None." For this study, "None" was coded as 1; "Little" was coded as 2; "Some" was coded as 3; "Good" was coded as 4; and "Full" was coded as 5. The Internet skills items have been used in a number of studies and have shown excellent internal consistency across datasets with Cronbach's $\alpha$ above 0.90 (Hargittai & Hsieh, 2012). Indeed, data from the current study found the Internet skills items to exhibit excellent internal consistency with a Cronbach's $\alpha$ of 0.96.

In any linear model of ICT use and grades, it is important to control for high school GPA (HSGPA), consistently found to be the strongest predictor of overall college GPA (DeBerard, Spielmans, & Julka, 2004; Geiser & Santelices, 2007; Williford, 2009). In this study, HSGPA was included in the analyses in order to parse out variance in the predictors attributable to pre-existing differences in academic ability and to also place the other predictors in context. Academic ability might be a student background characteristic related to multitasking frequency and to negative outcomes of multitasking (Junco & Cotten, 2011). For instance, it could be that students with lower academic ability may be more susceptible to the negative academic effects of multitasking. Students gave researchers permission to obtain their actual high school grade point averages (HSGPAs), which were submitted to the university during the admissions process. High school grades were measured on a 4.0 scale ranging from 0 for 'F' to 4.0 for 'A'.

Parental education was used as a proxy for socioeconomic status by asking students "What is the highest level of formal education obtained by your parents?" with prompts for "Parent/Guardian 1" and "Parent/Guardian 2." Parental education items were coded using a five-point Likert scale ranging from "Advanced graduate" to "Less than high school degree." For this study, "Less than high school degree" was coded as 1; "High school degree" was coded as 2; "Some college" was coded as 3; "College graduate (for example: B.A., B.S., B.S.E)" was coded as 4; and "Advanced graduate (for example: master's, professional, J.D., M.B.A, Ph.D., M.D., Ed.D.)" was coded as 5. The highest parental education level was used for these analyses. Students were also asked to select their gender (male/female) and their ethnicity (African American, Asian American, Hispanic/Latino, Native American, White/Caucasian, or Other).

#### 2.2.2. Outcome measures

Students gave the researchers permission to access their academic records to obtain their overall grade point averages (GPAs). Overall GPAs were measured on a 4.0 scale ranging from 0 for 'F' to 4.0 for 'A'.

### 2.3. Analyses

Descriptive statistics were run to illustrate the demographic characteristics of the sample and to describe multitasking behaviors. Correlations were run to evaluate the relationship between reported average time spent on ICTs and time spent "yesterday" in order to serve as an accuracy check in reporting. To answer research question 2, a hierarchical (blocked) linear regression analysis was conducted to determine which multitasking variables predicted overall college GPA. Using hierarchical linear regression allows for the selection of number and order of predictors inserted into the model, and "blocks" or groups them based upon a theoretical construct. The blocks, in order, were: demographic variables (gender, ethnicity and highest parental education level), high school GPA, overall time spent preparing for class, Internet skills, and frequency of engaging in multitasking with various technologies. The blocks were selected for the following reasons: demographic variables were included in their own block because previous research has found the effect of gender, socioeconomic status and/or ethnicity in relation to technology use is significant (Cooper & Weaver, 2003; DiMaggio, Hargittai, Celeste, & Shafer, 2004; Hargittai, 2008a; Junco et al., 2010; Kaiser Family Foundation, 2004). High school GPA was included as both a control variable and in order to compare other predictors' relative impact on the dependent variables. Overall time spent preparing for class was included to control for the possibility that time spent multitasking was related to time spent studying. Internet skills were included because skills play an important role in how technologies are used and

presumably, those with lower levels of Internet skills may use the Internet less and be more prone to using it in problematic ways when they do (Hargittai, 2010; Hargittai & Hsieh, 2012; Junco & Cotten, 2011). Categorical variables were dummy-coded for purposes of the regression analyses. The reference categories for these variables were: female, Latino students and "some college" for highest parental education.

Analyses were conducted to test whether the data met the assumptions of hierarchical linear regression. To test for homoscedasticity, collinearity and important outliers, collinearity diagnostics and examinations of residuals were performed. The curve estimation procedure of PASW was used to plot both linear and quadratic functions to examine linearity and found that all variables met the requirements of linearity needed for a hierarchical blocked linear regression. Examination of model fit using the curve estimation procedure indicated there were a number of outliers, which were removed from subsequent analyses. In total, 125 outliers were removed because of extreme scores on either high school GPA (either lower than a 2.00 or higher than a 4.00), reported time spent preparing for class (spending more than 3000 min per week doing so), frequency of Facebook use (spending more than 600 min per day on the site), email use (more than 539 min per day), talking on their cell phone (talking more than 419 min per day), texting (sending more than 500 texts in one day), searching (spending more than 495 min per day), email multitasking (spending more than 180 min per day), talking on the cell multitasking (spending more than 180 min per day), IM multitasking (spending more than 180 min per day), or searching multitasking (spending more than 240 min per day), thus bringing the total sample size to 1649 students. Collinearity diagnostics found that the independent variables were not highly correlated, with all tolerance coefficients being greater than 0.20. Examination of the residual plots show that variance of residual error was constant across all values of independents, indicating homoscedasticity.

## 3. Results

### 3.1. Descriptive statistics

Sixty-four percent of those who took the survey were female. The mean age of the sample was 21, with a standard deviation of four. The age of participants ranged from 17 to 56, though 88% were between 18 and 22 years old. Thirty percent of students in the sample were first year students, 24% were sophomores, 21% were juniors and 25% were seniors. Highest educational level attained by either parent was as follows: 28% had a high school degree or less, 25% completed some college, 34% were college graduates and 13% had a graduate degree. In terms of race and ethnicity, the sample was overwhelmingly Caucasian, with 91% of students listing that as their race. Additionally, 5% of the sample was African American, 2% were Latino, 1% were Asian American, and 2% identified as "other" (Native Americans were included in "other" because there were only three in the sample). The gender, race, and ethnic breakdown of the sample was similar to that of the overall university population, excepting a slight overrepresentation of women in this sample. The average HSGPA in the sample was 3.32 (SD 0.45) and the average overall college GPA was 2.96 (SD 0.65). Lastly, students spent an average of 702 (SD 507) min per week preparing for class.

### 3.2. Correlations

ICT usage measures were strongly and significantly correlated with their associated "yesterday" usage measures (Pearson's $r$ ranged from 0.53 to 0.88 all with $p < 0.001$). We therefore used only average time spent on each ICT as well as average text messages sent for these analyses.

### 3.3. Research question 1: how frequently do college students use ICTs and how frequently do they use these technologies at the same time they are doing schoolwork?

Table 1 provides means and standard deviations of time spent using each ICT and amount of time spent multitasking while using each ICT. The college students in this sample spent the most time searching online, using Facebook, talking, and emailing. Students also reported sending 97 text messages per day on average. Instant messaging, on the other hand, was the least used with a mean of 14 min per day. When we examine the reported frequency of multitasking with these activities (see Table 2), it appears that texting, Facebook, and email multitasking are done most often; 51% of respondents reported texting, 33% reported using Facebook, and 21% reported emailing while doing schoolwork somewhat or very frequently. While not one of the top multitasking activities, 16% of students reported searching for information online that is not part of schoolwork while doing schoolwork somewhat or very frequently. Instant messaging was the least often used in multitasking, with 67% of respondents reporting that they never do this.

When examining amount of time spent doing schoolwork while using ICTs, it appears that students spent the most time using Facebook, searching for non school-related information online, and emailing. While doing schoolwork outside of class, students reported spending an average of 60 min per day on Facebook, 43 min per day searching, and 22 min per day on email. Lastly, students reported sending an average of 71 texts per day while doing schoolwork.

**Table 1**
Means and standard deviations of overall time spent using each ICT and of amount of time spent using each ICT while doing schoolwork ($N = 1649$).

| Activity | Mean min/day (SD) | |
|---|---|---|
| | Overall | Multitasking |
| Search | 118 (84) | 43 (51) |
| Facebook | 101 (89) | 60 (71) |
| Email | 49 (44) | 22 (28) |
| Talk | 51 (54) | 17 (27) |
| IM | 14 (38) | 7 (23) |
| | Mean number/day (SD) | |
| | Overall | Multitasking |
| Text messages | 97 (109) | 71 (95) |

**Table 2**
Frequency with which students reported doing schoolwork while using each ICT ($N = 1649$).

| Activity | Multitasking frequency (% reporting) | | | | |
|---|---|---|---|---|---|
| | Never | Rarely (25%) | Sometimes (50%) | Somewhat frequently (75%) | Very frequently (100% of the time) |
| Search | 26 | 34 | 25 | 12 | 4 |
| Facebook | 21 | 20 | 27 | 25 | 8 |
| Email | 21 | 31 | 28 | 17 | 4 |
| Talk | 35 | 38 | 21 | 6 | 1 |
| IM | 67 | 16 | 9 | 6 | 2 |
| Text messages | 8 | 16 | 25 | 34 | 17 |

### *3.4. Research question 2: controlling for demographic variables, high school grade point average, and Internet skills, how does frequency of using technology while conducting schoolwork relate to academic performance as measured by overall college GPA?*

The hierarchical linear regression predicting overall GPA ($F_{(18,1623)} = 28.274$, $p < 0.001$, Adjusted $R^2 = 0.232$) was significant. In block 1 (see Table 3), demographic factors were significantly related to GPA. Specifically, males had lower GPAs and African Americans had lower GPAs than Latinos. Block 2 added HSGPA to the demographic factors. The patterns remained the same for gender but African Americans were not less likely to have lower college GPAs in block 2. As expected, HSGPA was a significant positive predictor of GPA. In block 3, time spent preparing for class was added. In this block, gender was no longer a significant predictor while those with parents with an advanced degree had higher grades than those with some college. Time spent preparing for class was positively predictive of GPA.

Block 4 added the measure of Internet skills. The results remain the same as in block 3 in terms of class status, HSGPA, and time spent studying, while being male was again a significant negative predictor of GPA. Furthermore, Internet skill was positively associated with GPA. Block 5 added the multitasking variables. The results in block 5 show that the effects of multitasking on college GPA vary depending upon the specific types of ICT use being examined. For instance, multitasking while using Facebook and texting were associated with lower overall college GPA. Emailing, searching, talking on the phone, and instant messaging multitasking measures were not associated with college GPA. The results for the demographic and high school GPA variables remained the same as in block 4. Of particular interest was the finding that the $R^2$ change for time spent preparing for class was .036, just marginally higher than the $R^2$ change for the multitasking variables showing that time spent studying explains only slightly more of the variance in GPA than multitasking.

## 4. Discussion

### *4.1. Research question 1: how frequently do college students use ICT's and how frequently do they use these technologies at the same time they are doing schoolwork?*

Results show that students spend a large amount of time using ICTs. For example, students in this sample reported spending almost 2 h each day searching for information online. Additionally, the results show that students reported frequently using all of the ICTs studied, except IM, while they are doing schoolwork. Even though this sample is limited to one university, the results are congruent with other research on student use of technology. While other studies have not reported the amount of time spent conducting online searches, Fallows (2008) and Purcell, 2011 found that search engine use was the second most popular online activity after email while we found that searching was the most popular online activity. Congruent with Junco's (2012) finding that students spent an average of 1 h and 40 min a day on

**Table 3**
Hierarchical regression model exploring how demographics, high school GPA, Internet skill, and ICT multitasking predict overall GPA ($N = 1624$).

| | Block 1 demographics | Block 2 HSGPA | Block 3 study time | Block 4 Internet skills | Block 5 multitasking |
|---|---|---|---|---|---|
| Independent variables | $\beta$ | $\beta$ | $\beta$ | $\beta$ | $\beta$ |
| Male | −0.128*** | −0.053* | −0.038 | −0.047* | −0.080** |
| African American | −0.089* | −0.068 | −0.063 | −0.063 | −0.066 |
| Asian American | 0.015 | 0.001 | 0.001 | 0.000 | −0.001 |
| Other ethnicity | −0.029 | −0.032 | −0.037 | −0.037 | −0.050 |
| Caucasian | 0.040 | 0.017 | 0.016 | 0.017 | 0.007 |
| Less than high school | 0.004 | 0.032 | 0.029 | 0.029 | 0.024 |
| High school | 0.008 | 0.024 | 0.028 | 0.031 | 0.030 |
| College graduate | 0.041 | 0.027 | 0.038 | 0.039 | 0.039 |
| Advanced grad degree | 0.050 | 0.051 | 0.054* | 0.055* | 0.053* |
| High school GPA | | 0.387*** | 0.374*** | 0.375*** | 0.371*** |
| Time preparing for class | | | 0.190*** | 0.190*** | 0.170*** |
| Internet skills | | | | 0.045* | 0.049* |
| Facebook multitasking | | | | | −0.112*** |
| Email multitasking | | | | | 0.038 |
| Searching multitasking | | | | | 0.001 |
| Texting multitasking | | | | | −0.088*** |
| IM multitasking | | | | | 0.019 |
| Talking multitasking | | | | | −0.044 |
| Adjusted $R^2$ | 0.031 | 0.172 | 0.207 | 0.209 | 0.232 |
| $R^2$ change | 0.037*** | 0.140*** | 0.036*** | 0.002* | 0.026*** |

Note. $\beta$ = Beta, the standardized regression coefficient.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Facebook, we found that students spent an average of 1 h and 41 min per day on the site. Students in this sample spent almost an hour every day using email. They also sent an average of 97 text messages a day, generally congruent with the average of 118 texts per day found by Rideout et al. (2010) and the 123 found by Lenhart et al. (2010). Lastly, we found that IM use was the least popular activity. Students reported spending an average of 14 min per day on IM, which was congruent with the average of 14 min found by Rideout et al. (2010).

College students frequently used ICTs at the same time they are doing schoolwork. Results show that students sent texts, talked on their cell phones, used Facebook, used email and searched for information online that was not part of schoolwork frequently at the same time as doing schoolwork. Contrary to prior research by Junco and Cotten (2011), students did not multitask frequently while using IM with only 8% saying they did this either somewhat or very frequently and spending only 7 min per day on average doing so. This finding can be explained by the fact that the college students from this university did not report using IM a great deal.

### *4.2. Research question 2: controlling for demographic variables, high school grade point average, and Internet skills, how does frequency of using technology while conducting schoolwork relate to academic performance as measured by overall college GPA?*

Results from the hierarchical linear regression show that using Facebook and texting while doing schoolwork were negatively predictive of overall GPA. Even though online searching was a high-frequency activity (in both time spent on the activity and frequency of multitasking), it was not predictive of overall GPA. Moreover, emailing, talking on the phone, and using IM were not related to overall GPA. These findings are congruent with the literature in cognitive science showing that attempting to pay attention to two stimuli simultaneously reduces one's ability to both pay attention and process either of those stimuli (Koch et al., 2011; Marois & Ivanoff, 2005; Strayer & Drews, 2004; Tombu et al., 2011; Wood & Cowan, 1995). They are also congruent with our hypothesis that the use of ICTs in conjunction with attempting to complete schoolwork will result in detrimental educational outcomes. Furthermore, these findings, while based on self-report, were congruent with the studies by both Rosen et al. (2011) and Wood et al. (2012) that found that using Facebook and texting while attending to lectures caused students to perform more poorly on exams based on those lectures. However, unlike the Rosen et al. (2011) and Wood et al. (2012) studies, this one examined multitasking while outside of the classroom. It is conceivable that the way students multitask is different across contexts—in other words, students might be able to ignore distractors better in class since they understand they have a finite amount of time with which to learn the information.

Comparing the results of the current study with the results of the Rosen et al. (2011) and Wood et al. (2012) studies shows that multitasking with certain technologies, across contexts (i.e., in class and outside of class) while trying to learn relates to poorer academic outcomes. Specifically, attempting to pay attention to Facebook and text messaging was related to poorer academic outcomes in both contexts (in and out of class). These findings can be understood by using the framework provided by Mayer and Moreno (2003): attempting to pay attention to Facebook or text messaging and to schoolwork at the same time will yield reduced capacity for *essential processing* and *representational holding* while increasing the *incidental processing* necessary for a given task.

Engaging in Facebook use or texting while trying to complete schoolwork taxes the student's limited capacity for cognitive processing and precludes deeper learning. First, paying attention to Facebook or texting while studying limits *essential processing* because energies focused on attending to these technologies cannot be focused on making sense of study material. For example, reading a friend's Facebook wall uses up basic cognitive processes required for selecting and organizing words and images from class notes. Second, using Facebook or texting while studying limits the capacity for *representational holding* because working memory is taxed while trying to pay attention to competing stimuli. As such, *representational holding* is limited by the information processing bottleneck—there is only a limited amount of information that can be held in working memory and when that limit is reached, other information cannot be held (Koch et al., 2011; Marois & Ivanoff, 2005; Strayer & Drews, 2004; Tombu et al., 2011; Wood & Cowan, 1995; Wood et al., 2012). If *representational holding* is limited, the presented information cannot be encoded for deeper learning. Therefore, when a student is texting, she or he is unable to hold study material in working memory and in turn, cannot process that information in a meaningful way.

While the findings that using Facebook and texting were negatively related to GPA were congruent with previous research on multitasking as well as Mayer and Moreno's (2003) framework for understanding how multitasking can affect the learning process, the nonsignificant effects of multitasking while talking on the phone, using IM, emailing, and searching for information online that wasn't a part of schoolwork were not. While Junco and Cotten (2011) found a negative effect of IM use, Wood et al. (2012) found that IM use and emailing were not related to decrements in scores on tests of lecture material. In the current study, the finding that multitasking with IM was not significant can be explained by the fact that students did not use IM much overall and they did not use IM much while doing schoolwork. However, students reported frequently searching and using email while doing schoolwork and those variables were not significant in the current study while texting, emailing, and IM were not significant in the Wood et al. (2012) study.

As Wood et al. (2012) suggest, there may be something about the technologies themselves that leads to poorer outcomes when used while studying; an issue worthy of exploration in future research. It is also possible that the discrepancies in outcomes between using Facebook and texting or talking, emailing, and searching may lie in the nature of *how* the technologies are used. One possibility is the frequency with which students use these technologies while studying. For instance, Rosen et al. (2011) found that while students in the high text messaging interruption group (those who sent and received over 16 messages during a 30 min class period) scored lower on an information posttest than those in the no/low text messaging group (sent and received 0–7 messages), there was no difference in score between the moderate text messaging group (sent and received 8–15 messages) and the other groups. Students in the current study sent an average of 71 text messages per day while studying; however, it is unclear as to how those were spread across their study sessions. Moreover, while students reported spending an hour per day using Facebook while studying, we don't have data on frequency of actively engaging on the site (vs. leaving Facebook open and in the "background" while studying). Certainly, more frequent and active use of ICTs while studying would lead to increased impairment in *essential processing* and *representational holding*. It is possible that there is a threshold for impairments in *essential processing* and *representational holding* that may be related to a certain (and specific) combination of the characteristics of the ICT as well as frequency of use. Further research should examine these issues and attempt to differentiate frequency of use with even more detail than the current study.

Another possible explanation for the discrepancy between Facebook and texting and the other technologies is related to the activities students engage in while using each. For instance, research has shown that *how* Facebook is used is a better predictor of academic outcomes

than how much time is spent on the site (Junco, 2012). Specifically, Junco (2012) differentiates between using Facebook for activities that involve collecting and sharing information, which predicted better academic outcomes than using Facebook for socializing. The social/information gathering or sharing distinction seems to apply for multitasking behaviors as well—clearly, text messaging and Facebook use are social activities while using email and searching can be considered academic because students tend to use email for communication with their professors and their university and not for communication with friends and because searching for information (i.e., conducting research) is an academic activity encouraged by professors (Carnevale, 2006; Lenhart et al., 2005; Salaway et al., 2007). It is important to note that talking on the phone is a social activity; however, it was not significant in the analyses possibly due to the fact that like IM, students spent little time talking on the phone while studying because they were more likely to communicate via text messaging.

Using email for communication with peers has declined in recent years with the advent of social media such as Facebook and the ubiquitousness of cell phones (Carnevale, 2006; Lenhart et al., 2005; Salaway et al., 2007). An informal *post hoc* focus group with a first year seminar course (of 35 students) at the university where the research was conducted revealed that indeed, students used email for communicating with instructors about assignments and for communicating with university personnel while they used Facebook, text messaging, and talking on the phone almost exclusively with their same-aged peers. Therefore, the nonsignificant relationship between multitasking while using email and grades may be attributable to the fact that students are emailing with their professors to discuss course related content and instead of an interruption to the learning process, contact with professors might be part of said learning.

Searching for information online that was not a part of schoolwork is a popular activity for students as found both in the current study and in research by Shenton (2008). We posit that even though students reported searching for information that didn't relate to their schoolwork, that the behavior of and motivations for searching for information online relate to academic pursuits. Indeed, having the curiosity to search for information is a beginning stage in the academic research process. During the same informal *post hoc* focus group, students reported that they searched for non-related material online when something they read or thought about in their schoolwork piqued their interest or made them think of something else. For instance, one student reported reading something about Iceland in her book then searching for details of Icelandic culture (even though the reference to Iceland in her book was a minor one). Therefore, we categorize searching for information and emailing as academic activities that are related to behaviors and motivations that may be congruent with learning. Conversely, socializing while studying may not be congruent with learning.

Using Facebook and texting while studying were negatively related to overall GPA. As Facebooking and texting are social activities that are used frequently, students are dividing their attention between their schoolwork and communicating with friends. The distinction between social and academic activities is seen offline on college campuses—those students who spend more time socializing to the exclusion of engaging in academic work have poorer academic outcomes (Pascarella & Terenzini, 2005). It should be noted that socializing in this regard has qualitative differences from the concept of student engagement, which is related to improved academic outcomes (Pascarella & Terenzini, 2005). Future researchers should further explore how students use technologies for academic and social purposes—presumably, some students will use Facebook for academic purposes as faculty have been increasingly interested in using social media in the classroom (Junco, 2012).

Other variables were significant predictors of overall GPA. For instance, being male was negatively associated with overall GPA. Furthermore, having at least one parent with an advanced graduate degree was positively predictive of overall GPA. As with other research, we found that HSGPA was the single strongest predictor of overall college GPA, predicting 14% of the variance (DeBerard et al., 2004; Geiser & Santelices, 2007; Williford, 2009). Of particular interest to those involved in the curriculum planning process was the finding that Internet skills were positively predictive of overall GPA. Future research may want to focus on the relationship between Internet skills and academic outcomes and how those outcomes might be related to employability in an increasingly technology-reliant workforce.

### 4.3. Limitations

The major limitation of this study is that it is cross-sectional and correlational and therefore it is impossible to determine the causal mechanisms between ICT use and overall GPA. While the data show that doing schoolwork while texting or using Facebook were negatively related to GPA, the direction of the effect is difficult to determine in this study. For instance, it could be that students who spend more time multitasking have lower GPAs; however, it is equally likely that students who have lower GPAs spend more time multitasking. Put a different way, students who are worse off academically may spend more time socializing both online and offline and may have more trouble regulating their focus. Furthermore, other as-yet-to-be-measured variables may be causally linked to ICT use and GPA; a few candidates include student motivation, personality characteristics, time management skills, and self-regulation strategies (Quan-Haase, 2010). Further longitudinal and controlled studies are needed in order to determine the mechanisms of causation. To date, we know of only two controlled studies examining these issues, which separately found that multitasking while using Facebook (Wood et al., 2012) and text messaging (Rosen et al., 2011) in the classroom led to worse educational outcomes. A related limitation is that, while this sample was representative of the overall university population on which it is based, it may not be representative (with respect to racial, ethnic and income factors) of all institutions in the United States. Future research will want to replicate this study with more diverse samples in terms of race, ethnicity, income and academic institutions.

A final limitation was related to estimating the frequency with which students multitask while doing schoolwork. Specifically, all of the multitasking variables were assessed via self-report. Investigators conducting further research on this topic should keep in mind that asking students to estimate average time and time spent "yesterday" yield subtle differences. Therefore, future research will want to combine multiple measures of ICT frequency of use and multitasking frequencies to arrive at a more complete picture of the relationship between ICT use and educational outcomes. Additionally, future researchers may want to ask students how much time they are active on ICTs like Facebook in addition to how long they are logged on. Ideally, further research will attempt to make assessments of actual time spent on each ICT as well as actual time spent multitasking, either through observations or other logging methods.

## 5. Conclusion

Results from this study showed that, indeed, frequency of multitasking with certain ICTs (Facebook and text messaging) were negatively predictive of overall college GPA. While this finding was congruent with research on multitasking, multitasking while using email, IMing,

talking on the phone, and searching for information not related to class were not related to overall GPA. This discrepancy can either be explained by characteristics of the technologies themselves or by qualitative differences in how the technologies are used by students—Facebook and texting are used for social purposes while emailing and searching are used for academic purposes. However, based on prior research on multitasking, it would seem that use of these other ICTs would also impact academic achievement as they would cause the student to switch between their studies and other tasks, thereby overloading their ability to process information and to engage in deeper learning (Chun et al., 2011; Drews et al., 2008; Koch et al., 2011; Marois & Ivanoff, 2005; Mayer & Moreno, 2003; Stavrinos et al., 2011; Strayer & Drews, 2004; Tombu, et al., 2011; Wood & Cowan, 1995). Future research should attempt to replicate these findings, investigate further these discrepancies, and attempt to clarify how characteristics of each ICT as well as frequency and types of use (i.e., social vs. academic) relate to academic outcomes.

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## References

Carnevale, D. (2006, October 6). E-mail is for old people. *The Chronicle of Higher Education, 53*(7), A27.
Chun, M. M., Golomb, J. D., & Turk-Browne, N. B. (2011). A taxonomy of external and internal attention. *Annual Review of Psychology, 62*, 73–101.
Cooper, J., & Weaver, K. D. (2003). *Gender and computers: Understanding the digital divide*. Mahwah, NJ: Lawrence Erlbaum Associates.
Cotten, S. R., McCullough, B., & Adams, R. (2011). Technological influences on social ties across the lifespan. In Karen Fingerman, Cynthia Berg, Toni Antonucci, & Jacqui Smith (Eds.), *Handbook of lifespan psychology* (pp. 647–671). Springer Publishers.
DeBerard, M. S., Speilmans, G. I., & Julka, D. L. (2004). Predictors of academic achievement and retention among college freshmen: a longitudinal study. *College Student Journal, 38*(1), 66–80.
DiMaggio, P., Hargittai, E., Celeste, C., & Shafer, S. (2004). Digital inequality: from unequal access to differentiated use. In K. Neckerman (Ed.), *Social inequality* (pp. 355–400). New York: Russell Sage Foundation.
Drews, F. A., Pasupathi, M., & Strayer, D. L. (2008). Passenger and cell phone conversations in simulated driving. *Journal of Experimental Psychology: Applied, 14*(4), 392–400.
Drews, F. A., Yazdani, H., Godfrey, C. N., Cooper, J. M., & Strayer, D. L. (2009). Text messaging during simulated driving. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 51*(5), 762–770.
Fallows, D. (2008). *Search engine use*. Washington, DC: Pew Internet and American Life Project. Retrieved September 7, 2011, from. http://www.pewinternet.org/Reports/2008/Search-Engine-Use.aspx.
Geiser, S., & Santelices, M. (2007). *Validity of high-school grades in predicting student success beyond the freshman year: High-school record vs. standardized tests as indicators of four-year college outcomes*. University of California/Berkeley Center for Studies in Higher Education. Research & Occasional Paper Series: CSHE.6.07.
Hargittai, E. (2005). Survey measures of web-oriented digital literacy. *Social Science Computer Review, 23*(3), 371–379.
Hargittai, E. (2008a). The digital reproduction of inequality. In D. Grusky (Ed.), *Social stratification* (pp. 936–944). Boulder, CO: Westview Press.
Hargittai, E. (2008b). Whose space? Differences among users and non-users of social network sites. *Journal of Computer-Mediated Communication, 13*(1), 276–297.
Hargittai, E. (2010). Digital na(t)ives? Variation in Internet skills and uses among members of the "net generation". *Sociological Inquiry, 80*(1), 92–113.
Hargittai, E., & Hsieh, Y. P. (2012). Succinct survey measures of web-use skills. *Social Science Computer Review*, Retrieved September 12, 2011, from. http://webuse.org/p/a34.
Horrigan, J. B. (2009). *Wireless Internet use*. Washington, DC: Pew Internet and American Life Project. Retrieved January 3, 2012, from. http://www.pewinternet.org/~/media//Files/Reports/2009/Wireless-Internet-Use-With-Topline.pdf.
Junco, R. (2012). Too much face and not enough books: the relationship between multiple indices of Facebook use and academic performance. *Computers in Human Behavior*, . doi:10.1016/j.chb.2011.08.026.
Junco, R., & Cotten, S. R. (2011). Perceived academic effects of instant messaging use. *Computers & Education, 56*(2), 370–378.
Junco, R., & Mastrodicasa, J. (2007). *Connecting to the net.generation: What higher education professionals need to know about today's students*. Washington, DC: NASPA.
Junco, R., Merson, D., & Salter, D. W. (2010). The effect of gender, ethnicity, and income on college students' use of communication technologies. *CyberPsychology, Behavior, and Social Networking, 13*(6), 37–53.
Kaiser Family Foundation. (2004). *The digital divide survey snapshot*. Menlo Park, CA: Kaiser Family Foundation. Retrieved March 1, 2011, from. http://www.kff.org/entmedia/loader.cfm?url=/commonspot/security/getfile.cfm&PageID=46366.
Koch, I., Lawo, V., Fels, J., & Vorländer, M. (2011). Switching in the cocktail party: exploring intentional control of auditory selective attention. *Journal of Experimental Psychology. Human Perception and Performance, 37*(4), 1140–1147.
Lenhart, A., Ling, R., Campbell, S., & Purcell, K. (2010). *Teens and mobile phones*. Washington, DC: Pew Internet and American Life Project. Retrieved September 4, 2011, from. http://pewinternet.org/Reports/2010/Teens-and-Mobile-Phones.aspx.
Lenhart, A., Madden, M., & Hitlin, P. (2005). *Teens and technology: Youth are leading the transition to a fully wired and mobile nation*. Washington, DC: Pew Internet and American Life Project. Retrieved September 4, 2011, from. http://www.pewinternet.org/~/media//Files/Reports/2005/PIP_Teens_Tech_July2005web.pdf.pdf.
Marois, R., & Ivanoff, J. (2005). Capacity limits of information processing in the brain. *Trends in Cognitive Sciences, 9*(6), 296–305.
Mayer, R., & Moreno, R. (2003). Nine ways to reduce cognitive load in multimedia learning. *Educational Psychologist, 38*(1), 43–52.
Nielsen. (2008). *In U.S., SMS text messaging tops mobile phone calling*. NielsenWire. Retrieved September 3, 2011 from. http://blog.nielsen.com/nielsenwire/online%5fmobile/in-us-text-messaging-tops-mobile-phone-calling/.
Pascarella, E. T., & Terenzini, P. T. (2005). *How college affects students: A third decade of research*. San Francisco, CA: Jossey-Bass. Pew Internet and American Life Project. (2009). Trend data. Retrieved September 12, 2011 from. http://www.pewinternet.org/Trend-Data-for-Teens.aspx.
Pew Internet and American Life Project. (2009). *Trend data*. Retrieved September 12, 2011 from. http://www.pewinternet.org/Trend-Data-for-Teens.aspx.
Purcell, K. (2011). *Search and email still top the list of most popular online activities*. Washington, DC: Pew Internet and American Life Project. Retrieved September 4, 2011. http://www.pewinternet.org/Reports/2011/Search-and-email/Report/Findings.aspx.
Quan-Haase, A. (2010). Self-regulation in instant messaging (IM). *International Journal of E-Collaboration, 6*(3), 22–42.
Rideout, V. J., Foehr, U. G., & Roberts, D. F. (2010). *Generation M2: Media in the lives of 8–18 year olds*. Menlo Park, CA: Kaiser Family Foundation. Retrieved September 7, 2011 from. http://www.kff.org/entmedia/upload/8010.pdf.
Rosen, L. D., Lim, A. F., Carrier, L. M., & Cheever, N. A. (2011). An empirical examination of the educational impact of text message-induced task switching in the classroom: educational implications and strategies to enhance learning. *Psicologia Educativa, 17*(2), 163–177.
Salaway, G., Caruso, J. B., & Nelson, M. R. (2007). *The ECAR study of undergraduate students and information technology*. Boulder, CO: EDUCAUSE. Retrieved September 4, 2011 from. http://www.educause.edu/ir/library/pdf/ers0706/rs/ERS0706w.pdf.
Shenton, A. K. (2008). Use of school resource centre-based computers in leisure time by teenage pupils. *Journal of Librarianship and Information Science, 40*(2), 123–137.
Smith, S. D., & Caruso, J. B. (2010). *The ECAR study of undergraduate students and information technology*. Boulder, CO: EDUCAUSE. Retrieved September 4, 2011, from. http://www.educause.edu/Resources/ECARStudyofUndergraduateStuden/217333.

Smith, A., Rainie, L., & Zickuhr, K. (2011). *College students and technology*. Washington, DC: Pew Internet and American Life Project. Retrieved September 4, 2011 from. http://www.pewinternet.org/Reports/2011/College-students-and-technology.aspx.

Stavrinos, D., Byington, K. W., & Schwebel, D. C. (2011). Distracted walking: cell phones increase injury risk for college pedestrians. *Journal of Safety Research, 42*, 101–107.

Strayer, D. L., & Drews, F. A. (2004). Profiles in driver distraction: effects of cell phone conversations on younger and older drivers. *Human Factors, 46*(4), 640–649.

Tombu, M. N., Asplund, C. L., Dux, P. E., Godwin, D., Martin, J. W., & Marois, R. (2011). A unified attentional bottleneck in the human brain. *Proceedings of the National Academy of Sciences of the United States of America, 108*(33).

Williford, A. M. (2009). Secondary school course grades and success in college. *College & University, 85*(1), 22–33.

Wood, N., & Cowan, N. (1995). The cocktail party phenomenon revisited. How frequent are attention shifts to one's name in an irrelevant auditory channel. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21*(1), 255–260.

Wood, E., Zivcakova, L., Gentile, P., Archer, K., De Pasquale, D., & Nosko, A. (2012). Examining the impact of off-task multi-tasking with technology on real-time classroom learning. *Computers & Education, 58*(1), 365–374.