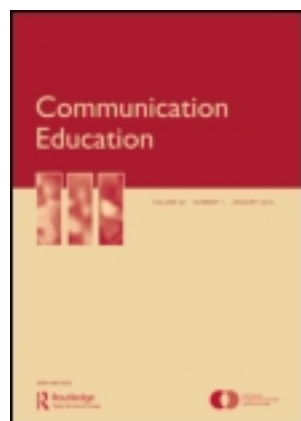


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Publisher: Routledge

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Communication Education

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/rced20>

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Published online: 12 Feb 2013.

To cite this article: Jeffrey H. Kuznekoff & Scott Titsworth (2013) The Impact of Mobile Phone Usage on Student Learning, Communication Education, 62:3, 233-252, DOI:

[10.1080/03634523.2013.767917](https://doi.org/10.1080/03634523.2013.767917)

To link to this article: <http://dx.doi.org/10.1080/03634523.2013.767917>

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The Impact of Mobile Phone Usage on Student Learning

Jeffrey H. Kuznekoff & Scott Titsworth

In this study, we examined the impact of mobile phone usage, during class lecture, on student learning. Participants in three different study groups (control, low-distraction, and high-distraction) watched a video lecture, took notes on that lecture, and took two learning assessments after watching the lecture. Students who were not using their mobile phones wrote down 62% more information in their notes, took more detailed notes, were able to recall more detailed information from the lecture, and scored a full letter grade and a half higher on a multiple choice test than those students who were actively using their mobile phones. Theoretical and pedagogical implications are discussed.

Keywords: *Texting; Student Learning; Texting in the Classroom; Technology; Mobile Phone*

In modern classrooms, instructors face many challenges as they compete for students' attention among a variety of communication stimuli. Rapid growth of mobile computing, including smart phones and tablets, presents a double-edged problem: along with previously unimaginable access to information come previously unforeseen distractions. Of wide concern to many instructors is the potential distraction caused by students using their mobile devices to text, play games, check Facebook, tweet, or engage in other activities available to them in a rapidly evolving digital terrain. That concern has potential merit; recent statistics from the Pew Foundation show that the median number of daily texts for older teens rose from 60 in 2009 to 100 in 2011 (Lenhart, 2012). Moreover, 64% of teens who own cell phones have texted during class, even in schools where cell phones are technically banned (Lenhart, Ling, Campbell, & Purcell, 2010). Those texts potentially come at the expense of learning, as texting during class reduces students' ability to self-regulate and give sustained attention to classroom tasks (Wei, Wang, & Klausner, 2012).

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Cell phones, and the broader array of digital mobile devices, pose unique communication challenges for both users and those with whom they interact. Some critics argue that texting and other digital communication behavior potentially diminish key social skills like effective listening. As one commentator noted, “We think of phones as a communication tool, but the truth is they may be just the opposite” (Skenazy, 2009, np). Other views suggest that people are adapting to new communication norms in an increasingly digital world, learning to quickly attend to, process, and respond to multiple and sometimes simultaneous messages (Davidson, 2011). Given the many possible ways that digital communication tools will continue to influence practices of teaching and learning (Schuck & Aubusson, 2010), instructional communication scholars should enact programmatic research to understand how these tools impact classroom communication and subsequent learning outcomes.

The present study builds on past research by examining whether texting or posting to a social network site has negative impacts on students’ note-taking behaviors and subsequent performance on exams. Participants took part in simulated classroom conditions where they watched a recorded lecture, took notes over the lecture, and were then tested over lecture content. There were three conditions in the study: a control group and two experimental groups. The control group simply watched the lecture, took notes on the lecture, and answered exam questions over lecture content. The other two groups engaged in the same activities as the control group, but also took part in simulated texting/Facebook interactions during the lecture; one group had a low frequency of texts/posts, and another had a high frequency. By using simulated text messages and Facebook posts, the objective of the study was to determine what effects, if any, these distractions had on student learning.

Literature Review

Mobile Phone Usage and Features

Modern phones have a variety of features that simply were not possible years ago: Mobile phones are not just for voice communication anymore (Ishii, 2006). College students can access the Internet, send or receive text messages, check email, and even video chat with others quite literally from the palm of their hand. In addition, students can access a variety of social network sites (SNS) from their mobile phones. Scholars boyd and Ellison (2008) explain that SNS are online services that allow people to create a profile, create a list of other users who share a connection with the user, and view the lists of connections created by others within that system. For the purposes of the current study, we use the technical term SNS in place of other terminology (e.g., social networking sites) because SNS better conveys the way in which users communicate with others via these systems. boyd and Ellison note that other terms, like social networking sites, emphasize relationship initiation and users forming connections with others with whom they might not normally have come in contact. However, the term SNS better conveys the way in which users communicate with other people they have connected with. As boyd and Ellison put it, “They are

primarily communicating with people who are already part of their extended social network” (2008, p. 211). Thus far, survey data indicate that young adults are highly active users of SNS and other communication tools like text messaging.

Texting, the ability to send short messages to another person, is perhaps one of the more popular features of modern cell phones. Roughly 94% of 18–34-year-olds report that they send or receive text messages using their phones, and 63% of this age group access the Internet using their phone (Zickuhr, 2011). There is little question that students’ communication habits regularly lead them to text while in class. Research conducted by the Pew Internet & American Life Project found that 14–17-year-olds who text typically send and/or receive roughly 60 text messages a day. Furthermore, 64% of teens with mobile phones have texted in class, and 23% access SNS via their phone (Lenhart, 2010). Indeed, researchers at one university found that 62% of students admitted that they had texted while in class (Ransford, 2009). Campbell (2006) reported that young people ages 18–23 are more tolerant of mobile phones in the classroom when compared to older age brackets. Essentially, “Young people tend to have very positive perceptions of mobile phones and regard the technology as an important tool for social connection” (Campbell, 2006, p. 290).

Besides texting, accessing the Internet and SNS has become a prolific communication activity among college students. Research shows that roughly 75% of online adults (18–24 year olds) have profiles on an SNS, and 89% of online adults use those sites to keep in touch with friends (Lenhart, 2009). In regard to teens, 77% of teens report that they contact their friends daily via text messaging, and 33% do so via SNS (Lenhart, 2010). Statistics from Facebook, which as of June 2011 had over 500 million active users, documents that over 50% of the users log in each day (Facebook, 2011). According to Facebook’s own statistics, over 250 million active users access Facebook through a mobile device, and “People that use Facebook on their mobile devices are twice more active on Facebook than non-mobile users” (Facebook, 2011, p. 1). In short, one might reasonably conclude that students’ use of Facebook during class would be similar to rates of texting. However, posting to Facebook and sending a text message do serve different purposes. For example, a text message is typically sent to one recipient and is inherently interpersonal in nature. A Facebook post, or a status update, is generally viewable by a wider audience or even publicly available. Although texting and posting can serve different purposes, the physical act of both activities on a mobile device is fundamentally the same (i.e., users engaging in communication activities via their mobile device). Because texting and posting both require the user to actively interact with her/his mobile device, these potentially distinct communication activities would reasonably manifest in similar ways and with similar effects. As such, the remainder of this article will use the term *texting/posting* to refer to both activities. This labeling approach provides conceptual clarity while also incorporating both forms of communication.

Clearly, texting/posting offers new communication channels that are frequently used by young adults to stay in contact with others. This ability to stay connected with others has allowed today’s college students to remain constantly connected to other people, something that was not the case even a decade ago. As a practical

matter, instructors remain concerned that such connection to the social world disconnects students from learning, leading some to ban all electronic communication devices from lectures (Steinfatt, 2009). Both theoretical and empirical evidence supports this concern, suggesting that students potentially split their attention in ways that cause them to miss important details presented during class, an outcome that could have potentially damaging effects on their achievement (Kraushaar & Novak, 2010; Wei et al., 2012).

Classroom Attention

Recent studies exploring the effects of texting/posting on student learning outcomes have relied on information processing theory (see Mayer, 1996) as a basis for arguing that texting can cause distractions that hamper student learning. Briefly, information processing identifies attention, working memory, short-term memory, long-term memory, and metacognition as key resources used by individuals when they learn new information. Because learning is a process, diminished capacity with any single resource can impact other resources. Thus, in the case of texting/posting, students' attention can be divided, which can distract attention from on-task behavior. In turn, information processed in working/short-term memory may be incomplete or inaccurate, which could lead to inaccurate or insufficient storage of information in long-term memory.

A variety of studies outside of the educational setting provide evidence that texting/posting can impede information processing. For instance, Just, Keller, and Cynkar (2008) found that simulated mobile telephone conversations disrupted driving performance by diverting attention away from the task of driving. Other researchers found that drivers talking on a mobile phone experienced visual distractions, such as failing to notice important visual cues like traffic lights or the environment surrounding road intersections (Trbovich & Harbluk, 2003). In general, these researchers concluded that "distracting cognitive tasks compete for drivers' attentional resources" (Harbluk, Noy, Trbovich, & Eizenman, 2007, p. 378). Given the evidence surrounding dangers associated with using mobile devices while driving, many states now have laws penalizing drivers who text behind the wheel.

Although not life-threatening in the classroom, texting/posting produces negative consequences for students and instructors. Burns and Lohenry (2010) found that both students and instructors identified mobile phone use as a distraction in class, and Campbell (2006) found that students and instructors perceived the ringing of cell phones in class as a problem. Although texting is considerably more covert than actual telephone conversations, a growing body of literature suggests that it is equally problematic.

Kraushaar and Novak (2010) explored connections between classroom laptop usage and course achievement. The authors recruited students who voluntarily installed activity-monitoring software onto their laptops. This software recorded what programs were running and the times that each program was in use. Kraushaar and Novak developed a rubric to classify programs as productive or distractive

towards the student. Productive programs were those programs that were course-related (e.g., Microsoft Office), while distractive programs included web surfing, entertainment, email, instant messaging, and computer operations. “Using a browser to view an active window containing a course-related PowerPoint slide would be considered productive, while viewing an active window for a Web site that was unrelated to the course would be considered distractive” (Kraushaar & Novak, 2010, p. 244). Their study found that 62% of the programs that students had open on their laptops were considered distracting. In addition, and of particular relevance to the current study, the researchers found that instant messaging was negatively correlated with quiz averages, project grades, and final exam grades.

In an experiment testing whether texting negatively impacts students’ ability to learn information, Wood and colleagues (2012) observed a small but consistent negative effect on exam performance when students engaged in simulated texting, emailing, or Facebook posting. They reasoned that when students engage in multiple simultaneous tasks, like texting and listening to lectures, one or both behaviors suffer. Similarly, Wei et al. (2012) found support for a causal model identifying texting as a significant mediating variable in the relationship between students’ self-regulation, a key aspect of metacognition, and cognitive learning. Specifically, when higher rates of texting behavior are present, students tend to be less able to self-regulate their behaviors in ways that allow them to succeed on performance assessments. Although each of these studies concluded that texting can diminish learning because students’ attention is divided, they did not identify specific mechanisms through which the diminished attention/diminished achievement link is made. By providing specific analysis of these mechanisms, teachers will have a greater ability to explain to students how their grades could be impacted when they text or post to Facebook during class. For example, when teachers want to explain the negative impact of texting in class, they can perhaps be more detailed by noting specific ways in which texting impacts student note taking and recall, and perhaps even work towards mitigating these negative effects.

Lecture Listening and Note Taking

Note taking is one of the most commonly practiced student behaviors; it is also one of the most important. In a meta-analysis of 33 separate studies, Kobayashi (2006) observed a large average weighted effect size of .77 when comparing the exam scores of students who take and review notes with those who do not. Practically speaking, students can score nearly one and one-half letter grades higher on exams when they take notes (Titsworth & Kiewra, 2004). The types of notes students take are also important. Makany, Kemp, and Dror (2009) found that when students took time to construct visual non-linear notes, they recorded more complete notes and had a 20% jump in comprehension assessment performance. Stated plainly, the quantity and quality of students’ notes has dramatic impact on their ability to retain and use information.

The link between note taking and learning is established through two functions: the encoding and external storage hypotheses (see Rickards, 1979). First, note taking allows students to create an external repository for information. After hearing a lecture, students can later go back to review information in preparation for an exam or other performance measure (Kiewra, 1987). The encoding hypothesis assumes that the act of taking notes helps students process information into long-term memory. In describing the encoding function, Kiewra and colleagues (1991) note that the external storage and encoding functions complement one another and act in unison to promote learning.

Despite the importance of taking notes, the classroom poses many obstacles to attaining a great set of notes. "During lecture learning, students must continuously and simultaneously listen, select important ideas, hold and manipulate lecture ideas, interpret the information, decide what to transcribe, and record notes" (Kiewra et al., 1991, p. 241). The challenge of these tasks can be compounded in situations with difficult subject matter, large enrollment classes that offer little opportunities for interaction, or student learning preferences for non-auditory presentation of materials (see Boyle, 2012). In fact, numerous studies show that students are not very good note takers, generally recording less than 40% of the details contained in a lecture (e.g., Boyle, 2011; Kiewra, 1985; Titsworth & Kiewra, 2004).

Synthesis and Hypotheses

In the current study, we posit that, like driving, engaging in classroom activity is a cognitively intensive task that requires vigilance and active listening (Titsworth, 2004). If students split attention between lecture listening and actively communicating on an SNS or by texting, they may miss important cues and information from classroom lectures or discussion. Although previous research has shown that texting impedes learning (Kraushaar & Novak, 2010; Wei et al., 2012), few scholars have attempted to document specific processes through which such degradation in learning occurs.

The goal of the present study is to ascertain the potential impact of texting/posting on students' note taking behaviors, and ultimately on student learning. The design used in this study called for dividing participants into one of three groups: a control group who listened and took notes and two groups who listened, took notes, and engaged in simulated texting/posting—one with a moderate level and another with a higher level of texting. We predicted that, like Kraushaar and Novak (2010), we would observe significant differences in students' test scores when comparing the control group against the moderate and high texting groups.

- H1: Students' scores on a multiple-choice test covering lecture material will be greatest for the group that does not text/post, followed by the group with moderate texting/posting and then the group with frequent texting/posting behaviors.
- H2: Students' scores on a free recall test will be greatest for the group that does not text/post, followed by the group with moderate texting/posting and then the group with frequent texting/posting.

Whereas the first two hypotheses replicate patterns already observed in the literature, our primary objective was to explore mechanisms through which texting/posting disrupts learning. Because note taking helps students encode information and serves as an external storage mechanism, we reasoned that any distraction caused by texting/posting would be apparent in the notes taken by students. Scholars have previously examined the number of details from the lecture that are also contained in the students' notes (see Titsworth & Kiewra, 2004; Titsworth, 2004). If students' attention is diminished when texting/posting, the number of details recorded in their notes should be higher in the control group, followed by the two texting/posting groups.

- H3: Details recorded in students' notes will be greatest for the group that does not text/post, followed by the group with moderate texting/posting and then the group with frequent texting/posting.

Finally, we predicted that note taking will be positively related to achievement levels on the two tests. This prediction is based on previous research showing a significant positive relationship between the number of details contained in notes and scores on both multiple-choice and open-ended tests (see Titsworth & Kiewra, 2004).

- H4: There will be a positive correlation between the number of details recorded in students' notes and their scores on multiple choice (H4a) and open-ended (H4b) tests over lecture material.

Method

Recruitment of Participants

Participants in the study were students enrolled in one of several communication courses at a large Midwestern university. In those courses, students are required to participate in a research participation pool for a small amount of course credit. Following established departmental policies, students in the research pool were randomly assigned to one of several research projects being conducted within the department, of which this project was one. All students in the research participation pool completed a brief screening questionnaire when they initially registered for the overall research pool. The questionnaire posed several questions that helped the research pool administrator ascertain which participants met conditions to participate in particular studies. Students assigned to our study needed to meet three requirements, which were included in the screening questionnaire. First, students needed to be 18 years of age or older and a current university student. Second, students needed to have access to a mobile phone capable of accessing the Internet. Finally, students needed to have *not* taken two specific classes: the Introduction to Human Communication course and the Interpersonal Communication course. Students who took either of the courses were excluded because those courses address theories covered in the lecture materials used for the study. Excluding students who had taken those courses minimized the risk of including participants with previous knowledge of the theories used in the stimulus materials. Both the research pool

generally, and the procedures of this study in particular, were approved by the university's Institutional Review Board.

A total of 54 students meeting the screening criteria signed up for and attended one of the meeting times for the present study. Participants were divided into one of three groups: a control group, a low-distraction group, and a high-distraction group. Seven participants experienced technical problems that did not allow them to fully participate. These participants did receive credit for participating in the study, but because they were not able to complete all of the required steps, their information was excluded from the study. This left a total of 47 participants, 19 in the control group, 14 in the low-distraction group, and 14 in the high-distraction group. The age of the participants ranged from 18 to 22, with the average age being 18. The majority of participants (55.3%) were first-year students, 38.3% were sophomores, and 6.4% were juniors. The mean self-reported GPA of the participants was 3.33 ($SD = 0.380$). No statistically significant difference in age, GPA, or year in school was found between the three experimental conditions. All other aspects of the participants' demographics (e.g., sex and ethnicity) appeared consistent with the general student population of the university.

Procedures and Manipulation

After students had been assigned to this study, they were contacted by email and provided with basic directions for participation. They were asked to sign up, through the research participation system, to attend one of six meeting times in order to participate in the study and receive course credit. To achieve maximum participation, follow-up reminder emails were sent. Each timeslot was scheduled to last no longer than one hour, and timeslots were scheduled for Monday through Thursday of the fifth week of the term. All study timeslots were scheduled for the early evening, and each timeslot was randomly assigned to one of the three conditions: control, low-distraction, or high-distraction.

All meeting sessions for the study occurred in a standard university classroom designed to accommodate approximately 30 people. Prior to participant arrival, an envelope was placed on each desk containing materials used in the study; each envelope was marked with a unique identification number. After questions had been answered and informed consent was obtained, students were shown a video lecture and instructed to take notes over the lecture using paper provided in the packets; they were instructed to take notes as they normally would in a typical class. Students were informed that at the end of the lecture they would be given a 3-min review period, during which they should review their notes as if they were studying for a test or quiz, and after this review they would take several learning assessments.

After receiving initial instructions from the researcher, students in groups randomly assigned as the control condition were instructed to put their mobile phones away and then started watching the video lecture. Those groups assigned to either the low- or high-distraction conditions had two additional steps. First, students were instructed to take out their mobile phone capable of accessing the

Internet and to open their mobile web browser to a specific URL shown on the projection screen. The webpage to which they were directed provided a link to an online survey that was used to simulate texting/posting activity. The first question of the survey asked students to input the unique code found on their envelope. After this was completed, the survey proceeded to the second page that instructed students to wait while others entered their identification code. After everyone in the timeslot had arrived at this landing page, the researcher instructed the students to hit "Continue" and that they would automatically be presented with simulated texts/posts following a predetermined schedule. For instance, one text/post asked participants, "What is your favorite restaurant for dinner?" and another asked participants to "Comment on this photo (the simulated text/post showed an actual photo)." Participants were instructed to respond to the texts/post presented to them by the survey. Aside from language describing the simulated communication as a text or a post, the simulated texts/posts were rather similar in nature. Of course, students were instructed to listen to the lecture and take notes as this was occurring.

The two randomly assigned experimental groups represented low- and high-distraction conditions. In the low-distraction condition, participants were automatically given a new simulated text/post approximately every 60 seconds. The second condition, the high-distraction group, automatically received a simulated text/post approximately every 30 seconds. Students in the low-distraction group viewed roughly 12 texts/posts, while those students in the high-distraction group viewed roughly 24 texts/posts. The actual response to the simulated texts/post was left to the participants.

Prior literature offers little guidance on how often students receive texts/posts during the course of a day, let alone during a class lecture. Survey research indicates that 18- to 24-year-olds send or receive nearly 110 text messages per day, and this is greater than the average of all other age groups combined (Smith, 2011). Given these research findings, responding to 12 or 24 text messages in a short span of time is not outside the usual experience of many students. Though some participants may have found it overly distracting, it is important to note that students were instructed to respond to each interruption as best they could; the texts/posts merely comprised an element of the learning environment.

Lecture

The lecture used in this study lasted roughly 12 min and covered four communication theories: uncertainty reduction theory, social penetration theory, social exchange theory, and relational dialectics theory. Within each theory, the lecture covered four topics: general explanation of the theory, assumptions of the theory, how the theory explains relationship formation, and how the theory explains relationship dissolution. A male instructor not involved in this study was recruited to present the lecture from a script and to have this lecture recorded. Procedures called for each group to view the exact same lecture; thus, the content students viewed did not change, and

only the conditions under which they watched the lecture differed (i.e., the group they were assigned to).

Tests of Student Learning

At the end of the video lecture, students were given a three-minute review period to look over their notes. After the review period, they were instructed to place their notes in the envelope and take out a sheet of paper labeled *Free Recall Test*. The free recall test provided students with the organization or main headers from the lecture, but without corresponding details. For this test, students were given five minutes to fill in all details that they could remember from the lecture. After five minutes had elapsed, they were instructed to place the recall test in their envelope and take out a *Multiple-Choice Test*. The multiple-choice test consisted of 16 questions covering material from the lecture. Students were given five minutes to complete the multiple-choice test, after which they were instructed to place the completed test in their envelope and take out a brief survey asking various demographic questions. After completing the survey, students were instructed to make sure all study materials had been placed in their envelope and to then return the envelope to the researcher.

Coders and Grading

After all data had been collected, two coders were recruited to score materials following procedures similar to those used by Titsworth (2001). The coders were responsible for grading two items: the notes participants took during the video lecture and the free recall test. Both coders were trained to use a codebook and coding sheet to score the materials. The coding sheet contained the text of the lecture broken down into individual statements. Appropriate statements were identified as details that should be recorded in students' notes and described on the free recall test. Details were discrete items consisting of examples, specific explanations, and definitions contained in the lecture.

Coders were instructed to compare students' notes to the coding sheet to determine whether each statement on the sheet appeared in the notes. To receive credit for noting a particular point, exact wording was not necessary. If a particular statement was not included in a set of notes, the participant received a zero for that statement, indicating a failure for that particular point. Some items recorded in notes were obviously related to details on the scoring sheet, but lacked complete information or was otherwise not perfectly clear; those items received one point as an indication that *something* was present but that the recorded detail was not perfect. In situations where participants' notes fully covered the content for a specific detail, they were awarded two points. Another way of interpreting this coding technique is that zeros were failed answers, ones were a minimally sufficient answer, and twos were an outstanding answer. There were a total of 76 possible details that could be recorded in students' notes. This same grading technique was used to score participants' answers on the free recall test, which had 78 possible items.

By using the three-tier scoring system for the notes and the detail tests, we were able to determine an overall score indicating how many details were recorded in notes and on the recall test, as well as specific values indicating the quality of answers (or complete absence of answers) for each detail. While related, the specific failure and excellent values provided an additional level of information in our analysis not present in other note taking studies. Thus, for both note taking and the free recall test, we recorded the overall score for details, the number of failures, and the number of excellent/perfectly worded details.

A subset of 10% of the total participant materials ($N=47$) was randomly chosen to test consistency between the coders. Both coders graded the notes and free recall test from this subset independently, and their coding sheets were then used for calculating intercoder reliability. After addressing minor differences between the two coders, Cohen's kappa was calculated for overall details recorded in students' notes and for details noted on the free-recall test. For note details Cohen's kappa was .84, and for recall test details Cohen's kappa was .77. Landis and Koch (1977) note that kappa values between .61 and .80 can be considered to have substantial agreement. In addition, percent agreement statistics were calculated and indicated that the coders agreed nearly 95% of the time. The KR-20 for the multiple-choice test was .524. Although this reliability estimate is lower than desired, it should be noted that the formula includes error introduced by the various experimental conditions in this study. That variance in students' scores, coupled with the relatively small number of questions, likely means that this is an underestimate of the actual consistency of the test.

Results

The first hypothesis predicted that students' scores on a multiple-choice test over lecture content would be greatest in the control group, followed by the low-distraction group and then the high-distraction group. Because the hypothesis essentially predicted a linear negative relationship between students' frequency of texting/posting and their test scores, we were able to test this hypothesis using a series of planned comparisons in the SPSS ONEWAY procedure. The first comparison tested for a linear polynomial trend for students' test scores across the three groups. That trend was significant, $F(1, 44) = 7.207$, $p < .05$, and there was no significant deviation away from linearity, $F(1, 44) = .000$, $p > .05$. Table 1 shows means and standard deviations for each group. As indicated by those values, there was a negative relationship between texting/posting frequency (i.e., zero texts/posts in the control group, one per minute in the low-distraction group, and two per minute in the high-distraction group) and students' test scores. Using a set of orthogonal comparisons, we observed that the control group was significantly different from the combined means for the low and high texting/posting conditions ($M = 8.965$, $SD = 2.154$), $t(44) = 2.389$, $p < .05$, Cohen's $d = .70$. The comparison between the control group and the low texting/posting condition group was not significant, $t(44) = 1.347$, $p > .05$, Cohen's $d = .48$, observed power = .763. The comparison of the control

Table 1 Means and Standard Deviations for Students' Multiple-Choice Scores, Free Recall Scores, and Noted Details Across Groups

Variable	Group		
	Control	Low-distraction	High-distraction
Multiple choice	10.58 (2.43) _a	9.50 (2.07)	8.43 (2.24) _a
Free recall	12.84 (8.65) _b	8.14 (5.86)	6.21 (5.06) _b
Noted details	25.05 (11.97) _c	20.36 (10.16)	15.50 (7.06) _c

Note. Values in parentheses are standard deviations. Common subscripts indicate a statistically significant difference between groups ($p < .05$).

versus the high-distraction group was significant, $t(44) = 2.685$, $p < .05$, Cohen's $d = .92$. The comparison between the low- and high-distraction groups was not significant, $t(44) = 1.246$, $p > .05$, Cohen's $d = .50$, observed power = .822.

In evaluating the first hypothesis, data were consistent with the prediction. First, the linear polynomial trend coupled with the ordering of the means in Table 1 indicates a significant negative relationship between texting/posting and test performance. Coupled with the fact that the control group outperformed the combined texting/posting groups, and that the control group significantly outperformed the high-distraction group, we conclude that the data were consistent with the hypothesized predictions.

The second hypothesis predicted that students' scores on a free recall test would be greatest in the control group, followed by the low-distraction group and then the high-distraction group. The linear trend was significant, $F(1, 44) = 7.333$, $p < .05$, and there was no significant deviation away from that trend, $F(1, 44) = .388$, $p > .05$. A significant contrast was observed when comparing the control group against the mean ($M = 7.18$, $SD = 5.46$) of the combined low and high-distraction groups, $t(44) = 2.742$, $p < .05$, Cohen's $d = .78$. There was also a significant contrast when comparing the control group against the high-distraction group, $t(44) = 2.708$, $p < .05$, Cohen's $d = .94$. Neither the contrast comparing the control versus the low-distraction group, $t(44) = 1.920$, $p > .05$, Cohen's $d = .64$, observed power = .76, nor the contrast comparing the low and high-distraction groups, $t(44) = .734$, $p > .05$, Cohen's $d = .35$, observed power = .81, were significant. The pattern of means shown in Table 1 indicates that students' scores on the free recall test diminished as the frequency of texting/posting increased, this providing support for Hypothesis 2.

The third hypothesis predicted that the number of details recorded in students' notes would be higher in the control group, lower in the low-distraction group, and lowest in the high-distraction group. The linear trend was significant, $F(1, 44) = 7.082$, $p < .05$, and there was no significant deviation away from that trend, $F(1, 44) = .001$, $p > .05$. As shown by the values in Table 1, detail scores diminished as the rate of texting/posting went from zero in the control group, to one text/post per-minute in the low-distraction condition and two texts/posts per minute in the high-distraction condition. A set of orthogonal planned comparisons was also calculated to test significant differences between the groups. The first comparison

indicated a significant difference between the control group and the combined average for both texting/posting groups ($M=17.93$, $SD=8.61$), $t(44)=2.352$, $p<.05$, Cohen's $d=.68$. Neither the comparison of the control group to the low texting/posting condition, $t(44)=1.308$, $p>.05$, Cohen's $d=.42$, nor the comparison between the low and high texting/posting conditions, $t(44)=1.261$, $p>.05$, Cohen's $d=.55$, were significant; observed power for the two tests was .61 and .81, respectively. There was a significant contrast effect when comparing the control group versus the high-distraction group, $t(44)=2.661$, $p<.05$, Cohen's $d=.97$. Taken collectively, the first hypothesis was supported based on a) the significant linear polynomial trend, b) the pattern of means, and c) the significant contrast between the control and high-distraction groups.

The final hypothesis predicted significant positive correlations between the number of details recorded in students' notes and their scores on multiple-choice and free recall tests. One-tailed hypothesis tests resulted in significant positive correlations observed between noted details and multiple-choice test scores ($r=.362$, $p<.05$) as well as free recall test scores ($r=.424$, $p<.05$). These results were consistent with the predictions in Hypothesis 4.

In addition to the tests for each of the four hypotheses, we conducted post hoc analyses to determine whether texting/posting resulted in quality differences in students' notes, particularly in reference to details recorded and answers on the free recall test. Specifically, we compared the average number of zeroes (failure to write down or recall the piece of content), ones (minimally sufficient answer), or twos (outstanding answer) scored for each group. Observed significant differences among the groups would add specificity to our understanding of how students' notes and memory differed among the groups.

The first set of post hoc analyses focused on details recorded in students' notes. We obtained an ANOVA to compare differences in the average number of zeros for each group in the detail column. No statistically significant differences in the average number of zeros awarded to each group, for detail, was found, $F(2,46)=2.51$, $p>.05$, $\eta^2=.103$. A second nonsignificant finding was obtained when we compared the average number of minimally sufficient answers awarded for detail, $F(2,46)=0.51$, $p>.05$, $\eta^2=.023$. A statistically significant difference was observed between the average number of outstanding answers awarded to each group for detail, $F(2,46)=4.45$, $p<.05$, $\eta^2=.168$. Tukey post hoc testing indicated that the average number of outstanding answers awarded to the control group ($M=8.26$, $SD=4.37$) was significantly greater than the high-distraction group ($M=4.29$, $SD=2.23$). However, the low-distraction group ($M=6.57$, $SD=4.13$) was not significantly different from the other two groups.

The second set of post hoc analyses examined the quality of students' answers on the free recall test. The ANOVA examining the average number of zeros on the free recall test was statistically significant, $F(2,46)=4.71$, $p<.05$, $\eta^2=.177$. Tukey post hoc testing indicated that the control group ($M=68.32$, $SD=6.55$) received fewer zeros than the high-distraction group ($M=73.14$, $SD=3.44$). No statistically significant difference between the low-distraction group ($M=72.50$, $SD=3.50$)

and the other two groups was found. The difference between the average number of ones awarded on the free recall test was also statistically significant, $F(2,46) = 5.29$, $p < .05$, $\eta^2 = .194$. Tukey post hoc testing indicates that the control group ($M = 6.53$, $SD = 4.75$) was significantly different from both the low-distraction ($M = 2.86$, $SD = 1.92$) and high-distraction groups ($M = 3.50$, $SD = 2.57$). No significant difference between the low-distraction and high-distraction group was found. Finally, we observed no statistically significant differences in the average number of twos awarded to each group, $F(2,46) = 2.38$, $p > .05$, $\eta^2 = .098$.

Discussion

The goal of this study was to test whether or not texting/posting during a class negatively impacts students' note taking and subsequent performance on tests. Literature indicates that many students use their mobile phones, while in class, to send or receive text messages and post/respond to SNS content. Some studies (e.g., Lenhart, 2010) show that over 60% of teens with mobile phones have texted while in class. Previous research exploring laptop use during class lecture found a strong, negative correlation between student use of instant messaging services and quiz averages, project grades, and final exam grades (Kraushaar & Novak, 2010). Previous research has also observed that frequent texting during class influenced students' ability to attend to material being covered in that class and potentially results in decreased perceived cognitive learning (Wei et al., 2012). Results of the current study contribute new information to this body of literature by showing that texting/posting diminishes the number of notes recorded by students during lectures and results in subsequent impaired performance on various types of tests.

In this study, we posed four hypotheses, each predicting a negative linear relationship between the amount of texting/posting and students' scores on different learning assessments. The first hypothesis predicted that students' scores on a multiple-choice test would decrease as students text/post more. Results provide support for this hypothesis. The control group scored the highest on the multiple-choice test, followed by the low-distraction group and the high-distraction group. Although planned comparison tests did not show significant differences among each of the groups, the significant linear trend, pattern of means, and observed significant differences between the control and high-distraction group led us to conclude that hypothesis 1 was tenable.

One way of meaningfully interpreting the results of hypothesis 1 is by converting the average points received on the multiple-choice test into a percentage grade. In this case, the control group's average grade was 66%, while the average grade for the high-distraction was 52%. In practical terms, the difference in grade between those students that were actively texting/posting (high-distraction) and those that were not (control group) was over one full letter grade, or roughly 13 percentage points. These results are generally consistent with those reported by Wood et al. (2012) who observed percentage scores between 53% and 74% for a control group who refrained from texting/posting or emailing; scores for students who used one or more SNS were

as low as 42%. In addition, this result also appears to be consistent with the findings of Titsworth and Kiewra (2004), who found that when students take notes they can score nearly one and one-half letter grades higher on exams.

The second hypothesis predicted that students' scores on the free-recall test would be greatest for the group that did not text/post, followed by the group with moderate texting/posting and then the group with frequent texting/posting. Results from this study provided support for this linear relationship. In particular, we observed a statistically significant difference between scores of the control group and those of the high-distraction group, and the magnitude of this difference was large (Cohen's $d = .954$). The control group scored significantly better on the free-recall test than the high-distraction group. This finding conformed to the hypothesized trend, and our results indicated that the scores for the three groups did not deviate from the negative linear trend.

The practical implication stemming from the tests surrounding hypothesis 2 is that students who were actively texting/posting simply recalled less information than students who were not texting/posting. Specifically, students in the control group scored 36% higher than the group with low rates of texting/posting and 51% higher than the group with high rates of texting/posting. Because neither Wood et al. (2012) nor Wei et al. (2012) explored free recall as a measure of cognitive learning, this study adds new information about the effects of texting/posting on students' academic performance.

The third hypothesis posited that details recorded in students' notes would be greatest for the group that did not text/post, followed by the group with moderate texting/posting and then the group with frequent texting/posting. Again, results provided support for a negative linear trend between frequency of texting/posting and details recorded in students' notes. There was no significant deviation from this trend, and the proposed ordering of the groups—control, low-distraction, and high-distraction—was also observed. We found a statistically significant difference between the control group and high-distraction group; however, we failed to find a significant difference between the low-distraction group and other two groups. Put simply, the control group had significantly more details in their notes than the high-distraction group, and the magnitude of this difference was rather large (Cohen's $d = .937$).

In typical college classroom situations, students record about 40% of the details from a lecture (Kiewra, 1984). In the present study, students in the control group recorded 33% of the details. In comparison, students in the low-distraction group recorded only 27% and in the high-distraction group only 20%. Thus, the act of texting/posting had a negative effect on students' likelihood of recording details in their notes. In essence, students in either of the texting/posting groups were asked to do two things at once, both of which required students to use their hands to either respond to texts/posts or to note lecture material. From a purely physical standpoint, texting impedes note taking. Cognitively, as students engage in dialogue with others through texts/posts, they will likely be less capable of adequately processing information, taking notes on that information, and recalling information during assessment opportunities.

The final hypothesis proposed that there would be a positive correlation between the number of details recorded in students' notes and their scores on multiple-choice (H4a) and open-ended (H4b) tests over lecture material. Results indicated moderate to strong positive correlations similar to those reported by Titsworth (2004), suggesting that note taking did have a meaningful impact on students' ability to encode information.

Taken collectively, the results of this study have meaningful implications for both classroom practices and theory surrounding the effects of texting/posting. From a practical standpoint, these results provide additional documentation for the negative effects of texting/posting during class. Compared to those students who do not text/post, when students engage in these behaviors they will potentially record 38% fewer details in their notes, score 51% lower on free-recall tests, and 20% lower on multiple-choice tests. Both teachers and students should explore viable options for minimizing the impact of texting/posting on students' grades, including explicit course policies against such behavior as well as other options. Finn and Ledbetter (2013) suggest that instructors carefully consider classroom technology policies and that simply ignoring the issue altogether is not a viable option in the modern classroom. If instructors wish to discourage mobile device use in the classroom, instructors should talk with students about why they should avoid using mobile devices during class.

Although the practical negative effects of texting/posting are meaningful for both teachers and students, worth noting is the caveat that these results could be linked to the content of the texts and posts. For instance, Kraushaar and Novak (2010) noted that productive uses of personal computers during class—for instance, viewing course-related content like lecture slides—could potentially be conducive to learning. Similarly, Stephens, Murphy, and Kee (2012) noted that use of a chat feature in Adobe Connect, a tool for synchronous two-way audio and video that is commonly used for distance-learning classes, promoted higher levels of engagement and satisfaction among students. In the present study, students engaged in texting and posting about topics irrelevant to information presented in the lecture; students engaging in similar behaviors with topics related to the lecture material may achieve at higher levels. Future studies should explicitly test how the content of texts/posts potentially interacts with frequency to influence attention and learning.

Results of this study also suggest that theoretical explanations surrounding the negative effects of texting/posting should be expanded. Previous researchers (e.g., Wei et al., 2012; Wood et al., 2012) relied on attention as the primary way in which texting/posting could impact information processing. Results of our study do not contradict that explanation; however, our results point to additional possible explanations. Namely, we observed evidence suggesting that texting/posting could impede students' ability to effectively process information in short-term memory and to subsequently store information into long-term memory.

First, note taking provides a strong indication of what is actively being processed in short-term memory (see Titsworth & Kiewra, 2004). In particular, the encoding function of note taking implies that noted items are actively held in short-term/working

memory; some of those items are immediately stored in long-term memory while others are transitioned to notes—the external storage function. Evidence in the current study shows that students note fewer details when they text, which could imply that even if information is attended to by students, it may not be adequately processed in short-term/working memory.

In addition to the differences between groups on overall noted details, results from the post hoc analyses also shed light on how texting could disrupt students' ability to process information accurately. Students in the control group recorded a larger number of details scored as excellent by the coders than did students in the high-distraction group. In addition, the high-distraction group was more likely than the control group to completely miss a detail (a potential indication of lack of attention) or to record the detail in a way that is not completely accurate or clear, which is a potential indication that short-term/working memory was disrupted by the act of texting. If attention were the only plausible explanation of how texting impacts information processing, we would expect the effects to be most visible in errors of omission, or the zero scores. Because students were able to recall some aspects of the details, a lack of attention cannot be the only explanation—texting/posting must also impact how students process information after the information has passed through their attention filters. This finding adds greater detail to the theory-based explanation of why texting has a negative effect: not only is attention diminished, but the act of processing information in working memory could also be compromised.

The findings of this study point to several directions for future research. First, it appears that the method used in this study was successful and could be used by future researchers. One suggestion for future researchers is to further refine the online survey used to simulate texting and Facebook posts. While the online survey we used did automatically display a new text message or piece of SNS content after a set period of time, it would be interesting to time this pairing with specific content from the video lecture. For example, a future study could attempt to time a mobile-phone distraction to coincide with specific detail from the prerecorded lecture and then see if students write down, recall, and answer, correctly, questions about that content. This level of precision may allow for additional information about the effect of mobile phone usage or distractions on student learning. Future researchers should also devise approaches to test the attention vs. working memory explanations for how texting/posting affects information processing. Although the net outcome for students would remain the same, knowledge of how texting/posting affects various information processing mechanisms would provide a more complete theoretical explanation for observed effects.

Based on these findings, we offer some practical advice for both teachers and students. Teachers should inform students of the results of this study. For example, including a short summary of our results in a course syllabus may allow students to make a more informed decision about their mobile-phone usage during class lectures. In many classroom settings, the instructor has little control over student mobile phone usage. However, we believe that instructors, by helping inform students of the

potential consequences of their actions, can help educate students and perhaps lead them to making a more informed decision to not use their mobile phone while in class.

Although we did find statistically significant results, this study is not without limitations. The sample size was admittedly small, but we did find statistically significant differences for many of our hypotheses. Even on the tests with nonsignificant results, our observed power was typically at an acceptable level, roughly .80. Although the sample size was statistically sufficient for the analyses we intended to perform, future researchers should attempt to replicate these findings to establish greater ecological validity for the results. In addition, it might be beneficial to include a pretest to gauge student prior knowledge in the content area covered in the lecture. The prescreening questions used in the current study likely mitigated the effects of differential prior knowledge on the findings; however, future studies should explicitly examine how this variable potentially influences the effects of texting on note taking and exam performance.

Another limitation of the study could be the length and/or content of the video lecture. The video was approximately 12 minutes long and covered four different communication theories. It very well could be that too much information was presented in the video, or the pacing of the video was perhaps too quick. Using this design as a potential guide, future scholars should attempt to replicate these findings using a prerecorded lecture from an actual class. This step would add realism to the findings and would better account for the natural ebb and flow of a typical classroom lecture.

Finally, it is worth pointing out that use of simulated text/posts can itself be a limitation. Our study does not account for the content of the simulated messages but instead focused on creating simulated text/posts that would require the participant's attention to respond. Future studies could build on our findings by examining whether the content of texts/posts has an impact on student recall or note taking. For example, it would be interesting to determine if the context of the texts/posts plays a role in impacting student learning. It may very well be that an ongoing conversation taking place via texts/posts competes more for a student's attention than an innocuous status message. Pairing participants with friends who are instructed to send texts or posts while a lecture is being shown could provide a more realistic manipulation and could allow researchers to fully analyze variance in content for texts/posts in relation to learning outcomes. As noted previously, future studies should explore differential effects of texts/posts about course material with varying levels of salience to the lesson.

Conclusion

The goal of this study was to further understand and examine the impact of student texting/posting, during class lecture, on student learning. We found that students who were using their mobile phone frequently during a video lecture scored, on average, 13 percentage points, or a letter grade and a half, lower on a multiple-choice test than those students who were not using their phones. Students who were not using their mobile phones not only did 62% better on overall note taking, but also

recorded 93% more outstanding answers in their notes than the group of students who were frequently using their mobile phones. Finally, students who were not using their mobile phones recalled 87% more minimally sufficient answers than the high-distraction group and in general did substantially better at recalling information from the lecture. These findings provide clear evidence that students who use their mobile phones during class lectures tend to write down less information, recall less information, and perform worse on a multiple-choice test than those students who abstain from using their mobile phones during class.

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