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Preference for multitasking, technological dependency, student metacognition, & pervasive technology use: An experimental intervention

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ABSTRACT

Technology-enabled multitasking has garnered increased critical attention in recent years. Research on multitasking in educational environments commonly assert a multitude of undesired outcomes such as heightened distraction, hindered learning, and hampered productivity. This study considers critical research gaps related to media multitasking, including student metacognitive awareness. In addition, this study tested a commonly suggested, yet previously untested, educational response wherein students are made aware of the problematic phenomenon, with the aim of mitigating the pervasive behavior. Findings suggest that student technology use is highly attributed to their anxiety without technology and dependency on technology, rather than any actual preference for multitasking. Metacognitive awareness was inconclusively correlated with rampant technology use; however, those who exhibited higher behavioral management tendencies demonstrated greater control of their technology use. And while the quasi-experimental awareness intervention failed to shift student media multitasking behavior, promising areas for future research were illuminated through the qualitative analysis.

1. Introduction

Multitasking has garnered increased critical reception with the rise of technological affordances and portability. Once a praised skill within certain scholastic and professional environments, multitasking has dramatically evolved (Monk, Trafton, & Boehm-Davis, 2008). With the ubiquity of cellular connection, text messaging, social media, and the Internet, the modern multitasker is consistently engaged and always "on" at previously unimagined levels (Bellur, Nowak, & Hull, 2015).

K–12 and postsecondary institutions have similarly evolved. Smartphones, interactive whiteboards, personal tablets, and laptops define today's modern classroom. Technology's prominent role within pedagogy is far from new, especially as BYOD, 1:1, and TPACK need little to no explanation. With the burgeoning prevalence of personal technology, however, researchers have documented a concerning rise in problematic outcomes related to technology-enabled student multitasking in and out of the classroom (Foehr, 2006; Rideout, Foehr, & Roberts, 2010).

In the professional workplace, modern multitasking is often linked with increased distraction, frequent misuse of technology, heightened workplace accidents, diminished productivity, and loss of profits (Chisholm, Collison, Nelson, & Cordell, 2000; Juneja & Roper, 2010; Loukopoulos, Dismukes, & Barshi, 2009). On the road, technology-enabled multitasking is routinely linked with unsafe, inattentive driving (Engström, Johansson, & Östlund, 2005; National Safety Council, 2010). And in the classroom, early research links this prevalent phenomenon with hampered productivity, hindered scholastic performance, and heightened distraction at the expense of desired scholastic performance (Bergen, Grimes, & Potter, 2005; Hembrooke & Gay, 2003; Sana, Weston, & Cepeda, 2013; Unsworth, McMillan, Brewer, & Spillers, 2012). As neuroscience continues to affirm, the multitasking mind is a highly compromised mind that arduously toggles, divides, and sacrifices key mental faculties, often at the expense of proper information processing, encoding, and attention (Bozeday, 2013; Foerde, Knowlton, & Poldrack, 2006; Heatherton & Wagner, 2011; Levy & Pashler, 2001).

Research has yet to exhaust pertinent considerations related to technology-enabled multitasking. Educators are consistently

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witnessing and combatting student technology-enabled multitasking and misuse. Yet, there exist critical research gaps related to how educators may appropriately address and potentially mitigate this problematic and pervasive phenomenon. This study considers – both in analysis and in experiment – research gaps related to student-held motivating attitudes towards multitasking as well as potential pedagogical approaches. While the complicated, and often undesired, nature of technology-enabled multitasking has been well documented, this study aims to practically advance the burgeoning body of literature towards applicable considerations focused on individual multitasking behavior and subsequent educational responses.

Few studies have considered student attitude toward technology and preference for multitasking, even though “attitudes help guide action and interaction by providing efficient, valenced summaries of a larger amount of evaluative information that would be difficult to process piece by piece before each behavior we undertake in life” (Ledgerwood & Trope, 2011, p. 227). Accordingly, attitudinal beliefs, which can act akin to an antecedent or motivator, commonly correlate with exhibited behavior. Consequently, focused examination of student-held attitudes toward technology and preference for multitasking may further explain why students exhibit pervasive multitasking behavior (Dijksterhuis & Van Knippenberg, 1998; Ledgerwood & Trope, 2011).

In addition, no known studies have empirically considered student-held metacognitive awareness in concert with technology use or preference for multitasking. Should empirical data present a relationship between metacognitive awareness and technology-enabled multitasking behavior, a practitioner could theoretically construct a focused pedagogical response to bolster metacognitive awareness and potentially mitigate problematic multitasking behavior.

Last, existing research has sporadically conjectured varying educational responses to address the pervasive, distracted behavior. Of the many different recommendations as to how educators should respond, most encourage increasing student awareness to their technology-enabled multitasking tendencies with the hope of prompting greater student control, thereby mitigating the negative outcomes (Bowman, Waite, & Levine, 2015; Rosen, Carrier, & Cheever, 2013; Rosen, Whaling, Carrier, Cheever, & Rokkum, 2013; Sana et al., 2013). These recommendations, however, have largely remained untested and are speculative.

1.1. Media multitasking: background

Task-switching is the behavior of quickly toggling between separate tasks, attending to each independently, often for a short period of time. *Multitasking* is more appropriately the act of mutually dividing mental faculties between simultaneous tasks (Alzahabi & Becker, 2013; Rothbart & Posner, 2015). Because task-switching and multitasking produce similar effects, the two behaviors are often colloquially referenced as multitasking (Rothbart & Posner, 2015). As an extension, *media multitasking*, a term first coined by the Kaiser Foundation (Roberts, Foehr, & Rideout, 2005), is the consumption of two or more streams of content, facilitated by technology (Ophir, Nass, & Wagner, 2009).

Media multitasking resides within the construct of attentional control (e.g., Wood et al., 2012), and within the broader framework of self-regulation (e.g., Hagger, Wood, Stiff, & Chatzisarantis, 2010). *Attentional control* is the ability to sustain deep and focused cognitive attention (Unsworth et al., 2012). Daydreaming and mind-wandering also reside within attentional control (Smallwood & Schooler, 2006; Unsworth et al., 2012); however, these are often purely cognitive, whereas media multitasking considers both behavioral and cognitive control because the individual physically engages with the technology (Alzahabi & Becker, 2013).

Although research routinely notes the detrimental effects of multitasking, the activity sometimes persists as a touted professional competency (Monk, Trafton, & Boehm-Davis, 2008). To be fair, multitasking is necessary for certain professions and is an indisputable phenomenon in education and life (Wood & Zivcakova, 2015). Multitasking can be an efficient use of time; a relatively manageable endeavor when necessary; or, when well-monitored or well-regulated, and an effective tool in problem solving (Altmann & Trafton, 2002; Brasel & Gips, 2011; Levine, Waite, & Bowman, 2007; Lin, 2009).

1.2. Media multitasking: pervasiveness and outcomes

The burgeoning critical reception to technology-enabled multitasking is attributable, in part, to the rise in the pervasiveness of the phenomenon. With youth, “there has been a 120% increase in time that youth between the ages of 8 and 18 years old multitask with media” (Alzahabi & Becker, 2013, p. 1). A recent national study with 500 undergraduate students noted that 73% of students who were unable to study without some form of technology, and 38% exhibited distracted behavior within 10 min of studying (Kessler, 2011). Marci (2012) found that students switch tasks an average of 27 times per hour. Finally, an experience sampling study with university students found that students were using the Internet and multitasking in more than 50% of the texted samplings, which spanned throughout the day and evening, including their time in the classroom (Moreno, Jelenchick, Koff, Eikoff, Diermyer, & Christakis, 2012).

Classrooms and study halls are not immune to this multitasking behavior. Kraushaar and Novak (2006) suggest that students multitask 42% of class time, with an average of 65 (65.8) laptop windows (e.g. Internet window or tab) generated per lecture; the vast majority of which were labeled as distracted and off-task (40.7 distracted and 25.1 productive). Rosen, Carrier, et al. (2013) found that concurrent computer-window generation rose in conjunction with heightened distraction, with the peak number of generated windows often exhibited at the lowest level of students' on-task attention: 10 minutes into the lecture. Additionally concerning, as Sana et al. (2013) found, students seated near multitasking peers were consistently distracted and performed worse on retention measures compared to those sitting near students who were not multitasking.

The pervasiveness of media multitasking in and out of the classroom is attributable to the phenomenon's inherently human antecedents. Neuroscientists argue that competing tasks trigger different areas of the brain, mainly the prefrontal cortex (top-down processing: high-functioning, high-order) or the striatum (bottom-up processing: low-level; reactionary; having an emotional stimulus, such as anxiety) (Bozeday, 2013; Lin, 2009; Rosen, Lim, Carrier, & Cheever, 2011). As a result, the brain frequently prioritizes one task over the other, unable to stimulate both (Bozeday, 2013). As Heatherton and Wagner (2011) note, attentional failure, frequently instigated by subcortical (striatum) regions of the brain, often leads to a breakdown in prefrontal, top-down processing.

These neurological findings support Wang and Tchernev's (2012) finding that the “driving force behind multitasking is emotional rewards gained—even at the cost of learning,” (Rosen, Carrier, et al., 2013, p. 949) and not long-term goals (top-down processing). To this point, numerous studies have examined the relationship between anxiety and media multitasking (e.g., Becker, Alzahabi, & Hopwood, 2013; Pea et al., 2012; Rosen, Whaling, Rab, Carrier, & Cheever, 2013). Considering the documented value of social connection and social capital (Steinfield, Ellison, & Lampe, 2008), this neurological dynamic may explain common research findings in which socially focused forms of multitasking and distraction, such as Facebook and Twitter, are often the most pervasive multitasking endeavor (Junco, 2013; Junco, Heiberger, & Loken, 2011).

The foremost concern with pervasive student multitasking is more directly related to the negative performance implications. Studies routinely show that heavy multitaskers demonstrate comparatively poorer scholastic performance than those students who multitask less (Kraushaar & Novak, 2006; Rosen et al., 2011; Sana et al., 2013; Wood et al., 2012). In a controlled experimental study spanning three sessions, Wood et al. (2012) found a strong correlation between student distraction in the classroom and measurably diminished performance. In a seminal study from Ophir et al. (2009), students who identified as strong multitaskers performed measurably worse on retention measures compared to those students who self-identified as poor multitaskers. Ophir et al.'s study segues to a key consideration related to behavior, awareness, and performance: metacognition.

Metacognition refers to an awareness or understanding of one's mental faculties and abilities, and the definition often incorporates knowing how to best use "these skills and strategies" (Schunk, 2011, p. 286). Students with higher metacognitive awareness better understand their own abilities as learners and the subsequent behavior that best supports such efforts (Zimmerman, 2010). As Keith and Frese (2005) noted, errors or failures often prompt learners with higher metacognitive awareness to "stop and think about the causes of the error" (p. 680). This dynamic speaks to the often-cited relationship between metacognition and self-regulation as students frequently monitor and, when necessary, adjust their behavior (Lai, 2011).

Noting the cited undesirable scholastic outcomes with media multitasking, one could assume that students with higher metacognitive awareness will demonstrate less problematic media multitasking behavior. Although theoretically sound, this assumption is overly idealistic. Finley, Benjamin, and McCarley (2014) found that individuals "engage in multitasking behavior despite their metacognitive judgment about the performance costs" (p. 164). In contrast, Wei et al (2012) found that "self-regulated students were more likely to sustain their attention on classroom learning, and therefore less likely to text-message during class" (p. 200). The correlated, and not causal, relationship between metacognition and behavior (Schunk, 2008; Sperling, Howard, & Staley, 2010) may explain such incongruent findings. The incongruence also underscores the need to empirically measure, and not simply intimate, the relationship between metacognition and multitasking behavior.

There are many of recommendations to how student multitasking and its negative effects can be mitigated. These recommendations vary from pedagogical, such as planned technology breaks (Rosen, Carrier, et al., 2013); to procedural, such as limited technology access in the classroom (Sana et al., 2013). The vast majority of studies recommend against complete bans. As Sana et al. argued, a complete ban is extreme and unwarranted, especially as research suggests that removing physical distraction may not remove the internal distraction or anxiety. As Rosen, Carrier, et al. (2013) noted, "for younger learners 'out of sight' is most definitely not out 'of mind' …" (p. 956). Empowering older students to regulate their behavior and utilize their mental faculties - harkening the relevance of self-regulation and metacognition - has amassed the most conjectured confidence in extant research.

1.3. Study aim

This study considers the potential empirical relationship(s) between attitude, technology use, preference for multitasking, and metacognitive awareness. Any identified relationships – should they be significant – may advance our understanding of this pervasive phenomenon by further illuminating potential antecedents as well as contributing or perpetuating motivators.

In addition, this study tests the suggested educational recommendation that heightened student awareness will mitigate problematic and pervasive media multitasking behavior. This examination was tested via a quasi-experimental intervention with two control groups and one experimental group. These three groups were populated by a subset of students who completed the large measure focused on empirical relationships between technology use, attitude, and metacognitive awareness.

With the smaller set of participants, we were able to consider preference for multitasking against scholastic performance, as measured by school Grade Point Average (GPA), and also administer a set of qualitative open-ended responses. With the documented detriments of multitasking on scholastic performance, it stands to reason that those with higher GPAs may demonstrate lower multitasking tendencies. The GPA and qualitative open-ended considerations supported a stronger examination of the complex phenomenon by further triangulating our findings against scholastic performance and student testimonials.

2. Methods

2.1. Study Measures

Classic procedures to measure multitasking have predominately relied on observation. With the portability of new technologies, however, accurate measurement of media multitasking has become a significant challenge (Rosen, Whaling, Carrier, et al., 2013). As Rosen, Whaling, Carrier, et al. state, "With a Wi-Fi enabled mobile device, people can access the Internet, e-mail, text, and use applications that can do most traditional computing activities anywhere and at any time of the day or night and research shows that people are doing just that" (p. 2501).

To date, measurement of media multitasking largely relies on values that reflect time expended per day, frequency within a given period of time, and experience sampling (querying participants at particular or random times throughout the day). Many studies ask individuals to self-report their technology use, which has proven to be problematic. Junco (2013) found the estimates between actual (via monitoring software) and reported multitasking were drastically different. Self-report measures were "approximate, but … not accurate measures of actual use," with students overestimating their time spent on Facebook by 2 hours per day (p. 631).

In response to such challenges, Rosen, Whaling, Carrier, et al., (2013) developed the Media and Technology Usage and Attitudes Scale (MTUAS), a measure to capture self-reported frequency rather than self-reported time for multitasking. Rosen, Whaling, Carrier, et al.'s measure significantly contributes to the body of research on media multitasking because it reflects reported media use and considers—for the first published time—student attitude toward technology and preference for task-switching.

The MTUAS consists of 11 technology usage subscales (three of which are further defined as social media friendship/usage subscales), and 4 technology attitudinal subscales (positive attitudes toward technology; negative attitudes toward technology; preference for task-switching; and anxiety without technology and dependency on technology). The preference for task-switching subscale was originally validated as part of the Multitasking Preference Inventory (MPI) (Poposki & Oswald, 2010). As Rosen, Whaling, Carrier, et al., (2013) have noted, "The [15] subscales can be used together or separately as they are internally reliable and externally valid" (p. 2507).

Accompanied with the MTUAS measure, we administered two subscales of the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich, Smith, Garcia, & McKeachie, 1991). As Pintrich et al. note, the MSLQ "is a self-report instrument designed to assess college students' motivational orientation and their use of different learning strategies for a college course" (1991, p. 3). Along with the Learning and Study Strategies Inventory (LASSI) and the Metacognitive Awareness Inventory (MAI), the MSLQ is one of the most commonly administered measures when considering metacognitive awareness. Of these three, the MAI is commonly regarded as the most accurate and informative full measure because of its high reliability and validity (Schraw & Dennison, 1994). Both the MSLQ and MAI pertain to "the student's use of different cognitive and metacognitive strategies" and "student management of different resources" (Pintrich et al., 1991, p. 5).

The full MAI, however, surpassed the reasonable breadth for the current study, especially in addition to use of the MTUAS' 60-question measure. As a result, this study used two subscales from the full MSLQ study that were found to be empirically representative of the full MAI measure (Sperling, DuBois, Howard, & Staley, 2004). These two subscales are: time and study environment management, and metacognitive self-regulation. The two subscales total 20 questions and have been correlated with the full MAI at $r = 0.46$ ($p < 0.05$) and $r = 0.59$ ($p < 0.01$), respectively (Sperling et al., 2004).

As part of the experimental intervention, five additional qualitative were added. These questions sought to further examine the students' multitasking tendencies. The questions posed were as follows:

(a) Do you believe personal technology (laptops, cell phones, etc.) generally hurts or generally supports your work as a student? Please explain;
(b) Do you often multitask during school activities (in class, while studying, doing homework)? If *yes*, why? If *no*, why?;
(c) Do you often feel distracted doing school work? If *yes,* what distracts you? If *no,* what helps you keep focus?;
(d) Did your multitasking behavior or use of technology change since completing this same survey over a week ago? If *yes,* how?;
(e) You received many texts over the past week. Did these texts change your behavior or thinking? If *yes,* please explain. If *no,* please explain; (the last question was presented only to the text-message groups, and not the control group).

2.2. Study sample

This study was administered at a medium-sized university located near the Rocky Mountains. The institution is a highly rigorous and selective public Science, Technology, Engineering, and Mathematics (STEM) and applied-science university with approximately 4,150 undergraduate students. Only Bachelor of Science degrees are conferred at the undergraduate level. Admitted students in 2013 were in the top 10% of their graduating high-school classes and had an average high school GPA of 3.8 and an ACT score of 31. Like many STEM and applied-science universities, the school is predominately male, with 30% of the undergraduate population identifying as female. The school is also fairly racially homogenous, with 18.5% of the undergraduate population identified as belonging to an underrepresented minority; and an additional 8% represent international, non-US citizens. All 4,150 undergraduate students were invited to participate in study.

2.3. Measure administration: study protocol and analysis

All matriculated, active undergraduate students of at least 18 years-of-age were invited to participate in an online survey. The MTUAS measure was presented as close as possible to the published template from Rosen, Whaling, Carrier, et al. (2013). MSLQ questions were slightly modified to support universal responses. As an example, the question "I attend this class regularly" was modified to "I attend class regularly." All participants who completed the 80-question measure were eligible for two separate Amazon gift cards worth $150 and $100, respectively. The winners were chosen randomly. The survey was administered in mid-February, approximately six-weeks into the semester. No other known surveys were administered at this time.

Following data collection, erroneous student IDs, incomplete survey responses, and duplicate submissions were purged. First, data was compared against the published findings from Rosen, Whaling, Carrier, et al. (2013) via independent sample *t*-test. Second, bivariate correlational analysis was administered between the respective subscale means. Because each of the 17 subscales (15 for MTUAS and 2 from MLSQ) are internally reliable and valid (Pintrich et al., 1991; Rosen, Whaling, Carrier, et al., 2013; Sperling et al., 2004), no further reliability or validity tests were administered.

2.4. Experimental intervention: study protocol and analysis

Students who completed the administered survey could voluntarily note their interest in potentially participating in a follow-up study related to the focus of the survey. If a student noted an interest in a follow-up study, they were kindly asked to provide their personal cell-phone number. Of those who volunteered to participate in the follow-up study, 117 students were semi-randomly chosen assigned to one of the following three groups:

(a) Experimental group: Media multitasking awareness group (awareness)
(b) Control group one: Inoculation factoid group (factoid)
(c) Control group two: No intervention (control)

All students who noted an interest in the follow-up study were coded into one of three grade point averages (GPA) groups, depending on the cumulative GPA noted on their college student transcript: low (0.00–2.75), mid (2.76–3.29), and high (3.30–4.00). Each GPA group accounts for approximately 33% of the undergraduate student population. 39 students were randomly chosen for each GPA group. Following students from each GPA group were randomly coded to one of three study groups: awareness, factoid, or control. Ultimately, each group (awareness, factoid, and control) had 13 randomly assigned students with low GPAs, 13 with mid GPAs, and 13 with high GPAs ($N = 117$ students).

Students coded to the factoid and awareness groups received a series of daily texts (SMS), while students in the control group did not receive texts. Students in the awareness and factoid groups received three to four texts per day, sent at random times between 7 a.m. and 11 p.m. Recent research has shown success with targeted text-message interventions with postsecondary students (Castleman & Page, 2013; Soon, 2015). Callfire.com was used to distribute all texts to members. Tests were distributed for a period of one week, Monday through Monday.

Students in the factoid group received texts that relayed random facts such as "The Mona Lisa doesn't have eyebrows or eyelashes" and "Honey does not spoil. You could feasibility eat 3,000-year-old honey." Students in the awareness group received the same number of texts at the same time. However, messages pertained specifically to multitasking, metacognition, and self-regulation. For example, "Multitasking while studying can significantly hinder your ability to adequately recall information later," and "Consider setting time goals wherein you may work uninterrupted for a period of 1 hour". The factoid group controlled for any witnessed measure shift attributable to the frequent text distributions, rather than to the content presented in the texts.

At the conclusion of one week's time and the conclusion of all text distributions, all students from the awareness, factoid, and control groups received an email asking them to complete the full 80-question MTUAS and MSLQ measure once more. Five additional qualitative questions were posed at the end of the measure (see "2.1 Study Measures").

Following data collection, independent sample *t*-tests with a 95% confidence interval were administered between groups (e.g. factoid vs. awareness). In addition, Levene's Tests of Equal Variances were identified and effect size was calculated with both Pearson correlation coefficients and Cohen's *d*. Paired sample *t*-tests were also administered within groups and between responses (i.e., pre-experimental and post-experimental intervention comparison) (e.g., factoid first-measure administration vs. factoid second-measure administration). Last, qualitative responses were coded via nonhierarchical, axial coding. Following initial construction of the codebook, we then randomly shared 20% of all responses for each question with a colleague. Our colleague sought 80% or better perfect interrater reliability.

Last, students were asked to report any bias via an open-ended, qualitative question that inquired about discussions or conversations with fellow students during the experiment. None of the students reported bias. For this text-based portion of the study, students were incentivized with a one-in-three chance of randomly winning a $25 Amazon gift card.

3. Measure administration: results and discussion

3.1. Sample participation

One thousand and eighty-three students completed the first administration of the 80-question MTUAS & MLSQ measure, netting a completion rate of 86.71%. These respondents represented approximately 25% of the total undergraduate population ($N = 4150$), meriting a 99.5% confidence level. Of the 1083 respondents, 405 identified as female (37.4%), 677 identified as male (62.5%), and one student opted to not disclose gender. The age of all respondents is noted in Table 1 ($M = 20.29$; $Mdn = 20.00$; $SD = 1.51$).

This sample is starkly different from Rosen, Whaling, Carrier, et al.'s study, of which "62% were female, ranging in age from 18 to 73 ($M = 29.96$; $Mdn = 25$; $SD = 12.48$)" (2013, p. 2503). Further, Rosen, Whaling, Carrier, et al.'s sample had college and non-college participants, and also participants who had not earned and were not pursuing a college degree (17%). Rosen, Whaling, Carrier, et al. also considered marital status, income, employment, and race and ethnicity.

Table 1
Age of sample participants.

Age	Frequency	Percent	Cumulative percent
18	136	12.6	12.6
19	248	22.9	35.5
20	232	21.4	56.9
21	206	19.0	75.9
22	156	14.4	90.3
23 or older	105	9.7	100.0
Total:	1083	100.0	100.0

3.2. Analysis between measures

The results of the current study showed that the most commonly used technologies were, in order of reported use, text messaging ($M = 7.434$), emailing ($M = 6.6487$), phone calling ($M = 5.608$), and Internet searching ($M = 5.517$). This rank is nearly identical to that of the Rosen, Whaling, Carrier, et al. (2013) research results. The skewness and Cronbach's alpha findings were also comparable between both studies. Only online friendships (3.064) presented a suspect skewness score in the current study. Rosen, Whaling, Carrier, et al. noted a similar skewness with online friendships. Full access to Rosen, Whaling, Carrier, et al.'s data would support additional and more precise comparative analysis between the two studies (e.g., nonparametic Kruskal-Wallis analysis or Tukey's Ladder of Powers analysis). However, similar trends were identified between each study (skewness, technology usage, alpha scores, etc.), while reported numbers (e.g., sample means) differed considerably. These findings suggest that the MTUAS measure developed by Rosen, Whaling, Carrier, et al. is reliable and behaves similarly despite statistical sample differences in technology use and attitudes toward technology.

3.3. Technology use and student-held attitudes

The current study exhibited statistically significant correlations between all technology usage scales, at $p < 0.05$, or greater (e.g. smartphone usage correlated with text messaging). Adversely, preference for task-switching was positively correlated with three of seven technology usage subscales and two of three social media friendship/usage subscales (at $p < 0.01$) (see Table 2). In sum, preference for task-switching was only sporadically correlated with technology use.

Adversely, student-held attitudes related to technology were strongly correlated with technology use. For example, all eight technology usage scales correlated with positive attitudes toward technology. Similarly, student-held anxiety without technology and dependence on technology exhibited correlated relationships with all but one technology usage subscale (video gaming, $p = 0.057$). As Table 2 shows, a student's negative attitude toward technology correlated with five of eight technology usage subscales in an expected manner, at a $p < 0.01$. In sum, the subscales for anxiety and dependency and positive attitudes toward technology almost universally correlated with technology use. Student technology use is highly related to their positive attitudes towards technology as well as their anxiety without technology and dependency on technology.

3.4. Attitudinal and metacognitive subscales

Anxiety without technology and dependency on technology was correlated with both negative and positive attitudes toward technology ($r = -0.105$ at $p < 0.01$ and $r = 0.380$ at $p < 0.01$, respectively). However, no correlated relationship, negative or positive, existed between preference for task-switching and student attitudes toward technology (see Table 3). However, the results for students who expressed a preference for task-switching did exhibit a measurable, positive correlation with technological anxiety and dependence ($r = 0.132$, $p < 0.01$). As Table 3 indicates: Those students who preferred task-switching also demonstrated heightened anxiety without technology and dependence on technology.

While the two metacognitive subscales – metacognitive self-regulation and time and study environment management – were strongly correlated with one another ($r = 0.391$, $p < 0.01$), they were sporadically correlated with the varied technology usage subscales. These correlations were inconclusive, prompting no definitive

Table 2
Pearson correlations between attitudinal and technology usage subscales.

Subscales	Positive[c]	Anxiety and dependence[d]	Negative[e]	Preference for task-switching[f]
	Pearson correlation r			
Smartphone Usage[a]	0.246**	0.224**	−0.073*	0.031
General Social Media Usage[b,g]	0.096**	0.195**	0.026	0.136 **
Internet Searching[a]	0.188**	0.117**	−0.100**	0.013
E-mailing[a]	0.218**	0.175**	−0.086**	0.116**
Media Sharing[a]	0.240**	0.155**	−0.097**	0.096**
Text Messaging[a]	0.198**	0.228**	0.013	0.099**
Video Gaming[a]	0.216**	0.057	−0.108**	0.011
Online Friendships[b,g]	0.131**	0.092**	−0.070**	0.070*
Facebook Friendships[b,g]	0.027	0.100**	0.123**	0.058
Phone Calling[a]	0.067*	0.070*	−0.042	0.048

*Statistical difference of $p < 0.05$ (two-tailed).
**Statistical difference of $p < 0.01$ (two-tailed).
[a] Technology usage subscale (MTUAS).
[b] Social-media friendship/usage subscale (MTUAS).
[c] Positive attitudes toward technology subscale (MTUAS).
[d] Technological anxiety and dependence subscale (MTUAS).
[e] Negative attitudes toward technology subscale (MTUAS).
[f] Preference for task-switching subscale (MTUAS).
[g] $n = 1016$.

Table 3
Attitudinal and preference correlated subscales.

Subscale	Preference for task-switching[d]	Negative[c]	Anxiety and Dependence[b]
	Pearson correlation r		
Negative[c]	−0.043	–	–
Anxiety and Dependence[b]	0.132**	−0.105**	–
Positive[a]	0.038	−0.301**	0.380**

*Statistical difference of $p < 0.05$ (two-tailed).
**Statistical difference of $p < 0.01$ (two-tailed).
[a] Positive attitudes toward technology subscale (MTUAS).
[b] Technological anxiety and dependence subscale (MTUAS).
[c] Negative attitudes toward technology subscale (MTUAS).
[d] Preference for task-switching subscale (MTUAS).

relationship between technology use and metacognitive awareness. In other words, students with varying metacognitive awareness demonstrated similar technology usage.

When comparing the metacognitive scales against the attitudinal scales, only time and study environment management exhibited a significant correlation. Those students who reported higher time and environment management also noted less anxiety without technology and less dependency on technology ($r = -0.077$, $p < 0.05$; see Table 4).

The time and study environment management metacognitive subscale was negatively correlated, in an expected manner, with preference for task-switching ($r = -0.182$, $p < 0.01$; see Table 4). As such, those students who reported higher time and study management noted a lower preference to task-switching. Although this relationship was strongly correlated, the metacognitive self-regulation subscale showed no significant relationship to preference for task-switching. The incongruent results complicate the expected hypothesis that those with higher metacognitive awareness would prefer to task-switch less.

3.5. Discussion

The current study suggests that positive attitudes toward technology and anxiety without technology and dependence on

Table 4
Attitudinal and preference subscales with metacognitive subscales.

Subscale	Preference for task-switching[f]	Negative[c]	Anxiety and dependence[b]	Positive[a]	Metacognitive[d]
	Pearson correlation r				
Negative[c]	-0.043	–	–	–	–
Anxiety and Dependence[b]	0.132**	−0.105**	–	–	–
Positive[a]	0.038	−0.301**	0.380**	–	–
Metacognitive[d]	−0.047	−0.035	−0.018	0.052	–
Time and Study[e]	−0.182**	−0.055	−0.077*	0.022	0.391**

*Statistical difference of $p < 0.05$ (two-tailed).
**Statistical difference of p < 0.01 (two-tailed).
[a] Positive attitudes toward technology subscale (MTUAS).
[b] Technological anxiety and dependence subscale (MTUAS).
[c] Negative attitudes toward technology subscale (MTUAS).
[d] Metacognitive self-regulation subscale (MSLQ).
[e] Time and study environment management subscale (MSLQ).
[f] Preference for task-switching subscale (MTUAS).

technology were highly correlated with technology use. Negative attitudes towards technology also correlated with technology use in an expected manner, but not as universally. Only preference for task-switching presented inconclusive, anomalous findings with student technology use and student-held attitudes toward technology. Prevalent student technology use and the pervasive phenomenon of media multitasking may not be related to their preference for task-switching, but instead to their attitudes toward technology or a perceived need for technology. This supports cited research related to anxiety (Rosen, Whaling, Rab, et al., 2013) and neuroscience findings related to the bottom-up processing (Wang & Tchervnev, 2012) driven by emotional reward.

The two metacognitive subscales were chosen for their documented relationship as reliable proxies to the full Metacognitive Awareness Inventory (Sperling et al., 2004). Both subscales reside within the management subsection of the MSLQ, but the metacognitive self-regulation subscale and the time and study environment management subscales lean toward different foci. The time and study environment management subscale focuses on resource management and “study skills and the appropriate use of study time” (Credé & Phillips, 2011, p. 2). The metacognitive self-regulation subscale, however, “attempts to capture students' ability to monitor their own mental processes and adjustment when needed” (p. 2). Because the former more specifically considers behavioral management, and the later more specifically considers cognitive awareness, the results suggest that those students with reported higher time and study environment management numbers did prefer to multitask less; this outcome potentially underscores the self-regulatory nature of multitasking.

4. Experimental intervention: results and discussion

4.1. Sample participation

Of the 1083 students who completed the survey, 629 expressed interest in participating in the follow-up study. Following a semi-random assignment, 117 students were identified for the three groups: factoid, awareness, and control (see 2.0 Methods for more detail).

One individual asked to be removed from the study, a voluntary choice afforded to all 117 participants. Of the 39 students assigned to each group, 38 of the awareness group completed the second administration of the measure (97.4% completion rate). 37 of the factoid group (94.8% completion rate) and 29 of the control group (74.3% completion rate) completed the second administration. Because members of the control group were less engaged in the process (e.g. no texts received), greater attrition was to be expected (Rubin & Babbie, 2009). Following conclusion of all data collection, all members of the follow-up experiment received a complete debriefing participant disclosure that detailed the study, including their individual random assignments, in explicit detail. As part of this disclosure, participants could retroactively redact their responses and participation in the study; no student requested to do so.

4.2. Shift in measure responses

To the question, “Did students exhibit significant shifts related to technology use, student-held attitudes, or metacognitive awareness between administrations?”, there were negligible differences between groups (factoid vs. awareness, awareness vs. control, control vs. factoid), as calculated by independent sample *t*-tests with a 95% confidence interval. Of the technology usage subscale comparisons, three *t*-test calculations exhibited significant mean differences between groups: Phone Calling (awareness vs. factoid), Facebook Friend Social Media (awareness vs. factoid), and Phone Calling (awareness vs. control). Equally inconclusive, there were no significant shifts in student-held attitudes toward technology. Students from each group expressed similar attitudes towards technology. In sum, students from different groups expressed similar technology usage and attitudes as one another. Only two *t*-test calculations suggested significant metacognitive differences: awareness vs. control and factoid vs. control with the subscale of metacognitive self-regulation. In both instances, the control group behaved abnormally high, further challenging any suggestion of intervention affect. Cohen's d and Pearson's r effect-size calculations were administered and consistently exhibited negligible results.

Results were equally insignificant when the individual responses from the first measure were compared against their answers to the second measure, completed after the experimental intervention. The awareness group exhibited two significant shifts in reported technology usage from first administration to second administration: Smartphone Usage and Text Messaging ($p = 0.026$ and $p = 0.002$, at $p < 0.05$ respectively). In both instances, usage increased from first to second. Similarly, the factoid-group results reflected one significant shift in reported technology use, with Text Messaging ($p = 0.039$, $p < 0.05$); reported text messaging increased between administrations. These exhibited shifts arguably reflect the frequent text-messages sent as part of the study.

There were no shifts in student-held attitudes toward technology or metacognitive awareness in either the awareness or factoid group. Only the control group results exhibited a shift in student-held attitude change or metacognitive awareness between administrations: The reported metacognitive self-regulation decreased from first administration ($M = 4.68$, $SE = 0.150$) to second administration ($M = 4.35$, $SE = 0.146$); this is suspect, however, to effect size ($r = 0.58$) [$t\,(28) = 3.815$, $p = 0.001$]. This was the only significant shift in the control group from first to second administration of the measure.

Related to shifts in preference for task-switching, there was a significant difference between the awareness and factoid groups: The awareness group ($M = 2.51$, $SE = 0.123$) reported a lower preference for task-switching as compared to the factoid group ($M = 3.02$, $SE = 0.137$), thus producing results of $t\,(73) = -2.740$, $p = 0.008$ at $p < 0.05$, and a medium-sized effect of $r = 0.309$, $d = 0.387$. However, no significant shift was calculated for preference for task-switching between first and second administration of the survey. In other words, while those in the awareness and factoid groups reported different preferences for task-switching, there was no change or shift as a result of the experimental intervention.

4.3. Academic performance and preference for task-switching

Independent sample *t*-test (95% confidence interval) calculations between GPA and preference for task-switching yielded no significant differences between low, mid, and high GPA. Student preferences for task-switching appear to be relatively similar amongst all scholastic performance levels, as measured by student GPA in this study. This challenges the researcher's hypothesis that preference for task-switching would differ between students of varied scholastic performance.

4.4. Thematic qualitative analysis

Five qualitative responses were coded via nonhierarchical, axial coding procedures. Following initial construction of the codebook, we then randomly shared 20% of all responses for each question with an independent colleague. Our colleague sought 80% or better interrater reliability. Three of five questions were initially congruent. We independently reassessed the codebook to address the outstanding two questions, made slight amendments within the codebook, and randomly shared a new set of responses (20%) with the same independent colleague. Interrater reliability concluded at 82% or better perfect agreement for each question assessed individually. While there were multiple codes per question (10 or more), perfect agreement was only achieved when the independent codes matched perfectly for 80% or greater of all responses.

The question, "Do you believe personal technology (laptops, cell phones, etc.) generally hurts or generally supports your work as a student? Please explain." revealed that, between the identified themes of *supports*, *supports and hurts*, and *hurts*, 62.7% noted *supports and hurts,* while 33.3% noted *supports*. Only four students explicitly noted that technology hurt their work as students ($N = 102$). In qualifying their response, respondents noted technology affordances such as access to resources and perceived efficiency or portability (47%, $n = 48$) supported their work, and others noted that technology was an invaluable or necessary pedagogical tool (50%, $n = 52$). For example, "It is much easier to find important information/papers for research than to go looking in a library with hard copies of journals.". Without prompting, 38% of respondents mentioned that technology can be a distraction, or noted their propensity to misuse technology ($n = 39$). For example, "On the other hand, it's easy to be distracted by Reddit, games, etc.". These results validate the overall quantitative findings of the 80-question measure, which indicated a prevalence of positive attitudes toward technology as well as a general dependency on technology.

Between the identified responses of *yes*, *yes & no*, and *no* to the second question, "Do you often multitask during school activities? If yes, why? If no, why?", 50.9% responded *yes,* while the remaining responses were split between *yes & no* and *no* (27.5% and 21.5%, respectively; $N = 102$). When qualifying their response, students most commonly cited boredom and distraction, $n = 37$ (36.2%). As one participant noted, "Yes, I often multitask if I am bored or trying to procrastinate." Or as another student indicated, multitasking helped to not "feel like I'm drowning in homework and boredom." We identified two binary thematic codes: perceived/expressed value in multitasking and perceived/expressed value in not multitasking. Interestingly, responses were split between these codes, with 27.4% of respondents answering in the affirmative and 30.3% reporting value in not multitasking ($n = 28$ and $n = 31$, respectively). This validates earlier quantitative findings that preference for task-switching is a poor indicator of actual technology use.

Between the identified responses of *yes*, *yes & no*, and *no* to the third question, "Do you often feel distracted doing school work? If yes, what distracts you? If no, what helps you keep focus?", 47% of students responded *yes* and 39.2% responded *yes & no* ($n = 48$ and $n = 40$, respectively). External distractions, as opposed to internal distractions such as mind wandering, accounted for the vast majority of responses about why distractions occur: 20 students noted that other people often distract, an additional 22 students explicitly noted the Internet or some form of social media as the distraction, and 34 students noted external distraction (not otherwise specified). When answering what assists with focus, 27 (26.4%) students noted that music/headphones or location helped direct personal attention. Last, 25 students included an evaluation of school as it either assisted with focus (e.g., "If the school is interesting …") or helped to distract (e.g., "I feel distracted when doing school work by other school work. There are so many things to do at once …").

Of the identified responses of *no, some,* and *yes, significantly so* to the fourth online-survey question, "Did your multitasking behavior or use of technology change since completing this same survey over a week ago? If yes, how?", 70.5% of students noted *no*. Twenty-two of 102 total respondents noted *some* (21.5%). It was unsurprising, as a result, that the majority of factoid and awareness group members answered *no* to the follow-up question, "You received many texts over the past week. Did these texts change your behavior or your thinking? If yes, please explain. If no, please explain." Between the identified responses of *no, somewhat,* and *yes, significantly so,* 64.6% of students responded *no*; 16.9% and 18.4% of students respectively responded *some* and *yes, significantly so*. Nine responses reflected the expected intent: Texts prompted new understandings/reflection and behavioral change. For example, "It did change my thinking, I try and minimize distractions" and "Yes, I try to set goals during my study time instead of just diving in." These nine new responses were reported from the awareness group. However, there were also nine instances wherein the texts were described as disruptive and did not prompt any new understandings or reflection (e.g., "Not really. Most of it seemed like common sense"). There were 12 instances in which responses indicated the texts prompted new understanding and authentic reflection, but the students noted no behavioral change. This outcome reiterates the dualistic, tenuous, and complex nature of media multitasking as both a cognitive and behavioral construct.

4.5. Experimental intervention: discussion

Analysis revealed insignificant shifts in technology use, student-held attitudes, and metacognitive awareness. Within the individual groups, results underscored the null effect of the intervention. Responses from the awareness and factoid groups showed increases in text messaging, most likely attributable to the number of texts sent as part of the study. Only the no-text group exhibited a shift in preference for task-switching and in metacognitive awareness. This exhibited shift with metacognitive self-regulation is, however, suspect because of the large effect size.

The results suggest that the designed weeklong intervention had no substantive effect on technology use, metacognitive awareness, or student attitude toward technology, including student-held preference for task-switching. And the texts meant to heighten student awareness on topics such as attention, multitasking, and self-regulatory behavior had no different effect than the texts focused on random factoids. Additionally, students with varying levels of scholastic performance as measured by GPA showed no difference in preference toward task-switching.

Thematic analysis of the qualitative responses underscores many of the previously quantified findings. Relative to student-held technology attitudes, students were generally positive toward technology, an attitude highly correlated with technology use. Student use of technology, as the responses suggested, is inextricably linked with their status as students (e.g., their access to resources, including technology as an invaluable pedagogical tool). This underscores the complex and sometimes tenuous relationship between technologies role and prominence in school environments, evidenced by student distraction and technological misuse.

It is clear from the qualitative responses that students are often highly distracted by both internal and external factors; yet the majority of qualitative responses reiterated students' propensity to multitask for myriad reasons, sometimes in direct contradiction to their expressed condemnation of multitasking. Maybe not surprising, increased awareness failed to shift student technology use, metacognitive awareness, and student-held attitudes, including preference for task-switching. And although a subset of students noted some shifts in thinking, behavioral change was absent.

While the intervention did not produce the hypothesized results, it is still worth discussing. The study's intervention pivoted on the assumption that awareness can influence and direct behavior. As the study results suggest that anxiety/dependency is often an antecedent to technology use and as students demonstrated an awareness of the distracting but invaluable role technology plays, an "awareness-based" educational response may be inherently compromised. In other words, bringing awareness of the potential ramifications related to technology misuse or technology-enabled multitasking may not sway thinking or behavior.

Behavior change can also come about from a behavioral intervention. A redesigned and newly administered study that considered a behavioral intervention, such as a technology ban or limitation, may produce desired changes in usage and thinking. To this point, Professor Sherry Turkle, Ph.D. and the late Professor Clifford Nass, Ph.D. of Stanford, have suggested that temporary technology bans can promote desired student outcomes related to attention and focus (Franzen, 2015; Strauss, 2014).

5. Conclusions and limitations

5.1. Conclusions

Student technology use and student-held attitudes toward technology interacted in an expected manner, although preference for task-switching was a relatively uninformative variable in explaining technology use. Accordingly, rampant student multitasking behavior may more appropriately reflect their anxiety without technology and dependency on technology, rather than their actual attitudes related to the value of task-switching.

Although the metacognitive subscales were not mutually informative, the time and study environment management metacognitive subscale did correlate with the anxiety and dependency subscale. Students with lower anxiety without technology and dependency on technology also reported higher time and study management. Many qualitative responses explicitly identified or implicitly suggested a level of dependency on technology or anxiety without technology. Despite student verbalization of known variables that prompt distraction and a balanced student-expressed evaluation of the benefits and detriments related to multitasking, students also verbalized strong favorable attitudes toward technology and the perceived reality of multitasking. Student anxiety without technology and dependency on technology (perceived or real) is a promising area for further research. To this point, there has been recent work related to attention, multitasking, and mindfulness (e.g. The developing brain in a multitasking world, Rothbart & Posner, 2015). Such research may further increase our understanding of media multitasking antecedents and, therefore, potentially inform educational responses that address this pervasive, and often problematic, phenomenon.

The awareness-based intervention did not present significant behavioral, attitudinal, or metacognitive shifts. While these findings were null in nature, they challenge previously conjectured assertions that student awareness will potentially mitigate the problematic behavior. More, student technology use was inconclusively correlated with differences in student metacognitive awareness as well as scholastic performance, as measured by GPAs. Accordingly, the pervasive and problematic technology-enabled multitasking exhibited in the qualitative and quantitative analysis is a shared phenomenon that extends beyond differences in metacognitive awareness or scholastic performance. This pushes researchers to further consider why some students exhibit greater technology-enabled multitasking control.

Student qualitative statements illuminated the complex nature of technology-enabled multitasking. It is a phenomenon that may be both prompted and perpetuated by external and internal motivations or distractions; and, it may be exasperated by the ubiquitous nature of technology while potentially moderated by student-held attitudes, values, and ideologies related to technology. Despite the complexity, it is clear that students are navigating the value- and distraction-laden arena of technology on a consistent and pervasive basis.

5.2. Limitations

There are limitations to this study. First, the unique characteristics of the sample significantly limit the degree to which study findings can be generalized to other collegiate or scholastic settings. The significant response and completion rates throughout the study, however, support the validity of responses for comparable STEM and applied-science institutions of similar rigor, size, or focus (e.g., Cal Tech, RPI, Harvey Mudd). Also, inherent to the nature of both self-regulation and metacognitive awareness measures and that of technology use and held attitudinal beliefs is the potential for self-report inaccuracies (Junco, 2013).

There are numerous limitations with the intervention. First, the intervention was a purposefully designed inoculation wherein distracting, external technologies were used to bring awareness about technology use, technology-enabled multitasking, distractions, and metacognition. In addition, there was potential for attrition bias with calculations that pertained to the control group because the response size dwindled significantly. Moreover, as the qualitative responses noted, participants found the text messages disruptive and sometimes ignored them, therefore undermining the desired effect of the intervention. In addition, the intervention time of one week may have been too short. A longer, potentially less concentrated approach in distributing informative texts may have produced the desired outcomes. Although research has shown the efficacy of text-based interventions (Soon, 2015), future research should consider behavioral-based interventions, such as technology bans.

Last, the television viewing subscale was omitted from all analysis. On accident, only one of the two questions for this subscale was included in each administration of the 80-question measure. Because the MTUAS subscales may be administered independently, this omission had no effect on the presenting findings of other subscales.

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