Computers in Human Behavior 28 (2012) 2236–2243

Contents lists available at SciVerse ScienceDirect

Computers in Human Behavior

journal homepage: www.elsevier.com/locate/comphumbeh

In-class multitasking and academic performance

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ARTICLE INFO

Article history:
Available online 28 July 2012

Keywords:
Multitasking
Classroom
ICT use
Learning
Facebook
Texting

ABSTRACT

The omnipresence of student-owned information and communication technologies (ICTs) in today's college classrooms presents educational opportunities but can also create learning problems. Specifically, multitasking with these technologies can interfere with the learning process. Indeed, research in cognitive science shows that there are clear performance decrements when trying to attend to two tasks at the same time. This study examines the frequency with which students multitask during class using a large sample (N = 1,839) and examines the relationship between multitasking and academic performance as measured by actual overall semester grade point average (GPA). Students reported frequently text messaging during class but reported multitasking with other ICTs to a lesser extent. Furthermore, only social technologies (Facebook and text messaging) were negatively related to GPA.

1. Introduction

Research on multitasking has uncovered clear evidence that human information processing is insufficient for attending to multiple stimuli and for performing simultaneous tasks (Chun, Golomb, & Turk-Browne, 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, there is evidence that these performance decrements extend to more complex tasks. Because of shifts in student technology ownership and use, researchers have begun to examine how college students multitask and how this affects their ability to learn material and engage in the learning process (Fried, 2008; Junco & Cotten, 2011, 2012; Mayer & Moreno, 2003; Rosen et al., 2011; Wood et al., 2012).

1.1. College student technology use and the potential for multitasking

In the United States, most college students are part of what many have described as a digital generation that has never known a time when information and communication technologies (ICTs) weren't a part of daily life (Cotten, McCullough, & Adams, 2011). Most of today's students adopt and use new technologies at high rates, and therefore have many opportunities to multitask. For example, a recent EDUCAUSE Center for Applied Research (ECAR) study (N = 36,950 students and 127 North American universities) shows that over 73% of college students text message daily, 99% own a computer (with 84% owning laptops), and 90% use social networking websites (Smith & Caruso, 2010). Furthermore, anywhere between 87% and 92% of undergraduates use Facebook and spend an average of over 1 h and 40 min on the site per day (Junco, 2012; Smith & Caruso, 2010).

Cell phones are also very popular with college students. In the United States, a higher proportion of undergraduate college students own cell phones compared to same-aged non-students (Smith, Rainie, & Zickuhr, 2011). The latest Pew report focusing on college students found that 96% of all undergraduates owned cell phones (Smith et al., 2011). Junco and Cotten (2012) reported that college students sent an average of 97 text messages per day, with 71 of those messages being sent while doing homework. A small-scale study by Burns and Lohenry (2010) found that 53% of students reported text messaging during class.

Despite the high adoption rate of ICTs among college students, it is important to remember that 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; DiMaggio, Hargittai, Celeste, & Shafer, 2004; Hargittai, 2008a; Junco, Merson, & Salter, 2010; Kaiser Family Foundation, 2004; Rideout, Foehr, & Roberts, 2010). For instance, 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 that African American students were more likely to send text messages than whites. Hargittai (2008b) 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.

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http://dx.doi.org/10.1016/j.chb.2012.06.031

1.2. Multitasking and educational outcomes

For this paper, multitasking is defined as divided attention and non-sequential task switching for ill-defined tasks as they are performed in learning situations. Much research has examined the effects of multitasking on human information processing. Koch et al. (2011) found 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 the participant's attention. Tombu et al. (2011) found that participants responded more slowly and had poorer accuracy on dual task trials than on single task trials (for both auditory-vocal and visual-manual tasks). These studies support what has been long termed a "cognitive bottleneck", a limitation in decision making that slows the second task (Welford, 1967). Put another way, 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). These real-world consequences include a lessened awareness of stimuli, disruption of decision-making, and behavioral impairment on one or more tasks.

Some researchers have studied how the real-world consequences of multitasking affect educational outcomes (Fried, 2008; Junco & Cotten, 2011; Junco & Cotten, 2012; Mayer & Moreno, 2003; Rosen et al., 2011; Wood et al., 2012). This is especially relevant because of now-ubiquitous laptop initiatives that encourage or even require students to own a laptop computer (Weaver & Nilson, 2005). While these initiatives aim to enhance student learning both inside and outside the classroom, they also increase the potential for multitasking. Indeed, research has shown that unstructured use of laptops (i.e., not incorporating them into the learning process) is related to performing more off-task activities such as checking email and playing games during class (Kay & Lauricella, 2011). Fried (2008) had students in two large-lecture courses complete weekly surveys about how they were using their laptops during lectures. Students reported using their laptops for activities other than taking notes for an average of 17 min out of each 75-min class period. Additionally, Fried (2008) found that laptop use was negatively related to multiple learning outcomes including course grade, how much attention students reported paying to lectures, reported clarity of lectures, and understanding of course material.

Junco and Cotten (2011) surveyed a large sample ($N = 4{,}491$) of students at four universities about their use of instant messaging (IM). They asked students to report whether IM interfered with their completion of homework. Junco and Cotten (2011) found that students who reported studying while IMing were more likely to report that IM interfered with their completion of homework. While the Junco and Cotten (2011) study used a large sample, the measures were all based on self-report. Junco and Cotten (2012) conducted a similar study where they surveyed a large sample of students ($N = 1839$) from one university about the time they spent engaging in non-class related activities during study time. In this newer study, they collected GPA data from the university registrar. Controlling for background variables and high school GPA, they found that there was a negative relationship between student use of social technologies and overall GPA (Junco & Cotten, 2011). Specifically, Junco and Cotten (2012) found that time spent using Facebook and texting while studying was negatively related to overall college GPA. Interestingly, they found that time spent emailing, searching for content not related to courses, talking on the phone, and instant messaging while preparing for class were not related to GPA (Junco & Cotten 2011).

Another recent study by Wood et al. (2012) used an experimental design to assign 145 students to one of seven conditions: the four experimental conditions had students use Facebook, text messaging, IM, or email during a 20-min simulated lecture. They found that students who used Facebook while attending to the lecture scored significantly lower on tests of lecture material than those who were only allowed to take notes using paper and pencil; however, the scores of students who texted, emailed or sent IMs did not differ significantly from students in control groups. In a related experimental study, Rosen et al. (2011) had students watch a 30-min lecture video. They asked students to respond to text messages sent out at even intervals throughout the lecture by researchers. Students were split into a low text messaging group (that received 0–7 messages), a moderate text messaging group (8–15 messages), and a high text messaging group (16 or more messages). Rosen et al. (2011) found that the high text messaging group performed worse (by one letter grade) on an information posttest than the low text messaging group; however, the moderate text messaging group showed no difference on the posttest compared to the other two groups. The results of the Junco and Cotten (2012), Wood et al. (2012), and Rosen et al. (2011) studies all suggest there may be some instances where technology use while attending to course material may not be detrimental to academic performance. These findings; however, are not congruent with theories of information processing or cognitive science research on multitasking.

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. The human information processing system has two channels—visual and auditory; 2. Each channel has a limited capacity for cognitive processing; 3. Capacity is used when selecting and processing presented stimuli; and 4. Meaningful learning requires that a substantial amount of cognitive processing happen in either 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, music added to a presentation 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 video while answering the questions.

Mayer and Moreno's (2003) theory of learning and information overload states that humans have a finite amount of cognitive processes available at any one time and that these processes can be overloaded by additional stimuli. Specifically, a learner must have enough capacity for *representational holding* and *essential processing* in order to be able to learn material. If these processes are overloaded through *incidental processing*, deeper cognitive processing and learning cannot occur. This theory of learning and information overload is supported by cognitive science research showing that

human information processing is limited by a cognitive bottleneck that slows a task performed in tandem with another (Koch et al., 2011; Marois & Ivanoff, 2005; Strayer & Drews, 2004; Tombu et al., 2011; Wood & Cowan, 1995). In the classroom, off-task technology use engages *incidental processing*, which obstructs *representational holding* of the presented material and also the *essential processing* of this material. When this occurs, students will be unable to process the material in ways that lead to deeper learning. Therefore, multitasking during class time should negatively affect measures of learning such as grades.

1.3. Research questions and hypothesis

Only a handful of published studies have examined the effect of multitasking on educational outcomes (Fried, 2008; Junco & Cotten, 2011; Junco & Cotten, 2012; Rosen et al., 2011; Wood et al., 2012). The studies by Wood et al. (2012) and Rosen et al. (2011) examined the impact of multitasking on immediate recall of information in controlled experiments; however, they did not examine what the longer-term effects were on student grades. Presumably, students who multitask more during class will have lower course grades. Interestingly, Wood et al. (2012) studied a number of technologies (texting, email, IM, and Facebook), yet only found that students in the Facebook condition scored significantly lower on a test of lecture material.

This study will extend previous research by investigating how frequently students use technology during their classes. Like the Wood et al. (2012) investigation, this study will examine a number of different ICTs; however, unlike Wood et al.'s (2012) research, this study examines the real-world frequency of multitasking as well as how this multitasking is related to actual semester grade point averages (GPAs) collected from the university registrar. Presumably, the negative effects of multitasking on short-term recall of information found in the Wood et al. (2012) and Rosen et al. (2011) studies should translate to longer-term effects on GPA. The ICTs examined in this study are: Facebook, email, IM, talking on a cell phone, texting, and conducting online searches for material not related to course content. The distinguishing feature of these activities is that college students use them frequently for social purposes and they are highly likely to use them during class (Burns & Lohenry, 2010; Cotten et al., 2011; Junco, 2012; Junco & Cotten, 2012; Smith & Caruso, 2010; Smith et al., 2011). Furthermore, since it is possible that Internet skills played a role in the relationship between multitasking and academic impairment in the Junco and Cotten (2011) and Wood et al. (2012) studies, we will include an established measure of Internet skills as a control variable (Hargittai & Hsieh, 2012).

The research questions examined for the current study are:

- *Question 1: How frequently do college students in the United States use ICTs during class?*
- *Question 2: Controlling for demographic variables, high school grade point average, and Internet skills, how does frequency of using technology during class relate to academic performance as measured by overall semester 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, it is hypothesized that using ICTs during class time will result in detrimental educational outcomes. Specifically, the negative relationship between multitasking and short-term recall found in previous studies should translate to difficulties learning course material and should be reflected in lower semester grades (Rosen et al., 2011; Wood et al., 2012).

2. Methods

2.1. Participants

All students who were US residents admitted through the regular admissions process at a 4-year, public, primarily residential institution in the Northeastern United States were surveyed (N = 3,866). The students were sent a link to a survey hosted on SurveyMonkey.com, a survey-hosting website, through their university-sponsored email accounts. SurveyMonkey.com automatically identifies students who have not responded. Students who did not respond a week after the initial email were sent a second email through SurveyMonkey.com. Students who did not respond for a week after the second email were sent a final reminder. Participants were offered a chance to enter a drawing to win one of 90 $10 Amazon.com gift cards as incentive. A total of 1,839 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 IBM SPSS Statistics 19.0. Initial screening showed that 65 survey responses were unusable because they were not completed; therefore, the final sample size was 1,774. Data were kept confidential according to procedures approved by the university ethics board.

2.2. Instrument/measures

Independent Variables. The key independent variables were: frequency of multitasking during class, Internet skills, and high school GPA. The demographic variables included in the analyses were: gender, race/ethnicity, and parental education level.

Survey Instrument. The survey was developed by drafting question based on previous research on student technology use (Junco & Cotten, 2011; Rideout et al., 2010; Smith et al., 2011). The survey instrument was shared with two separate groups of undergraduate students (who were not study participants) for input. The survey was revised using this input and then shared with three survey methods researchers for feedback. An instruction page that contained the informed consent form approved by the university's ethics review board preceded the final survey. Frequency of multitasking during class was evaluated using the question "How often do you do the following activities during class?" with prompts for Facebook, IM, email, talking on the phone, texting, and searching for information online that is not related to the class. It is important to separate what Gasser, Cortesi, Malik, and Lee (2012) call *fortuitous searching*—"browsing from link to link in a undirected manner"—from searches involving course content (p. 8). The former involves searching for personal information while the latter involves finding academic content that should be more positively related to academic outcomes. Additionally, none of the other ICTs are used for in-class course assignments at the institution where this study was conducted. 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.

Internet skills were measured using a 27-item scale[1] developed by Hargittai (2005) and subsequently refined (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"

[1] The full 27-item scale can be found in Hargittai, E. (2009). An update on survey measures of web-oriented digital literacy. *Social Science Computer Review, 27*(1), 130–37.

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 α above .90 (Hargittai, 2007; Hargittai, 2009; Hargittai & Hsieh, 2012). Indeed, data from the current study found the Internet skills items to exhibit excellent internal consistency with a Cronbach's α of .96.

In any linear model of ICT use and grades, it is necessary to control for high school GPA (HSGPA), consistently found to be the strongest predictor of overall college GPA (DeBerard, Speilmans, & 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 also to place the other predictors in context. Academic ability might also be a student background characteristic related to multitasking frequency and to negative outcomes of multitasking (Junco & Cotten, 2011). For instance, it is possible 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), submitted to the university during the admissions process. High school grades were measured on a 4.0 scale ranging from 0 to 4.0.

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 higher of the two parental education levels was used for these analyses. Students were also asked to select their gender and their ethnicity.

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

2.3. Analyses

Descriptive statistics were run to illustrate the demographic characteristics of the sample and to describe frequency of multitasking during class. To answer research question 2, a hierarchical (blocked) linear regression analysis was conducted to determine which multitasking variables predicted overall semester GPA. The blocks, in order, were: demographic variables (gender, ethnicity and highest parental education level), high school GPA, 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 et al.,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. Internet skills were included because skills play an important role in how technologies are used and presumably, Internet skills may be related to frequency of Internet use as well as problematic Internet behaviors (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 SPSS was used to plot both linear and quadratic functions to examine linearity. Curve estimation allows the researcher to compare linear models to nonlinear ones in order to evaluate whether a linear procedure like regression is the best fit for the data. Results of curve estimation 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, 51 outliers were removed because of extreme scores on at least one variable of interest (for instance, 15 outliers had high school GPAs greater than 4.00) thus bringing the total sample size to 1,723 students. Collinearity diagnostics found that none of the independent variables were significantly 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 17–56, though 88% were between 18 and 22 years old. The skewness of the age distribution was 4.2 (SE .06) and the kurtosis was 22 (SE .12). 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 an overrepresentation of women in this sample. The university population was 55% female, 90% Caucasian, 6% African American, 2% Latino, 1% Asian American, and 1% other. The average HSGPA in the sample was 3.32 (SD .45) and the average overall college GPA was 2.96 (SD .65).

3.2. Question 1: How frequently do college students in the United States use ICTs during class?

Table 1 shows the frequency with which students reported using each ICT during class. When examining the reported frequency of multitasking with these activities, it appears that texting, Facebook, email, and searching are done most often; 34% of respondents reported texting, 13% reported using Facebook, 11% reported emailing, and 8% reported searching for information not related to class sometimes, somewhat frequently, or very frequently. Instant messaging and talking on the phone were the least often used during class, with 90% and 96% (respectively) of respondents reporting that they never use them.

Table 1
Frequency with which students reported using each ICT during class ($N = 1723$).

Activity	Multitasking Frequency (% reporting)				
	Never	Rarely (25%)	Sometimes (50%)	Somewhat frequently (75%)	Very frequently (100% of the time)
Texting	31	36	20	11	3
Facebook	72	16	8	4	1
Email	72	17	7	3	1
Search	79	13	5	2	1
IM	90	6	2	1	<1
Talk	96	3	1	1	0

3.3. Question 2: Controlling for demographic variables, high school grade point average, and Internet skills, how does frequency of using technology during class relate to academic performance as measured by overall semester GPA?

The hierarchical linear regression predicting overall semester GPA ($F_{(17,1715)} = 16.063$, $p < .001$, Adjusted $R^2 = .130$) was significant. In block 1 (see Table 2), demographic factors were significantly related to GPA. Specifically, males had lower semester GPAs while Whites had higher GPAs than Latinos. Having a parent with less than a high school degree or a college degree was positively related to GPA. Block 2 added HSGPA to the demographic factors. The patterns remained the same for gender and parental educational level but being White was not related to GPA in block 2. As expected, HSGPA was a significant positive predictor of semester GPA.

Block 3 added the measure of Internet skills. The results remain the same as in block 3 in terms of gender, parental education level, and HSGPA. Internet skill was not associated with GPA. Block 4 added the multitasking variables. The results in block 4 show that the effects of multitasking on semester GPA vary depending upon the specific types of ICT use being examined. For instance, multitasking while using Facebook and texting were associated with lower GPA. Instant messaging, emailing, searching, and talking on the phone were not associated with GPA. The results for the demographic and HSGPA variables remained the same as in block 3. Of particular interest was the finding that the R^2 change for the multitasking variables was .021, slightly lower than the R^2 change for the demographic variables, showing that multitasking explains slightly less of the variance in semester GPA than demographic variables. Furthermore, multitasking explained about one fourth of the variance explained by HSGPA, the strongest predictor of GPA (DeBerard et al., 2004; Geiser & Santelices, 2007; Williford, 2009).

4. Discussion

4.1. Question 1: How frequently do college students in the United States use ICTs during class?

Sixty-nine percent of students reported text messaging during class, which was much higher than the 53% who reported doing so in the Burns and Lohenry (2010) study. There were 197 students in the Burns and Lohenry (2010) study: 76% were female with a mean age of 25 (range 21–46). They were mostly students studying to be physician's assistants, unlike the current study that represented students from all academic disciplines. While comparable, the students in the Burns and Lohenry (2010) study were slightly older and in the medical disciplines which require more focus during class time.

While texting was the most popular activity during class, students reported using other technologies as well. They reported using Facebook, email, and searching for content not related to class, with 28% stating that they use Facebook and email in class and 21% stating that they search for content not related to class at least some of the time they are in class. Contrary to prior re-

Table 2
Hierarchical regression model exploring how demographics, high school GPA, Internet skill, and ICT multitasking during class predict overall semester GPA ($N = 1716$).

Independent variables	Block 1 demographics β	Block 2 HS GPA β	Block 3 internet skills β	Block 4 multitasking β
Male	−.115***	−.058*	−.063**	−.077**
African American	−.036	−.019	−.019	−.028
Asian American	.023	.012	.012	.009
Other ethnicity	.010	.006	.005	.001
Caucasian	.106*	.086	.086	.073
Less than high school	.049*	.070**	.070**	.063**
High school	.020	.030	.031	.024
College graduate	.070*	.059*	.059*	.056*
Advanced grad degree	.048	.048	.048	.048
High School GPA		.297***	.298***	.288***
Internet skill			.021	.035
Facebook multitasking				−.088**
IM multitasking				−.039
Email multitasking				.055
Searching multitasking				−.028
Talking multitasking				.041
Texting multitasking				−.088***
Adjusted R^2	.029	.112	.112	.130
R^2 change	.034***	.083***	.000	.021***

Note: β = Beta, the standardized regression coefficient.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

search by Junco and Cotten (2011), students rarely used IM during class, with only 10% reporting ever doing so. Lastly, students almost never spoke on their cell phones during class; only 4% reported doing so. Because there were such differences in frequency of ICT use during class, it is helpful to split the activities into three levels for further discussion. Therefore, frequency of ICT use was split into:

(1) High frequency—texting was the only ICT that falls into this category because 69% of students reported texting during class;
(2) Moderate frequency—using Facebook, emailing, and searching for content not related to class fall into this category as 21–28% of students used these during class; and
(3) Low frequency—IM and talking on the phone were the two ICTs in this category because students rarely used them with only 4–10% reporting doing so.

4.2. Question 2: Controlling for demographic variables, high school grade point average, and Internet skills, how does frequency of using technology during class relate to academic performance as measured by overall semester GPA?

Results from the hierarchical linear regression show that using Facebook and texting during class were negatively predictive of overall semester GPA. Even though emailing and searching were moderate-frequency activities like using Facebook, they were not predictive of overall GPA. In other words, the lack of a relationship between emailing and searching and GPA cannot be attributed to lower frequency of use. As might also be expected, low-frequency activities were not related to semester 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). The findings are also congruent with the hypothesis that the use of ICTs during class will result in detrimental educational outcomes, and with the studies by both Wood et al. (2012) and Rosen et al. (2011) that found that using Facebook and texting while paying attention to lectures resulted in poor performance on lecture-based exams.

Comparing the results of the current study with the results of the Wood et al. (2012) and Rosen et al. (2011) studies shows that multitasking with certain technologies—specifically, using Facebook and text messaging—while trying to learn relates to poorer long-term academic outcomes. These findings can be understood using the framework provided by Mayer and Moreno (2003): attempting to pay attention to Facebook or text messaging and to a class lecture at the same time will yield reduced capacity for *essential processing* and *representational holding* while increasing the *incidental processing* necessary for a given task. Paying attention to Facebook or texting in class limits *essential processing* because energies focused on attending to these technologies cannot be focused on making sense of lecture material. Second, using Facebook or texting in class generates an information processing bottleneck and therefore limits the capacity for *representational holding*; 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.

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 non-significant effects of multitasking while emailing, searching, using IM, and talking on the phone 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 more recent study, Junco and Cotten (2012) found a negative effect of using Facebook and text messaging while studying, but not for other ICTs. In the current study, the finding that using IM and talking on the phone were not significant can be explained by the fact that students rarely used IM or spoke on the phone during class. However, emailing and searching during class—categorized as moderate frequency activities, just like Facebook use—were not significant in the current study.

As Wood et al. (2012) and Junco and Cotten (2012) suggest, there may be something about the technologies themselves that leads to poorer outcomes—an issue worthy of exploration in future research. It is also possible that the discrepancies in outcomes between using Facebook and texting or emailing and searching may lie in the nature of *how* the technologies are used and the frequency with which they are employed. For instance, Rosen et al. (2011) found that while students who sent and received over 16 messages when they were watching a 30 min class lecture scored lower on an information posttest than those who sent and received 0–7 messages, there was no difference in scores between students who sent and received 8–15 messages and the other groups. Certainly, more frequent and active use of ICTs during class would lead to increased impairment in *essential processing* and *representational holding*. 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 (Carnevale, 2006; Junco & Cotten, 2012; Lenhart, Madden, & Hitlin, 2005; Salaway, Caruso, & Nelson, 2007).

Other variables were significant predictors of overall semester GPA. For instance, being male was negatively associated with GPA, while having at least one parent with a college degree was positively related. Consistent with other research, HSGPA was the single strongest predictor of semester GPA, predicting 8% of the variance (DeBerard et al., 2004; Geiser & Santelices, 2007; Williford, 2009). Unexpectedly, having a parent with less than a high school degree was also positively related to GPA. The effects of parental income and education on academic success have been well documented in the literature (Pascarella & Terenzini, 2005). Therefore, future research may want to investigate why a lower level of parental education was positively related to GPA.

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 during class and overall semester GPA. While the data show that using Facebook or texting during class 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 multitask more during class have lower GPAs;

however, it is equally likely that students who have lower GPAs spend more time multitasking. In other words, students who are worse off academically may spend more time socializing both online and offline and may have more trouble regulating their focus. Other as-yet-to-be-measured variables may be causally linked to ICT use during class and GPA, such as 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. 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 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.

The fact that participants were recruited via email and that the survey was administered online is a further limitation. There is no way to tell whether the students who responded to the survey happened to be part of the student population who regularly uses email. Regular users of email may be more active users of technology and may multitask more than other students. A final limitation was related to estimating the frequency with which students multitask during class. Specifically, all of the multitasking variables were assessed via self-report. This raises the issue of whether students can accurately estimate their frequency of multitasking. Future research will want to combine multiple measures of multitasking frequencies to arrive at a more complete picture of the relationship between ICT use and educational outcomes. Ideally, further research will also 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 semester GPA. Multitasking with other ICTs, such as using email, searching for information not related to class, IMing, and talking on the phone during class were not related to 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 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; Koch et al., 2011; Marois & Ivanoff, 2005; Mayer & Moreno, 2003; 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.

Acknowledgements

The author would like to thank the blind reviewers of this paper for their thorough and invaluable feedback. He is also grateful to Eszter Hargittai for helpful input on the survey instrument and permission to use the Internet skill items. He appreciates the help provided by Mike Abplanalp, Stephen Lee, Jerry Eisley, and Jill Mitchley in collecting and interpreting institutional-level data. Additionally, the author is grateful for funding from the Lock Haven University Faculty Professional Development Committee.

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