Computers & Education 86 (2015) 250–259

Contents lists available at ScienceDirect

Computers & Education

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

Exam performance and attitudes toward multitasking in six, multimedia–multitasking classroom environments

Edward Downs*, Angela Tran, Robert McMenemy, Nahom Abegaze

University of Minnesota Duluth, United States

ARTICLE INFO

Article history:
Received 6 January 2015
Received in revised form 12 August 2015
Accepted 13 August 2015
Available online 15 August 2015

Keywords:
Multimedia
Multitasking
Cognition
Attitudes
Experiential learning

ABSTRACT

Although many colleges and universities have implemented laptop programs, the use of these technologies in the classroom doesn't guarantee increases in exam performance. Used improperly, these technologies can hinder the learning process. An experiment was conducted comparing how the use or non-use of technology affected exam performance between six different classroom environments. Consistent with predictions based on theories of multitasking and multimedia processing, participants performed worst on an exam when distracted with social media. Moreover, having had this experience, participants in five of the six conditions showed a decrease in perceptions of their abilities to efficiently multitask from pre-test to post-test. Results are discussed in terms of theory and recommendations are made for the integration of experiential learning sessions into orientation programs to help promote a healthy classroom learning environment.

1. Introduction

Imagine sitting in a modern-day college lecture hall. Your attention is divided between listening to the professor, taking notes, an obnoxiously loud granola bar wrapper from somewhere close by, and the many glowing laptop screens in front of you. Some of the more studious classmates are typing notes, while others are shopping for the newest trends or catching the latest scores on ESPN. Almost everyone has a window open to some sort of social-media site: Twitter, Flickr, Reddit, Instagram, or the ubiquitous Facebook.

This is the technological environment that the current generation of college students occupies. Referred to as the *Net Generation*, or *N-Gen* (Tapscott, 1998), these students were born into a world of technological access and full-time connectivity. They are described as tech savvy, interested in multimedia, the creators of Internet content, and avid multitaskers (Berk, 2010). With wireless connectivity on college campuses, televisual media displaying messages in college hallways, and smartphones, laptops, tablets, and MP3 players always at hand, today's college students certainly know how to navigate today's media-saturated (Roberts, Foehr, & Rideout, 2005) environment. Given the N-Gen crowd is used to staying connected and that multitasking is normal for them (Frand, 2000), one would expect that this also leads to efficiency. That is to say, given the practice they have in their day-to-day lives, one would think that multitasking during class wouldn't present too many barriers to learning. However, the body of literature on multitasking and multimedia processing suggests otherwise.

The following paragraphs will review the literature on multitasking, or trying to complete two or more tasks simultaneously, with a focus on the effects of multitasking in the college classroom. Following this, the adaptive control of thought-

* Corresponding author.
E-mail address: epdowns@umn.edu (E. Downs).

http://dx.doi.org/10.1016/j.compedu.2015.08.008
0360-1315/

rational (ACT-R) cognitive architecture, theory of threaded cognition, and multimedia learning theories will be used to explain the conditions under which multitasking is likely to inhibit learning. Hypotheses and research questions will be advanced for an experiment to test exam performance and document attitudes toward perceived abilities to multitask in six different multimedia, multitasking environments. Results and discussion will follow in terms of theory and recommendations for classroom management in collegiate learning environments.

2. Literature review

When it comes to multitasking, strong evidence of generational differences has been observed. Survey data indicate that the Net-Generation reports more multitasking behaviors than their Generation-X counterparts, who in turn report more multitasking behaviors than their Baby-Boomer predecessors (Carrier, Cheever, Rosen, Benitez, & Chang, 2009). Although the frequency of multitasking endeavors may serve as a general proxy for approval or acceptance of this behavior, it does not necessarily translate into generational differences in the ability to effectively or efficiently process information. Across generations, there are similar opinions on which combinations of multitasking behaviors are more or less difficult (Carrier et al., 2009). For example, each of the generations mentioned above would agree that texting and driving while concurrently trying to use a navigation device in the car would be more difficult than watching T.V. and chewing gum.

The general acceptance of anytime, anywhere multitasking behaviors among N-Geners in today's media-saturated environment (Roberts et al., 2005) has infiltrated the college lecture hall. One study examining a large-lecture found that computer-using students were engaged in off-task activities 61% of the class time (Ragan, Jennings, Massey, & Doolittle, 2014). Another study using spyware on students' laptops (Kraushaar & Novak, 2010) concluded that students generated 65.8 active windows on their laptop screens for each 75 min lecture. Researchers were also able to determine differences between productive (course-related) and distractive (non-course-related) screens. Results showed that on average, 25.1 screens were productive, while 40.7 screens per class lecture were distractive. Not surprisingly, students with higher distraction ratios demonstrated lower levels of performance as measured by scores on homework, quizzes, projects, exams, and final class grades. Additional work (ex. Burak, 2012; Junco, 2012; Paul, Baker, & Cochran, 2012; Ravizza, Hambrick, & Fenn, 2014) recognizes the inverse relationship between increased multitasking and compromised course performance.

Experimental research also verifies the relationship between multitasking and compromised cognitive outcomes (ex. Sana, Weston, & Cepeda, 2013). Manipulating laptop use for a lecture (Hembrooke & Gay, 2003) resulted in significantly lower recall and recognition test scores for those using laptop computers during class. Others have found that those using Facebook or IM applications while in class performed significantly worse on multiple-choice exams than those taking notes using pencil-and-paper or word-processing technology (Wood et al., 2012). Still others have demonstrated a lack of task efficiency when engaged in multimedia, multitasking behaviors (Bowman, Levine, Waite, & Gendron, 2010).

That is not to say that all technologies in the classroom are bad. An experiment that manipulated structured (focused use of a laptop) and unstructured (ignoring how laptops were being used) environments during lectures found productive learning more often in the structured environment than in the unstructured classroom environment (Kay & Lauricella, 2011). Unfortunately, while this study demonstrated that students can stay on track with coordinated, relevant opportunities to engage with technology, no performance outcome or cognitive measure of learning was reported.

To summarize, survey research indicates that multitasking does occur in the classroom, and that often times, it's not productive. The experimental research indicates that cognitive processes are negatively impacted, but there is at least some evidence to suggest that used properly, technology can facilitate learning. Given this information, how do educators make sense of all this? At the heart of the matter, two different things are occurring which are disrupting cognitive processes. The first is the distracted multitasking behavior, and the second is related to an overloading of the senses in mediated message processing. A closer look at theories of multitasking, the ACT-R and threaded cognition theory (Borst Taatgen & van Rijn, 2010; Salvucci, 2005; Salvucci, Taatgen, & Borst, 2009) and multimedia learning theory (Mayer & Moreno, 1998; Mayer & Moreno, 2002; Moreno & Mayer, 1999) can explain how all of these findings fit together.

2.1. ACT-R and threaded cognition

Published research on human performance and limited capacity has been available for more than sixty years. Some scholars have used simultaneous auditory tasks to test human capabilities (Broadbent, 1958), while others have examined reaction times in multitasking environments (Hick, 1952). Others have theorized about resource pool management necessary to complete more than one task at a time (Kahneman, 1973), while still others have critiqued the experimental work in this area looking for alternative explanations for limited capacity (Duncan, 1980). Adaptive control of thought and rationale (ACT-R) and threaded cognition theory (Anderson, 2007; Salvucci & Taatgen, 2008) are the latest limited-capacity theories that combine to explain how people perform in various multitasking situations. At its most basic level, the literature on multitasking distinguishes between concurrent and sequential multitasking (Salvucci & Taatgen, 2008). Sequential multitasking is said to occur when two or more tasks are being accomplished in a given time frame, but are never being done at the exact same time. For example, microwaving a bowl of soup and then making a salad for lunch. Both are being done in the same time frame, but attentional resources can be focused on one task at a time. Concurrent multitasking occurs when a person is attempting to complete two or more tasks at the exact same time. An example of concurrent multitasking is texting while driving. A person is attempting to use resources at the same time to accomplish two different tasks at the same time.