



# In-class laptop use and its effects on student learning

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## Abstract

Recently, a debate has begun over whether in-class laptops aid or hinder learning. While some research demonstrates that laptops can be an important learning tool, anecdotal evidence suggests more and more faculty are banning laptops from their classrooms because of perceptions that they distract students and detract from learning. The current research examines the nature of in-class laptop use in a large lecture course and how that use is related to student learning. Students completed weekly surveys of attendance, laptop use, and aspects of the classroom environment. Results showed that students who used laptops in class spent considerable time multitasking and that the laptop use posed a significant distraction to both users and fellow students. Most importantly, the level of laptop use was negatively related to several measures of student learning, including self-reported understanding of course material and overall course performance. The practical implications of these findings are discussed.

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Computers, and especially laptops, have become standard equipment in higher education as the number of universities instituting laptop initiatives continues to grow (Weaver & Nilson, 2005). Brown, Burg, and Dominick (1998) and Brown and Petitto (2003) have coined the term ubiquitous computing to describe a campus where all students and faculty have laptops and all buildings have access to wi-fi technology. But recently there has been a backlash against such programs, with faculty banning laptop use in their classrooms due to concerns about the negative impact they have on student learning (e.g., Melerdiercks, 2005; Young, 2006).

There does seem to be a developing feud between those who want to promote laptop use and those who are resistant to it. For the past few years, many educational innovators have touted technological advances in general and laptops with wireless connectivity more specifically as the next great educational innovations. Brown and his colleagues (e.g., Brown et al., 1998; Brown & Petitto, 2003) have long advocated the benefits of universal and constant access to computers on college campuses. Much attention has been paid to finding ways of roll out laptop programs and get faculty to adopt and adapt to such programs (e.g.,

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Candiotti & Clarke, 1998; Hall & Elliot, 2003; McVay, Snyder, & Graetz, 2005; Platt & Bairnsfather, 2000; Schrum, Skeeel, & Grant, 2002). One common theme seems to be that if faculty would “take to” the new technology, everyone would reap the benefits of this educational revolution (e.g., Weaver & Nilson, 2005). The key question for most educators is simply whether these technological innovations will have a positive impact on education.

There is some evidence that laptop programs and the so-called ubiquitous computing environments they create on college campuses can have a positive effect. Some (e.g., Fitch, 2004; Partee, 1996; Stephens, 2005) have found that laptops can facilitate faculty-student interactions and in-class participation, thus increasing engagement and active learning. This is often done through preparing and posting discussion questions and using new devices such as response keypads to facilitate student interaction. Driver (2002) found that laptops, coupled with web-based activities, enhanced satisfaction with group projects and overall class satisfaction. Barak, Lipson, and Lerman (2006) demonstrated that laptop use in a wi-fi classroom enhanced active exploratory learning and promoted more meaningful interactions between students and with the instructor in large classes. Other researchers have found that the use of laptops in classes can increase students’ motivation, their ability to apply course based knowledge, and their overall academic achievements (Mackinnon & Vibert, 2002; Siegle & Foster, 2001). When compared to non-laptop classrooms, students in laptop classrooms reported higher participation rates, more interest in learning, and a greater motivation to perform well (Trimmel & Bachmann, 2004). Surveys of current students and alumni frequently show varying but generally positive levels of satisfaction with laptop programs (e.g., Finn & Inman, 2004; Mitra & Steffensmeier, 2000). Demb, Erickson, and Hawkins-Wilding (2004), in a survey of current students, found that students felt laptops had a positive effect on their study habits and were important to their academic success. Granberg and Witte (2005), in one of the few studies that looked at non-structured classroom use of laptops, even promoted instant messaging as a benefit. They claimed that this technology allowed students to make comments to or ask questions of fellow students “silently” without disturbing others, though they provided no evidence that this was beneficial to student learning.

Two issues stand out in the research on the benefits of laptops. First, much of the research focuses on student perceptions and the research often lacks objective measures of learning or a non-laptop control group. One exception, Granberg and Witte (2005) found no difference between laptop and non-laptop sections in overall class grades. Second, most of the research has been done on classes that have been specifically designed or revised to utilize the technology. Many of the published papers in this area (e.g., Barak et al., 2006; Hall & Elliot, 2003; Hyden, 2005; Pargas & Weaver, 2005; Weaver & Nilson, 2005) are simply prescriptions on how faculty can adapt their classes to make use of the technology. As a result, it is difficult to assess how applicable the laptop research is to more generic classes, or how laptop use truly affects student learning.

Perhaps because of this, the idea of in-class laptop use has not been universally embraced. Few faculty are fully integrating laptops into their classes (Olson, 2002). Many have raised concerns about the distraction posed by in-class laptop use. Even proponents of laptops have argued that the use needs to be carefully controlled. Levine (2002a) developed a way to integrate laptops into classroom experiences and found the need instigated a laptop-up laptop-down system. During lecture time, students are told to close their laptops and pay attention, thus actively preventing students from using laptops during lectures. Levine (2002b) has also advocated the use of software that will allow the instructor to monitor and control what students are doing with their laptops during class time.

Recently, a true backlash against laptops has begun to surface. Schwartz (2003) reported on professors so frustrated by their law students surfing during lectures that one faculty member manually unplugged the wireless transmitter, only to relent after student outcry. Others (e.g., Kladko, 2005; McWilliams, 2005; Szaniszló, 2006; Young, 2006) likewise describe the distractions posed by laptops, the frustrations felt by faculty, and the various fruitless efforts to control laptop use. Students and parents have begun to discuss the potential problem posed by the access to distracting material available through laptops (Jones, 2005; Sostek, 2005; Stickney, 2005). An online discussion group has even formed to air concerns about laptops and discuss the pros and cons of banning laptops in the classroom (Young, 2006). The press has reported on efforts in schools from University of Kansas (McGinnis, 2006), University of Pennsylvania (Chen, 2006), BYU (Palmer, 2006), Harvard (Szaniszló, 2006), Bentley College (Silva, 2006), and Michigan Law (Ridberg, 2006) to block or ban laptop use. This

backlash, however, is playing out more in the popular press than academic journals, and the evidence against laptop use is almost universally anecdotal and subjective.

Established research findings in the areas of cognitive science and human factors would certainly lead to the prediction that laptop use, particularly with wi-fi access, could interfere with learning. Human attention and capacity to process information is selective and limited (Kahneman, 1973; Posner, 1982). Too many sources of information can create cognitive overload, and new information coming in can cause attentional shifts and distraction (for general overview of attention theories, see Roda & Thomas, 2006). Computers and other high-tech equipment are likely sources of overload and distraction. The orientation and visual nature of laptops, along with pop-ups, instant messages, movement and lighting of text, and even things like low-battery warnings, make laptops inherently distracting (Bhave, 2002; Melderiercks, 2005; Wickens & Hollands, 2002). Inevitably, when attention is divided and attentional demands exceed capacities, task performance suffers (Gopher, 1993; Robinson-Riegler & Robinson-Riegler, 2004; Wickens & Hollands, 2002). Attentional shifts and cognitive overload can prevent information from being adequately processed and can interfere with learning (Chun & Wolfe, 2001). Moreover, although attention is often controlled voluntarily, external events and visual stimulation can result in involuntary shifts of attention (Chun & Wolfe, 2001). Recent research on cognitive interference (e.g., Altmann & Trafton, 2002; Bailey & Konstan, 2006; Trafton, Altmann, Brock, & Mintz, 2003) has shown that new information, such as a pop-up messages, appearing while a subject are performing a primary task slows performance speed and increases errors. Because of the vertical orientation of laptops, they also pose more of a distraction to fellow students than traditional notebooks (Bhave, 2002). Thus, the cognitive interference posed by laptops could spread from users to those seated nearby.

Given this research, there seems to be good reason for educators to be leery about in-class laptop use. Some schools, such as Duke, have opted out of laptop initiatives altogether because of unanswered questions about the problems laptops pose and the dearth of evidence that they are an overall valuable learning tool (Olson, 2002). Others have dropped programs because they have become disillusioned with the idea that the benefits of laptops in the classroom outweigh the costs (Mangan, 2001). Recently there has been a call for expanded research into the effects of laptops on classroom learning, especially research done in “real classes” and those not specifically tailored to laptop use (e.g., Borja, 2006; Zucker, 2004). According to Weaver and Nilson (2005), the lack of research, coupled with the high cost of laptop programs, are the primary causes for the backlash against such programs. Melderiercks (2005), in particular, has made an impassioned plea for such research. He claims that in a rush to adopt laptops as the tool-du-jour in higher education, research on the impact of laptops on learning has been neglected.

The campus in which the current research was conducted was an ideal platform for such research. It was on of the first universities to institute a campus wide laptop initiative, requiring all students to lease laptops. At the same time, most faculty have not fully integrated laptops into their classes, and many are becoming convinced that the laptops in the classroom are interfering with learning, rather than enhancing it. Several have banned laptops in their classes. The purpose of the present research is to examine student laptop use and how laptops influence student learning outcomes in a traditional lecture course. There were three primary research questions. (1) What is the level and character of laptop use in the classroom? (2) How does laptop use affect learning outcomes? (3) Do laptops present a sizable distraction to other students in the classroom?

## 1. Methods

### 1.1. Participants

One hundred thirty-seven students, from two sections of General Psychology taught by the same instructor, participated in the research. All students who completed the course (i.e., took all the exams) were included as participants. There were 83 freshmen, 41 sophomores, 9 juniors, and 4 seniors. All participants signed consent forms, and the instructor assured them that all data would be confidential and that the survey responses would not influence course grades.

## 1.2. Materials and procedure

### 1.2.1. Course structure and assessment

The research was limited to a lecture oriented class where laptops were not utilized in any organized fashion. All students in the class had laptops with wireless networking capabilities and both classrooms were equipped with wi-fi. Students were told at the beginning of the course that they could bring the laptops to class to take notes if they wanted to, but that they would never need their laptops.

The class was conducted in a very conventional manner. The required text was a standard general psychology text (Coon, 2004). Lectures covered much of the material presented in the text, with the addition of some new information. Approximately 70% of class time was devoted to lectures. Occasional videos, in-class demonstrations, and discussions, which accounted for approximately 25% of class time, complemented lectures. Student learning was measured by performance on objective exams and the completion of homework assignments. During the course, there were 4 exams and 10 homework assignments; 89% of the possible points were based on objective multiple-choice exams. These exams were designed to measure students understanding of core concepts and their ability to apply these concepts. Many of the questions were pulled from published test-banks and slightly modified. Approximately 75% of the information in the exams was covered in the lectures, within that approximately 20% was only covered in lectures.

### 1.2.2. Survey procedures and measures

Students logged in to a course Web site and completed weekly surveys on various aspects of the class. Ten of the weekly surveys, covering twenty class sessions, focused on class attendance, classroom experiences, and laptop use. These 20 class sessions were lecture sessions (as opposed to other class sessions where class time was primarily devoted to exams, movies, discussions, or in-class activities). Weekly surveys were used to increase the accuracy of the responses, as surveys covering longer periods would have been more susceptible to memory distortions and contamination and more frequent surveys would have been more susceptible to response set bias.

The survey questions asked students to report whether they had attended class, whether they had used their laptops during the class, how much time they had spent in each class period using their laptops for things other than taking notes, and how they had used their laptops. The options for the laptop use question were taking notes, checking e-mail, instant messaging, surfing the net, playing games, or other. Students were instructed to check as many as applied. There were also three items (on 5-point scales) assessing students perceptions of learning. Students rated how much they paid attention to the lectures, how clear they found the lectures, and how well they felt they understood the material presented.

In the first nine surveys, students were asked, in an open-ended format, to report on any aspects of the classroom experience or the behavior of their fellow students that they found distracting or that prevented them from paying attention to lectures. This item was optional and students were instructed to answer only if there was something in particular that distracted them during the week. The final survey of the semester had additional scaled items asking students to rate (on an 8-point scale) the degree to which various aspects of the class interfered with their ability to learn the course material over the semester. These included “Other people’s laptop use” and “Your own laptop use” as well as items about the course structure and class environment.

### 1.2.3. Other measures

American College Test (ACT) scores and high-school rank (HSR), obtained from the university assessment office, provided measures of each students academic preparation and aptitude. HSR was scored as a percentile rank where 100 was the top ranked student in the high-school graduating class.

## 2. Results

### 2.1. Response rate

Only those students who answered at least 7 of the 10 weekly surveys were included in the analysis. Nine students out of the original 137 failed to complete the requisite seven surveys, leaving an overall response rate of

93.4%. Sixty-five students completed all 10 surveys, 38 students completed 9 surveys, 15 students completed 8 surveys, and 8 students completed 7 surveys. For each subject, his or her responses for each item were averaged across all the surveys completed.

## 2.2. Level of laptop use

Of the total participants, 64.3% reported using their laptops in at least one class period; those who used laptops used them during 48.7% of the class periods on average. Users reported that they multitasked (did things other than take lecture notes) for an average of 17 min out of each 75 min class period. Of the students who reported their laptop uses during lectures ( $n = 78$ ), 81% reported that they checked email during the lectures, 68% reported that they used instant messaging, 43% reported surfing the net, 25% reported playing games, and 35% reported doing “other” activities.

## 2.3. Effects of laptop use on learning

The primary purpose of this study was to examine the relationship between laptop use and student learning. This relationship was analyzed using linear regression. For each participant, a ratio of laptop use was calculated based on the number of times they reported attending class and the number of times they reported using their laptops in class (e.g., students who reported using their laptops every time they reported attending class had a ratio of 1.0). Student learning was measured by the total points earned out of 100 ( $M = 76.4$ ,  $SD = 11.3$ ). ACT scores, HSR, and class attendance were all (positively) correlated with student learning. In order to control for these factors and isolate the relationship between laptop use and learning, ACT scores, HSR, and self-reported attendance were entered into the regression equation as predictor variables along with laptop use. ACT or HSR data were missing from nine participants, so they were not included in this analysis. The linear combination of these variables was significantly related to class performance,  $F(4, 115) = 13.84$ ,  $p < .001$ ,  $R^2 = .325$ . As can be seen in Table 1, the level of laptop use was significantly and negatively related to student learning,  $\beta = -.179$ ,  $t(115) = -2.286$ ,  $p = .024$ . The more students used their laptops in class, the lower their class performance.

Several other analyses were conducted to assess the impact of laptop use on student learning. The level of in-class laptop use was negatively correlated with how much attention students reported paying to lectures,  $r(128) = -.320$ ,  $p < .001$ . There were also negative correlations between level of laptop use and how clear students found the lectures,  $r(128) = -.169$ ,  $p = .049$ , and how well they felt they understood the course material,  $r(128) = -.191$ ,  $p = .024$ . There was a positive correlation between course performance and how clear students found the lectures,  $r(128) = .214$ ,  $p = .011$ , and how well they reported understanding the course material,  $r(128) = .329$ ,  $p < .001$ .

## 2.4. Distraction posed by laptop use

Two types of measures assessed the distraction posed by laptops. As described in the methods section, students had opportunity to report anything in the class or in the behavior of their fellow students that distracted them or prevented them from paying attention during lectures. There were 359 total responses to this item. Initially, the responses were coded into 10 categories, including categories like “other people talking” and “hallway noise”. Because of the low counts in some categories, the responses were ultimately coded into two

Table 1  
The influence of predictor variables, including in-class computer use, on course performance

Predictor variables	Unstandardized B	Standardized Beta	<i>t</i>	<i>p</i>	Partial correlations
Constant	19.79				
ACT score	1.12	.292	3.64	<.001	.279
H.S. rank	0.09	.200	2.41	.018	.184
Class attendance	30.14	.316	3.92	<.001	.300
Computer use	-5.12	-.179	-2.28	.024	-.175

Table 2

Degree to which students felt aspects of the class interfered with their ability to learn lecture material

Item	Mean	SD	<i>n</i>
Other students' computer use <sup>a</sup>	3.65	2.35	120
Own computer use <sup>a,b</sup>	3.55	2.13	78
Other students talking <sup>b,c</sup>	3.16	1.95	119
Length of class <sup>c</sup>	2.98	1.96	120
Other students coming, going, and fidgeting <sup>c</sup>	2.75	1.60	121
Style of class (primarily lecture) <sup>d</sup>	2.26	1.96	119
Time of day <sup>e</sup>	1.96	1.57	120
Classroom environment <sup>e</sup>	1.88	1.35	120
Instructor's use of PowerPoint <sup>f</sup>	1.37	.79	120

Higher numbers indicate greater reported levels of interference.

Note: Items that share a superscript do not differ at the .02 level, based on pairwise comparisons.

categories: (a) others' laptop use and (b) all other responses. Results indicate that laptop use by fellow students was the single most reported distracter ( $n = 229$ ), accounting for 64% of all responses. This was significantly greater than all other responses combined ( $n = 130$ ),  $\chi^2(1, N = 359) = 29.2, p < .001$ .

The final survey of the semester contained the second measure of the level of distraction posed by laptops. Participants rated the degree to which they felt various aspects of the class interfered with their learning. The survey asked about nine different aspects of the course and classroom environment, from the lecture format to the behavior of fellow students. A within-subjects ANOVA indicated that there were significant differences between the items,  $F(7, 114) = 30.39, p < .001$ . Table 2 contains results of individual items. Pairwise comparisons indicated that students reported other students' laptop use ( $M = 3.65, SD = 2.35$ ) was the issue that most interfered with their ability to pay attention and learn the material presented in class. This was significantly different from all other item except one, the interference posed by one's own laptop use ( $M = 3.55, SD = 2.13$ ),  $t(77) = .300, p = .765$ .<sup>1</sup>

### 3. Discussion

This research raises serious concerns about the use of laptops in the classroom. Students admit to spending considerable time during lectures using their laptops for things other than taking notes. More importantly, the use of laptops was negatively related to several measures of learning. The pattern of the correlations suggests that laptop use interfered with students' abilities to pay attention to and understand the lecture material, which in turn resulted in lower test scores. The results of the regression analysis clearly show that success in the class was negatively related to the level of laptop use. Obviously, the correlational nature of this research prevents drawing clear causal relationships. It is possible that students who are struggling in class are more likely to bring their laptops as a diversion. The inclusion of ACT scores, HRS, and class attendance should attenuate these alternate explanations to some degree and help isolate the direct influence of in-class laptop use on learning. ACT scores, HSR, and attendance should act as proxy measures for variables such as academic aptitude, preparation, and conscientiousness. After controlling for these variables, laptop use was still negatively related to academic success.

There are some potential limitations to the interpretation and application of these results. Self-reported responses always raise concerns about social desirability. However, general social desirability pressures, when relevant here, would most likely have pushed responses in the opposite direction. For example, participants

<sup>1</sup> The differing response rates of the items presented a problem in this analysis. Since roughly one-third of the students never used laptops, they did not answer the question on the distraction posed by their own computers. Had the full data set been analyzed as a within-subjects ANOVA, the exclusion of all those subjects because of the missing data would have resulted in a biased sample. In order to control for the uneven response rates and make use of all the possible data points, two within-subjects ANOVAs were conducted. The first excluded the question of subjects' own computer use, the second included the question. The results of the second ANOVA were used only to examine the pairwise comparisons between that item and other individual items.

should have felt pressure to report that they were doing nothing but taking notes with their laptops. If anything, the self-report nature of the data would suggest that the degree and variety of laptop use, as well as the interference posed by one's own laptop use on attention and learning, were underreported. Another potential weakness, due to the repeated nature of the surveys, is response set bias. Although this cannot be ruled out in the present study, it is unlikely that it had a significant effect. One or two weeks passed between survey administrations, and students could not go back and review their previous responses. Students recalling how they answered many of the questions and automatically responding the same way seems doubtful. Response sets are also unlikely to have affected key measures such as whether students reported bringing their laptops on a particular day, and they would have had no effect on exam scores.

The primary limitation to the generalization of these results is the nature of the course used – a large lecture oriented introductory level class where laptop use was not controlled. Obviously, these results are not applicable to every classroom experience. Faculty who tailor their classes to laptops may have an entirely different experience. In many classes and labs, computers are necessary and learning may depend on immediate and constant access to computers during class time.

The findings and limitations of the present study suggest several avenues for future research, which can be summed up as asking “why” and “when”. First, why does laptop use interfere with learning? Is it distraction caused by incoming information, is it cognitive overload caused by juggling too much information, or is it simply the lighted text moving across the screen. Once researchers and educators better understand why laptop use has a negative effect on learning, more strategic solutions can be developed.

Second, when do the costs of laptop use outweigh the benefits? Previous research, as cited in the introduction, has demonstrated that laptops can be beneficial in courses specifically designed to utilize them. The present study shows that unstructured use of laptops in lecture courses is a disadvantage. Future research should begin to examine systematically what factors in the course and classroom environment are favorable to laptop use, and what factors are associated with laptops interfering with learning.

Future research may also be improved by finding ways to monitor laptop use directly. This would avoid the problems of self-reporting and provide a more accurate measure of the quantity and nature of off-task use. This type of data would undoubtedly give a clearer picture of why and when laptop use interferes with learning. However, for ethical reasons, students would need to give consent for such monitoring. This in turn may raise additional concerns about the validity of the data (i.e., students may behave differently because they know they are being monitored). Still, such data collection methods would complement the self-report methods used in the present study and would improve our understanding of the nature of laptop use and its influence of learning.

Ultimately, however, these results clearly demonstrate that the use of laptops can have serious negative consequences. These results suggest that the negative influence of in-class laptop use is two-pronged; laptop use is negatively associated with student learning and it poses a distraction to fellow students. Faculty who do not use laptops in an integrated way should consider ways to limit or control their use, or at least inform students about their pitfalls and attempt to limit the distraction laptops pose to other students. This is by no means a novel suggestion. Several other researchers have likewise suggested that laptops should not be used in classes where they are not integrated into the course (Barak et al., 2006; Gay, Stefanone, Grace-Martin, & Hembrooke, 2001). I believe students, faculty, and administrators need to find ways to promote the appropriate use of laptops while simultaneously reducing the negative impacts of inappropriate use.

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## References

Altmann, E. M., & Trafton, J. G. (2002). Memory for goals: an activation-based model. *Cognitive Science*, 26, 39–83.

- Bailey, B. A., & Konstan, J. A. (2006). On the need for attention-aware systems: measuring effects of interruption on task performance, error rate, and affective state. *Computers in Human Behavior*, *22*, 685–708.
- Barak, M., Lipson, A., & Lerman, S. (2006). Wireless laptops as means for promoting active learning in large lecture halls. *Journal of Research on Technology in Education*, *38*, 245–263.
- Bhave, M. P. (2002). Classrooms with Wi-Fi. *T.H.E. Journal*, *30*(14), 17–20.
- Borja, R. R. (2006). Researchers weigh benefits of one computer per lap. *Education Week*, *25*(36), 10–11.
- Brown, D. G., Burg, J. J., & Dominick, J. L. (1998). A strategic plan for ubiquitous laptop computing. *Communications of the ACM*, *41*, 26–35.
- Brown, D. G., & Petitto, K. R. (2003). The status of ubiquitous computing. *Educuse Review*, *38*, 25–33.
- Candiotti, A., & Clarke, N. (1998). Combining universal access with faculty development and academic facilities. *Communications of the ACM*, *41*, 36–41.
- Chen, E. (2006). Laptops mixed in some U. Penn law classes. *The Daily Pennsylvanian*, p. A1. Retrieved August 31, 2006, University Wire service via <http://web.lexis-nexis.com>.
- Chun, M. M., & Wolfe, J. (2001). Visual attention. In E. B. Goldstein (Ed.), *Blackwell's handbook of perception* (pp. 272–310). Oxford UK: Blackwell Publishing.
- Coon, D. (2004). *Introduction to psychology: gateways to mind and behavior* (10th ed.). Belmont CA: Thomson Wadsworth.
- Demb, A., Erickson, D., & Hawkins-Wilding, S. (2004). The laptop alternative: student's reactions and strategic implications. *Computers and Education*, *43*, 383–401.
- Driver, M. (2002). Exploring student perceptions of group interactions and class satisfaction in the web-enhanced classroom. *The Internet and Higher Education*, *5*, 35–45.
- Finn, S., & Inman, J. G. (2004). Digital unity and digital divide: surveying alumni to study effects of a campus laptop initiative. *Journal of Research on Technology in Education*, *36*, 297–317.
- Fitch, J. L. (2004). Student feedback in the college classroom: a technology solution. *Educational Technology Research and Development*, *52*, 171–181.
- Gay, G., Stefanone, M., Grace-Martin, M., & Hembrooke, H. (2001). The effects of wireless computing in collaborative learning environments. *International Journal of Human-Computer Interactions*, *13*, 257–275.
- Gopher, D. (1993). The skills of attentional control: acquisition and execution of attention strategies. In D. E. Meyer & S. Kornblum (Eds.), *Attention and performance* (14, pp. 299–322). Cambridge, MA: MIT Press.
- Granberg, E., & Witte, J. (2005). Teaching with laptops for the first time: lessons from a social science classroom. *New Directions for Teaching and Learning*, *101*, 51–59.
- Hall, M., & Elliot, K. M. (2003). Diffusion of technology into the teaching process: strategies to encourage faculty members to embrace the laptop environment. *Journal of Education for Business*, *79*, 301–307.
- Hyden, P. (2005). Teaching statistics by taking advantage of the laptop's ubiquity. *New Directions for Teaching and Learning*, *101*, 37–42.
- Jones, A. (2005). Computers in college classrooms: a new way not to pay attention. *The Atlanta Journal-Constitution*, *2*(October 18), 1B.
- Kahneman, D. A. (1973). *Attention and effort*. Englewood Cliffs, NJ: Prentice Hall.
- Kladko, B. (2005). Wireless classrooms: tool or distraction? *The Record*(April 16), A1.
- Levine, L. E. (2002a). Using technology to enhance the classroom environment. *T.H.E. Journal*, *26*(6), 16–18.
- Levine, L. E. (2002b). Laptop classrooms present new teaching challenge. *T.H.E. Journal*, *30*(5), 10.
- Mackinnon, G. R., & Vibert, C. (2002). Judging the constructive impacts of communication technologies: a business education study. *Education and Information Technology*, *7*, 127–135.
- Mangan, K. (2001). Business schools, fed up with internet use during classes, force students to log off. *Chronicle of Higher Education*(Sept. 7), A43.
- McGinnis, N. (2006). Instructors at U. Kansas forbid laptop use in classrooms. *University Daily Kansan*. Retrieved September 2, 2006, University Wire service via <http://web.lexis-nexis.com>.
- McVay, G. J., Snyder, K. D., & Graetz, K. A. (2005). Evolution of a laptop university: a case study. *British Journal of Educational Technology*, *36*, 513–524.
- McWilliams, G. (2005). The laptop backlash. *The Wallstreet Journal*(October 14), B1.
- Melderiercks, K. (2005). The dark side of the laptop university. *Journal of Ethics*, *14*, 9–11.
- Mitra, A., & Steffensmeier, T. (2000). Changes in student attitudes and student computer use in a computer-enriched environment. *Journal of Research on Computing in Education*, *32*, 417–433.
- Olson, F. (2002). Duke U decides against requiring freshmen to own laptops. *Chronicle of Higher Education*(Jan. 11), A44.
- Palmer, H. (2006). At BYU, laptops in class seen as being a mixed bag. *The Daily Universe*. Retrieved August 31, 2006, University Wire service via <http://web.lexis-nexis.com>.
- Pargas, R. P., & Weaver, K. A. (2005). Laptops in computer science: creating the “learning studio”. *New Directions for Teaching and Learning*, *101*, 43–51.
- Partee, M. H. (1996). Using e-mail, web sites, and newsgroups to enhance traditional instruction. *T.H.E. Journal*, *23*(11), 79–82.
- Platt, M. W., & Bairnsfather, L. (2000). Compulsory computer purchase in a traditional medical school curriculum. *Teaching and Learning in Medicine*, *11*, 202–206.
- Posner, M. (1982). Cumulative development of attention theory. *American Psychologists*, *37*, 168–179.
- Ridberg, M. (2006). Professors want their classes ‘unwired’. *Christian Science Monitor*(May 4), 16.
- Robinson-Riegler, G., & Robinson-Riegler, B. (2004). *Cognitive psychology: applying the science of the mind*. Boston MA: Pearson.



- Roda, C., & Thomas, J. (2006). Attention aware systems: theories, applications, and research agenda. *Computers in Human Behavior*, 22, 557–587.
- Schrum, L., Skeeel, R., & Grant, M. (2002). One college of education's effort to infuse technology: a systematic approach to revisioning teaching and learning. *Journal of Research on Technology in Education*, 35, 256–271.
- Schwartz, J. (2003). Professors vie with Web for class's attention. *New York Times*(January 2), A1.
- Siegle, D., & Foster, T. (2001). Laptop computers and multimedia and presentation software: their effects on student achievement in anatomy and physiology. *Journal of Research on Technology in Education*, 34, 29–37.
- Silva, C. (2006). Some colleges crack down on laptop use in classroom: teachers say it detracts from class participation. *The Boston Globe*(June 10), B1.
- Sostek, A. (2005). Laptops give students a license to roam. *Pittsburgh Post-Gazette*(November 6), A1.
- Stephens, B. R. (2005). Laptops in psychology: conducting flexible in-class research and writing laboratories. *New Directions for Teaching and Learning*, 101, 15–26.
- Stickney, V. (2005). School laptops need policing. *Omaha World-Herald*(December 27), B1.
- Szanişzlo, M. (2006). Harvard profs lay down law: no laptops in class. *The Boston Herald*(June 4), A6.
- Trafton, J. G., Altmann, E. M., Brock, D. P., & Mintz, F. E. (2003). Preparing to resume an interrupted task: effects of prospective goal encoding and retrospective rehearsal. *International Journal of Human-Computer Studies*, 58, 583–603.
- Trimmel, M., & Bachmann, J. (2004). Cognitive, social, motivational and health aspects of students in laptop classrooms. *Journal of Computer Assisted Learning*, 20, 151–158.
- Weaver, B. E., & Nilson, L. B. (2005). Laptops in class: What are they good for? What can you do with them? *New Directions in Teaching and Learning*, 101, 3–13.
- Wickens, C. D., & Hollands, J. G. (2002). *Engineering psychology and human performance*. Upper Saddle River, NJ: Prentice Hall.
- Young, J. R. (2006). The fight for classroom attention: professor vs laptop. *Chronicle of Higher Education*(June 2), A27–A29.
- Zucker, A. (2004). Developing a research agenda for ubiquitous computing in schools. *Journal of Educational Computing Research*, 30, 371–386.