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On or off task: The negative influence of laptops on neighboring students' learning depends on how they are used

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A B S T R A C T

Previous research indicates that students' classroom laptop use distracts their peers and negatively affects the learning of their neighbors. The purpose of this study was to determine whether the types of activities that laptop users undertake (i.e., on-task note-taking versus off-task Web browsing) differentially affect their neighbors' learning. Sixty-two participants listened to a lecture in a classroom setting while seated either in front of, to the left of, to the right of, or behind a laptop-using confederate who switched from taking notes on their computer to browsing the internet at specified points during the lecture. Participants performed better on post-lecture quiz questions that asked about material covered while the confederate was on task than those that asked about material covered while the confederate was off task. This effect was comparable regardless of where participants sat in relation to the confederate. Our results support previous evidence that students' laptop use distracts neighboring students and expands on prior literature by further demonstrating that the types of activities that laptop users engage in during lecture matters for all neighboring students' comprehension of material.

1. Introduction

As the use of technology becomes more prevalent in teens and young adults (Pew Research Center, 2015; Pew Research Center, 2018), it also becomes more prevalent within educational settings (Gray, Thomas, & Lewis, 2010; U.S. Department of Education, 2000a;2000b). Although many instructors and researchers praise technology as one way to enhance student engagement within classrooms (e.g., Debevec, Shih, & Kashyap, 2006; Driver, 2002; Finn & Inman, 2004; Hall & Elliott, 2003; Hyden, 2005; Lindorth & Bergquist, 2010; McVay, Snyder, & Graetz, 2005; Weaver & Nilson, 2005), ample evidence shows that laptops can also distract students and decrease their in-class learning (Barak, Lipson, & Lerman, 2006; Bugeja, 2007; Driver, 2002; Finn & Inman, 2004; Hembrooke & Gay, 2003; Kraushaar & Novak, 2010; Sana, Weston, & Cepeda, 2013; Wood et al., 2012; Wurst, Smarkola, & Gaffney, 2008). This is perhaps not surprising given a long-standing literature that has documented the limits of attentional resources and the consequences of exceeding them. Posner (1982), for example, applied this idea to the ability to attend to and process material in the specific context of encoding and later retrieval of new information. Both prior and subsequent to Posner's study, many researchers have documented the limitations of our attentional resources (e.g., Konig, Buhner, & Murling, 2005; Navon & Gopher, 1979; Pashler, 1994; Wickens, 2002) as well as the decreases in learning and memory that result when those limits are surpassed in distracting environments (see, for example, Broadbent, 1958; Rubinstein, Meyer, & Evans, 2001; Tulving & Thomson, 1973).

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Although laptops can be distracting in many different ways, past research has demonstrated that the extent to which student learning is negatively influenced by their laptop use depends on whether they use their laptops in ways that support their mastery of classroom material (e.g., taking notes, looking up information related to class topics, answering classroom polls that probe their learning) or whether they use their laptops to perform classroom-unrelated tasks (e.g., reading or answering emails, checking Facebook, browsing information that does not pertain to class). This has been referred to as on-task versus off-task laptop use (Wood et al., 2012). Engaging in *both* on-task and off-task laptop use (i.e., using a laptop for multiple purposes) is one of many forms of multitasking. Multitasking consists of "carrying out several tasks in succession" and "requires both task shifting and maintaining future goals while current goals are dealt with" (Ward, 2010, p. 326). Every time an individual switches tasks, cognitive efficiency is lost (Jersild, 1927; Meyer & Kieras, 1997; Rogers & Monsell, 1995). This switch cost may underlie the negative effect off-task laptop use has on classroom learning.

Researchers have also begun to investigate how students' use of laptops in the classroom influences the learning of their neighboring peers. Sana et al. (2013), for example, conducted two experiments to investigate the effect of multitasking and laptop usage in a classroom setting. In their first experiment, participants attended a lecture and were instructed to bring their personal laptops to take notes. Half of the participants were given additional instruction to multitask by alternating between taking notes and performing other, secondary tasks on their laptops. These secondary tasks were meant to mimic student laptop usage in an actual classroom. All participants were then given a comprehension test to measure retention of information. Consistent with past studies of multitasking in other contexts (e.g., Ophir, Nass, & Wagner, 2009; Rubinstein et al., 2001), the researchers found that participants who multitasked performed significantly lower on the comprehension test than those who were not multitasking.

In their second experiment, Sana et al. (2013) measured the effect of being in view of a multitasker on learning. Participants took notes over a lecture using paper and pencil. Confederates sat among the participants and switched between taking notes on a laptop and performing secondary tasks similar to those in the first experiment. The researchers placed the participants either in view or not in view of the confederates' laptops. Using the same comprehension test as in the first experiment, the researchers measured retention of information from the lecture. The researchers found that participants who were in view of the multitasking confederates scored significantly lower on the comprehension test than those who were not in view of the multitasking confederates. Importantly, Sana, Weston, and Cepeda did not compare comprehension of material covered when the confederate was on task to comprehension of material when the confederate was off task.

Research has also demonstrated that students recognize that they are frequently distracted by other students' laptop use in the classroom. Fried (2008) administered weekly surveys to General Psychology students across an entire semester and asked them to report any aspects of their experience in the classroom that they found distracting or that inhibited their ability to pay attention in class. She found that "other people's laptop use" was reported more than any other type of distractor, constituting 64% of all open-ended responses. The rate at which this distractor was reported was significantly greater than all other distractors combined, including other students' talking, entering and leaving the classroom during class, and fidgeting.

Some researchers have speculated about why other students' laptop use is so detrimental to classroom learning. Maxwell (2007), for example, reported that the colorful visual display and movement of items on a neighboring student's screen draw students' attention away from the instructor. She also noted that the noise of typing on a laptop may be distracting to nearby students. In addition, McCreary (2009) argued that some students are unable to resist the urge to look at other students' laptop screens, which makes what neighbors are doing on their laptop potentially even more relevant. For example, viewing of "provocative" material while sitting in the front row can distract an entire room of students if the screen is large enough (Yamamoto, 2007). At the same time, neighbors taking notes on the lecture may not be as distracting to others as their watching a basketball game, but no studies to date have examined the possible differential effects of neighbors' on-task notetaking versus off-task activities on students' learning.

Given that laptop use can be detrimental to the learning of both the laptop user and of surrounding students, we designed the current study to determine whether the types of activities (on-task versus off-task) undertaken by laptop users in a classroom environment differentially affect their neighbors' learning. Furthermore, we sought to determine whether students recognize the negative effects of their neighbors' laptop use on their own learning by incorporating Judgment of Learning measures at multiple points throughout the procedure. This study combines two previous lines of research: that investigating the effects of laptop use on neighboring students and that examining on-task vs. off-task laptop use. Specifically, we sought not only to replicate the findings of Sana et al. (2013) but also to extend their research by directly comparing participants' comprehension for material covered while their confederate neighbor was on task to their comprehension for material covered while their confederate neighbor was off task. We hypothesized that students taking notes by hand during a lecture would learn and remember less information when their laptop-using neighbor was off task than when their laptop-using neighbor was on task. We expected this effect to be stronger for students sitting within sight of the laptop screen (those sitting behind, to the left or to the right of the laptop user) than for those students sitting in front of the laptop user.

2. Method

2.1. Participants

Sixty-two undergraduate students at a private university in the Midwest participated in this study in exchange for course credit in a Psychology course or for a $10 gift card to a local restaurant. We recruited participants through the online participant management program, Sona. Demographic data were missing for 16 of the 62 participants, but in general, those who participated were representative of the student population in our department in age ($M = 19.74$, $SD = 1.13$), class year ($M = 2.28$, $SD = 0.90$), and gender (82% female).

2.2. Design

We used a 2 × 4 mixed-factorial design. Participant position (in front of confederate, behind confederate, to the left of confederate, to the right of confederate) was manipulated between-participants and confederate activity (on-task vs. off-task) was manipulated within-participants. The dependent variable of interest was participants' comprehension of lecture material, operationally defined as the percentage of multiple-choice test questions out of 20 they answered correctly. We also measured participants' judgments of learning, operationally defined as the number of multiple-choice questions out of 20 they believed they would get or had gotten correct on the comprehension quiz.

2.3. Materials

The primary materials we used in this study were a lecture about droughts and a 20-question quiz that participants completed after the lecture. The lecture consisted of 19 PowerPoint slides, each addressing one aspect of droughts. Embedded in the presentation was one animated video that elaborated on some of the factors that contribute to drought conditions and described different categories of drought severity (https://youtu.be/i7F6QwRqyVI). While listening to the lecture, participants followed along on handouts that included a flow chart about droughts and an outline of the lecture content. The complete presentation, including the handouts that participants received, the script that researchers read as each slide was presented, and the quiz, can be accessed at: https://tinyurl.com/s2qmc2z. The post-lecture quiz consisted of 20 multiple-choice questions with four answer options each. All questions focused directly on informational content presented during the lecture such as "According to the maps that were shown, in which region of the US do droughts mostly occur?" and "What is the first step that can be taken in order to prepare for possible future droughts?" rather than being conceptual or inferential. A total of 10 of the quiz questions related to content that was covered while the confederate was on task, and 10 of the questions related to content that was covered while the confederate was off task.

In addition to these materials, participants offered Judgments of Learning three times during the study by reporting the number of quiz questions they expected to answer correctly out of 20 or by reporting the number of quiz questions they thought they had answered correctly out of 20. They also completed a Demographic Questionnaire that asked their age, gender, and year in college.

2.4. Procedure

We tested participants in groups of 1–16 (depending on how many signed up to participate) in a classroom setting. Before arriving at the study, participants received an email telling them that they would be randomly assigned to take notes on paper or to take notes on a laptop (provided by the experimenters) during the study. The purpose of this email was to create a cover story. In reality, all of the participants took notes on paper; the students in the room using laptops during the lecture were confederates (i.e., student research assistants affiliated with the study) who had been trained to switch from on-task to off-task activities at specified points during the lecture.

Before each testing session began, the experimenters set up the room in groups of five seats (one laptop open in the middle seat and blank paper in the surrounding seats; see Appendix). The experimenters met with confederates before the session began and instructed them to individually enter the classroom and act as though they were participants. When participants arrived, they were randomly assigned to sit in a location around one of up to four confederate/laptop seats. Confederates were "randomly assigned" to the laptop condition. A group of four participants surrounding one confederate was filled in before another group of four was started. This was to ensure equal numbers of participants at each location surrounding the laptop-using confederates.

Participants completed an informed consent agreement and then received instructions that they would be listening to a 20-min lecture on droughts and that they should take notes on either the blank piece of paper or the handouts as though they were in class because they would be quizzed over the material at the end. They then provided a pre-lecture judgment of learning. Next, they listened to the 20-min lecture on droughts while viewing the accompanying PowerPoint slides, following along on the handout and taking notes. During the lecture, participants' confederate neighbor alternated between spending time taking notes on their laptop (on task) and scrolling through Facebook and Buzzfeed (off task). The order of on-task and off-task activities was counterbalanced across confederates, with some beginning off task before shifting to on-task activities and others beginning on task before shifting to off-task activities. This was to assure that the difficulty of the lecture content and quiz items that followed were equally distributed across on-task versus off-task time periods across participants. Shifts occurred every 5 min so that each confederate spent two 5-min periods of time on task and two 5-min periods of time off task. After the lecture, participants provided a post-lecture (but pre-quiz) judgment of learning, took the quiz, and provided a final, post-quiz judgment of learning. Finally, they completed the demographic questionnaire, and they were fully debriefed.

3. Results

3.1. Judgments of learning

Before evaluating our primary hypothesis, we assessed whether where participants were seated relative to the confederate affected their judgments of learning from before the lecture to after the quiz. We ran a 4 (Participant Position: Behind, Left Side, Right Side, In Front) x 3 (Time: Pre-Lecture, Post-Lecture, Post-Quiz) ANOVA with participant position being a between-subjects and time being a within-subjects variable. Participants' estimates of how well they would perform or had performed on the quiz (i.e., expected/believed number correct out of 20) served as the dependent variable. Table 1 summarizes these data. Two participants were missing one or more JoLs and were excluded from these analyses. We used Wilks' Lambda to evaluate statistical significance in order to control for potential violations of the homogeneity of treatment difference variances assumption associated with multivariate analyses.

The main effect of participant position did not reach statistical significance (F (3, 56) = 0.73, p = .54, η_p^2 = 0.04). The main effect of time was statistically significant, F (2, 55) = 4.38, p = .02, η_p^2 = 0.14. Three post-hoc paired-samples t-tests revealed that, across seating positions, judgments of learning decreased significantly after participants took the quiz. Specifically, Pre-Lecture JoLs (M = 14.62, SD = 2.56) did not differ significantly from Post-Lecture JoLs (M = 14.15, SD = 2.96; t (59) = 1.49, p = .14). In contrast, both Pre-Lecture and Post-Lecture JoLs were significantly higher than Post-Quiz JoLs, M = 13.43, SD = 2.72; Pre-Lecture t (59) = 2.98, p = .004; Post-Lecture t (59) = 2.19, p = .03. Participants' seating position and time did not interact to significantly affect judgments of learning, F (6, 110) = 1.41, p = .22, η_p^2 = 0.07. Thus, participants sitting behind, beside, or in front of the laptop-using confederate offered comparable judgments of learning, and these judgments decreased similarly after they experienced the quiz.

3.2. Objective performance on the post-lecture quiz

To examine the effect of on-task versus off-task laptop use on neighboring students' learning, we ran a 4 (Participant Position: Behind, Left Side, Right Side, In Front) x 2 (Confederate Activity: On-Task, Off-Task) ANOVA with participant position being a between-subjects and confederate activity being a within-subjects variable. Percentage correct on quiz items probing content from the sections of the lecture delivered while the confederate was on task versus off task served as the dependent variable. Table 2 summarizes the data. We again used Wilks' Lambda to determine statistical significance.

The main effect of confederate activity reached statistical significance, F (1, 58) = 11.81, p = .001, η_p^2 = 0.17. Consistent with our hypothesis, participants performed better on the questions from the post-lecture quiz that asked about material covered while the confederate was on task (M = 72.90, SD = 17.50) than those that asked about material covered while the confederate was off task, M = 63.55, SD = 18.03. The main effect of participant position was not significant (F (3, 58) = 1.33, p = .27, η_p^2 = 0.06), and participant position did not interact significantly with confederate activity to influence how well participants performed on the post-lecture quiz, F (3, 58) = 1.20, p = .32, η_p^2 = 0.06.

4. Discussion

The purpose of our study was to determine the effect of on-task versus off-task laptop use on neighboring students' comprehension of lecture material in a classroom setting. We predicted that off-task laptop use would be more detrimental to neighboring students' learning than on-task laptop use and that this effect would be stronger for participants sitting behind or beside than for participants sitting in front of the laptop user. Overall, our results supported the first part of our hypothesis by demonstrating that participants' comprehension and retention of material covered while their laptop-using neighbor was on task was indeed significantly better (over 9 percentage points higher) than their comprehension and retention of material covered while their neighbor was off task. Interestingly, the second part of our hypothesis was not supported, as the effect of what the laptop-using neighbor was doing was statistically similar regardless of where the laptop was located relative to the participant.

Our results extend the findings of Sana et al. (2013, Experiment 2). Their study provided evidence that being in view of a multitasking peer while trying to take notes by hand is distracting to students, but their study did not examine whether the degree of distraction varied based on what the multitasking peer was doing. Our results suggest that what a neighbor is doing on a laptop matters—a multitasking laptop-using peer is not as disruptive to neighboring students' comprehension of lecture material when their laptop activity is on task (i.e., taking notes) compared to when it is off task (e.g., surfing the internet, scrolling through social media). Although not directly assessed by our study, these results suggest that the more time a peer spends off task, the more the laptop use will disrupt a neighboring student's learning. Like Sana et al. (2013), we evaluated the effect of a multitasking laptop-using peer on participants' comprehension of lecture content when participants, themselves, took paper-and-pencil notes. Thus, we cannot draw conclusions about the potential on-task/off-task effect of neighbors' laptop use on the comprehension of other laptop-using students.

Unlike Sana et al. (2013), we did not find differences in lecture comprehension and retention based on the four participant positions. We expected that participants sitting behind and beside the laptop-using peer (those "in view" of the screen) would perform more poorly on the post-lecture quiz than participants sitting in front of the laptop user, particularly when answering questions about lecture content covered when the confederate was off task. Participant position did not influence either judgments of learning or quiz scores, nor did it interact with what the confederate was doing to affect performance on the post-lecture quiz. One possible explanation for this lack of findings is that those participants sitting to the right or to the left of the laptop user were not actually "in view" of the laptop screen. In Sana and colleagues' study, "in view" only included participants sitting behind laptop-using confederates, not beside them. Additionally, in their study, participants were able to see two laptop screens rather than only one, which could have strengthened their effect. A quick perusal of the means in Table 2 shows that participants in our study who sat behind the laptop user did, in fact, score lower on average (M = 62.00%) than those in the other three positions, M = 70.12%.[1] This position effect replicates the findings of Sana et al. (2013); laptop users who are sometimes on task and sometimes off task disrupt the learning of the

[1] A post hoc 2 (Participant Position: Behind, Not Behind) x 2 (Confederate Activity: On-Task, Off-Task) ANOVA yielded a significant participant position effect, F (1, 60) = 4.01, p = .050, with participants sitting behind the confederate performing more poorly on the post-lecture quiz than those sitting beside or in front of the confederate.

Table 1
Mean (SD) Judgments of Learning (JoL) for Participants in Four Different Positions Relative to the Confederate.

	Behind Confederate (n = 14)	Left of Confederate (n = 15)	Right of Confederate (n = 15)	In Front of Confederate (n = 16)
Pre-Lecture JoL	14.29 (2.67)	14.50 (2.08)	14.87 (2.77)	14.78 (2.87)
Post-Lecture JoL	13.25 (2.42)	13.53 (3.68)	14.43 (2.60)	15.25 (2.82)
Post-Quiz JoL	13.57 (2.03)	13.17 (3.66)	12.67 (2.50)	14.25 (2.41)

Table 2
Mean (SD) Percentage Correct on the Post-Lecture Quiz for Material Covered while the Confederate was On Task or Off Task for Participants in Four Different Positions Relative to the Confederate.

	Percentage Correct for On-Task Lecture Material	Percentage Correct for Off-Task Lecture Material
Behind Confederate (n = 15)	69.33 (21.20)	54.67 (26.15)
Left of Confederate (n = 15)	76.67 (12.34)	65.33 (17.67)
Right of Confederate (n = 15)	70.67 (20.17)	70.00 (11.95)
In Front of Confederate (n = 17)	74.71 (15.86)	64.12 (11.21)

Note: A significant main effect of confederate activity (p = .001) indicated that participants scored higher on portions of the quiz concerned with lecture material covered while the confederate was on task compared to those covered while the confederate was off task.

paper-and-pencil note-taking peers sitting behind them. Putting these results together with the main effect of confederate activity in our primary analysis, our study suggests that off-task laptop use interferes more with all neighbors' learning (regardless of where they are sitting) than on-task laptop use, and laptop use in general (on- or off-task) most profoundly disrupts the learning of neighbors within sight of the laptop screen.

When interpreting our results, it is relevant to note that we did not ask participants to study their notes between the completion of the lecture and the comprehension quiz. We would expect quiz scores to increase, overall, if participants studied their notes, and we did not want to risk a ceiling effect that might mask differences between the experimental conditions. At the same time, we believe that allowing students to study between the lecture and quiz might instead enhance the on-task/off-task effect. If participants took fewer (or less detailed) notes when they were distracted by their off-task neighbor than when their neighbor was on task, there would be a greater benefit of studying notes for the material that was covered when the confederate was on task than for the material that was covered when the confederate was off task, leading to a larger difference in on-task versus off-task quiz scores.

Interestingly, our judgment of learning results suggest that students are not fully aware of the detrimental effects of their neighbors' laptop use on their own learning until they are tested on the lecture material. Thus, even if given a chance to prepare for the quiz, they may not compensate for their impaired learning with additional studying. Perhaps providing students with the opportunity to take a low-stakes quiz after the lecture would help them to realize the impact of their neighboring students' laptop use on their own learning and would spark additional studying or more concerted efforts to master the material outside of class. However, in the absence of low-stakes feedback, it is likely that giving students an opportunity to study between the lecture and quiz would not diminish the negative impact neighbors' laptop use had on their learning given that they did not appear to recognize the magnitude of this interference immediately following the lecture.

Although our results demonstrate that what laptop-using neighbors do on their laptops matters, our study has limitations that may affect the interpretation of its results. Beyond the modest sample size that limits the generalizability of our findings, the number of participants varied across testing sessions. Larger groups simulated a classroom setting more realistically than smaller groups did. Furthermore, in a smaller group, the laptop-using confederate going off task may have been especially distracting, as it may be less socially acceptable and perceived as particularly audacious to scroll through Facebook or Buzzfeed when there are only a few people in the room. Alternatively, in the larger group sessions, participants may have been in view of multiple confederate laptops at once. Whereas the change from on task to off task and vice versa was counterbalanced, confederates all changed their laptop activities at the same points in the lecture. This may have made the laptop activity more obvious and distracting than if the shifts occurred more naturally and less synchronously in a manner more reflective of a typical classroom environment. We also elected to utilize a within-subjects approach to evaluate differences in learning when laptop-using neighbors were on-task versus off-task because we wanted to hold individual subject-variables constant across the two conditions. Future research could instead implement a between-subjects design with confederates remaining on-task or off-task throughout the entire lecture. Systematically varying the amount of time neighbors spend on task versus off task in future research studies could address whether more consistent off-task laptop use is something paper-and-pencil-using students would become habituated to, potentially rendering it less (rather than more) distracting than the frequent shifts between on-task and off-task activities that we implemented in the current study.

Another factor worthy of consideration is that most of our participants were female psychology majors who have participated in many research studies in the past. Therefore, our participants may have past experience with research-related deception and, thus, may have been more likely to suspect that the laptop-using confederate was not a real participant, particularly given the fact that there were four "on paper" participants for every one "laptop participant" (clearly not random assignment to equal conditions). In fact, in a post-experiment questionnaire that listed eight possible characteristics of the study and asked participants to check which ones they believed to be true, 50.0% of participants[2] selected, "The participants on laptops were not 'real' participants." Of note, the data of participants who checked this box showed an even stronger on-task/off-task effect than that of participants who did not suspect that the laptop user was a confederate. One possible explanation is that suspicion of deception caused participants to pay more attention to what the confederate was doing on their laptop, thereby strengthening the on-task/off-task effect. At the same time, it is also possible that participants who were more distracted by the laptop noticed the systematic switches from on task to off task leading them to be suspicious that the laptop user was not a "real" participant. Replicating our results with a more gender balanced and research-naïve sample will be necessary to determine the generalizability of our findings.

Finally, although we instructed confederates to go off task at specific points during the lecture and recommended Facebook and Buzzfeed as appropriate off-task activities, we left it up to confederates to choose what they perused while off task. It is possible that some off-task activities are more distracting than others and even that some confederates' Facebook feeds were more distracting than others. Although this freedom that we afforded confederates made for a more realistic classroom situation, in future studies, the off-task activity of confederates could be held consistent. Additionally, future research could increase experimental control by presenting the lecture via prerecorded video instead of having a person delivering the lecture live. This would ensure a consistent lecture experience for all participants.

5. Conclusion and practical applications for classrooms

Past research has demonstrated that students' laptop use is detrimental to their comprehension of lecture material (Barak et al., 2006; Bugeja, 2007; Driver, 2002; Finn & Inman, 2004; Hembrooke & Gay, 2003; Kraushaar & Novak, 2010; Wood et al., 2012; Wurst et al., 2008), and our current study supports others that indicate that it distracts neighboring students as well (Sana et al., 2013). Furthermore, our results show that what students are doing on their laptops matters to their neighbors. As such, instructors may wish to seat laptop-using students in the back of the classroom and away from other students in order to minimize the distracting effect of being near a laptop user during class on those students who choose to take notes using a more traditional paper-and-pencil method. Of course, an alternate approach would be for instructors to assure that laptop-using students never stray from utilizing their laptops solely for classroom-related activities given that on-task laptop use did not have the same detrimental effects on neighbors' learning as off-task laptop use. Blocking internet access in the classroom could potentially decrease students' off-task laptop use, but it would also prevent students from accessing the internet for classroom-related purposes like searching a topic online or responding to online student learning polls. Consistently walking around the classroom and monitoring students'laptop activities might also curb off-task laptop use.

As an additional option, Kay and Lauricella (2011) proposed creating "structured" classroom environments to curb off-task laptop use. They conducted a research study contrasting "unstructured" environments (i.e., those in which instructors lecture and students simply take notes on laptops) with "structured" environments that involved active, laptop-supported teaching techniques such as asking students to research a topic online, use online software while completing individual or group projects, access and discuss websites, or view online videos. They found that students reported less frequent off-task laptop use in the "structured" environment that they created in their classroom than in the typical "unstructured" environments of other instructors.

As a final option, our results, in conjunction with those of past studies, support implementing a voluntary "no technology" incentive system to improve the learning of all students in the classroom—the would-be laptop users as well as their potentially distractible paper-and-pencil note-taking neighbors. Encouraging all students to avoid technological distractions and to pay attention in class, especially at times when technology is not being used in direct support of classroom activities, not only promotes student learning but also enhances student engagement (Burkholder, 2017; Gingerich Hall & Lineweaver, 2018; Katz & Lambert, 2016; Whittington, 2019). Thus, reinforcing students for refraining from using their mobile phones or laptops except when they are necessary for the completion of planned classroom activities may be the most effective approach for building a positive classroom environment that maximally supports the learning of all students.

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CRediT authorship contribution statement

Amanda C.G. Hall: Conceptualization, Methodology, Formal analysis, Writing - original draft, Writing - review & editing, Supervision, Project administration. **Tara T. Lineweaver:** Conceptualization, Methodology, Formal analysis, Writing - original draft, Writing - review & editing, Supervision, Project administration. **Eileen E. Hogan:** Methodology, Software, Formal analysis, Investigation, Resources, Data curation, Writing - review & editing, Visualization. **Sean W. O'Brien:** Investigation, Data curation, Writing -

[2] It occurred to us partway through data collection that we should ask this of participants. Therefore, the 50.0% of participants was calculated for only 46 of our 62 participants; we do not know whether the remaining 16 participants suspected that the laptop user was a confederate.

review & editing.

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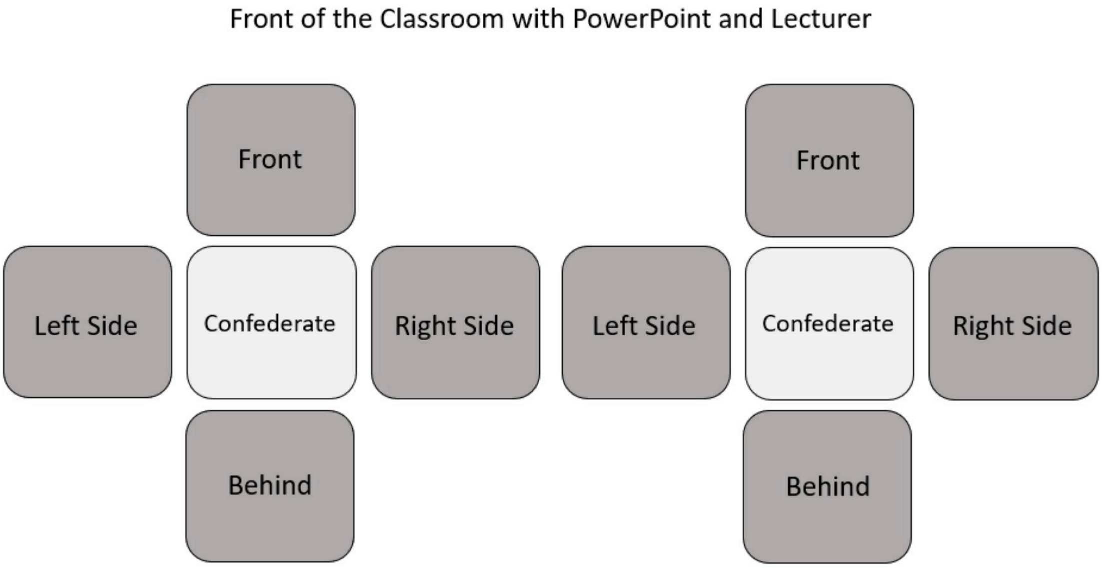
Appendix

Schematic of Room Layout



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