

Draft

Impact of Laptop Computers on Students' Academic Lives

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Introduction

Many universities and even K-12 schools are requiring or strongly recommending that students have laptop computers to use in class and around campus (Peneul, 2006). One informal estimate lists 212 universities in North America that have university-wide or program-specific laptop initiatives, with some institutions providing or leasing laptops to students while other institutions are requiring students to purchase their own (see http://www.wcmo.edu/wc_users/homepages/staff/brownr>NoteBooklist.html). Despite the growing popularity of laptop programs, there have been very few systematic or behavioral studies examining *how* students use laptops to support their learning or how the multiple uses of laptops affect the work and lives of students. In this study we use multiple methods to systematically investigate how the availability of laptops affects the culture of the classroom, the process and quality of students work, student engagement in their work, and how laptops affect the social interactions of students.

Beyond the convenience and flexibility of working anytime, anywhere (Ni, & Branch, 2004), very little is known about how laptops might affect students lives in a university setting. Some suggest that laptops can change the nature of in-class instruction, from the dominant lecture model to more interactive, problem-based sessions, with instant submission of work, and greater opportunities to revise (Nilson & Weaver, 2004). In this context, changes in instruction are crucial, and the use of technology is but one means to support the instructional model. Others have found that introducing laptops into the classroom can interfere with learning. In one study, students who were given the opportunity to work on laptops during lecture performed less well on traditional tests of memory for the material than students who were prevented from using their laptops

(Hembrooke & Gay, 2003). They found that students with laptops often engaged in off-task and on-task web-surfing, and both of which were associated with poorer performance on recall tasks.

In terms of the broader university experience, the learning and development that occur outside of the classroom, some claims have been made that the portability of laptops will create greater opportunities for peer help and collaboration, whereby students can create learning environments anywhere, with a wider and more diverse group of students than they might otherwise interact with. However, portability could also result in greater student isolation, narrower social networks, and less face-to-face contact because it enables students to choose work environments that are more private or selective. This could inadvertently reduce the broader value that a university experience can afford students.

To better understand how students use laptops both within and outside of the classroom and how these practices might enrich or diminish their university experience, we conducted a longitudinal study comparing student work habits and performance with and without access to a laptop computer. This study was conducted within the School of Design at a major research university in the Midwest. The study tracked the 2003 ($N = 24$) and 2004 ($N=27$) sophomore classes across their fall and spring semesters. The fall semester of 2003 focused on collecting baseline data on the current culture of a sophomore Typography I class, the first design class that requires extensive computer use. These data included classroom observations to obtain information on how a typical class unfolds, computer cluster usage, process and performance measures from instructors, and self-report data from assignment logs, surveys and student focus groups.

In spring 2004, this same group of students was given laptop computers for their coursework and personal computing needs. Once again we observed the classroom (Typography II), collected process and performance data, and collected student self-report data from logbooks, surveys and focus groups. In addition, an interview with the instructor was conducted at the end of the spring semester. In Fall 2004 and Spring 2005 we distributed laptops to the new sophomore class in Typography I and II, allowing us to compare the student and classroom measures across Typography I for classes with and without laptops.

Procedure

All students in the Fall 2003 and 2004 sophomore class volunteered to participate in the study. The study collected six types of data:

1) Classroom observations: Selected class periods were observed to capture how and where students worked (e.g., on paper or computer; in class, or in computer lab), the pattern of peer support and interaction, and how instructors interacted with students and supported student work. Observations were conducted by an anthropologist, a social psychologist and a cognitive psychologist.

2) Student Surveys: At the end of the semester students were asked to complete a short survey regarding their work routines, such as when and where they usually work on their computer-based assignments, if they receive feedback or ideas from other students while they work, and the advantages and disadvantages of using the computer cluster.

3) Student Logbooks: For each assignment students were asked to track and report where and when they developed and completed an assignment, and if during the

process they received help, shared ideas, or received feedback from other students or faculty. Each student completed a log for three randomly selected assignments.

4) Focus Groups: At the end of the semester students participated in a focus group with the researchers to share their experiences regarding the class. Questions focused on their use of the computer cluster or their own computer for their work, the role of peers from their own and other design classes, their use of the studio space outside of class hours, and the positive and negative aspects of how the course is currently conducted.

5) Performance Data: As part of the course requirements, students maintained a Design Logbook, which includes their final assignment as well as the earlier drafts of the assignments. The instructor scores student assignments along three dimensions: exploration, resolution, and engagement.

Results

Classroom Culture without Laptops

During the first semester of the study, periodic classroom observations were conducted to understand how students and the instructor worked and interacted in the class without laptops. The class was held in the sophomore studio, a large room reserved for the sophomore class to work in during and outside of class time. All students had a desk, with two-foot high bulletin boards mounted on 3 sides of the desk for displaying their work. The classroom walls were also made of bulletin board material to support the posting and sharing of work. Most class periods started with the instructor making announcements about assignments, due dates or other administrative issues, posing questions or informing students about relevant events or issues, and an introduction to the activity or goal of the

class. This was also a time for general questions or comments by students. Most classes consisted of a class activity, conducted as either a whole group or small groups activity. The TA and the instructor would circulate among the students, asking questions or making comments. Frequently, the class period was used for working on course assignments, with the TA and the instructor working one-on-one with students, asking questions, making suggestions, and providing feedback. Students would work at their desks, some would go from desk to desk looking at other students' work, and others would wait for the instructor to become available. Students were observed sketching, re-arranging materials in their assignment, posting their work on the wall, and those with their own laptop computers would use them to work on their assignments. During this time the TA would usually go downstairs to the computer cluster, which was reserved for the class during class hours, to work one-on-one with students who requested help or feedback while working on the computers. In our observations we noticed that about half of the students would leave the classroom when given the opportunity to work on assignments and only a few of them went down to the computer cluster to work.

Critiques were conducted during class prior to and after the deadline for submitting assignments. The critiques provided students with the opportunity to view each other's work and get feedback on their own work from the instructor and the other students. Students would print out their assignments and post them on the wall of the studio and take turns presenting their work and getting feedback. Students, the instructor, and the TA all actively participated in providing feedback.

Classroom Culture with Laptops

The general format of the class remained the same with the introduction of the laptops. Most students would open their laptops almost immediately upon entering the classroom. Some of the computer activity was not course related, such as surfing the web, reading the news, instant messaging, and checking email. When the instructor introduced an assignment, many students would close their laptops and take notes using paper-and-pencil. Once the students were given the opportunity to work on their assignment, all the students opened their laptops, with some beginning to use their computers to work on their assignment immediately, others first engaging in non-course related work, and others first working on paper, sketching and writing down ideas. The instructor sometimes had to suggest to students to work on paper so they wouldn't initially be constrained by the size limitation of the computer screen. This seemed to encourage students to move back and forth between working on the computer and working on paper. In contrast to the classroom without laptops, all the students remained in the studio for the duration of the class period (and some stayed after class) to work on their assignments. Working on the computer was interspersed with periods of non-course activity, such as checking mail, instant messaging and web surfing.

During critiques, the majority of students took notes on paper and laptops were closed. At break times students would open their laptops to check email and then some would stay on their laptops after the critiques resumed, resulting in a less focused, and less interactive session compared to sessions when students did not have laptops. On some occasions students used their laptops to present their work during the critiques, such as to show colors or alternative versions of their work. In once instance, problems with

the printer resulted in many students not being able to present paper versions of their work. Students quickly adapted to the situation by placing their laptops along the wall with their work displayed on the screens.

Our observations did show a change in the class as a result of the introduction of the laptops. Students were more likely to stay in the studio for the duration of the class period and beyond, and to spend the majority of the time working on their assignments, although they also engaged in unrelated computer activities intermittently. The computers did change the dynamics of the critiques, with some students being less focused and participatory when other students were presenting their work.

Students' Work Behavior

The effect of laptops on student behavior was analyzed using the data from the assignment logbooks, end-of-semester surveys and focus groups. Students used the logbooks to record the start and end time of each work session, the percentage of the work time spent on the computer, where they were working, and whom they interacted with while working. Information collected from the surveys and focus groups provided additional information on work behavior and preferences.

Did laptops affect the amount of time students spent on their work?

A one-way ANOVA, using average number of hours spent on assignments as the dependent variable and Condition (Laptop vs. No Laptop) as the independent variable found that Year 1 students spent significantly more time working on projects when they had laptops (Spring 04) than when they didn't have laptops (Fall 03), $F_{(2, 35)} = 8.6$,

$p < .001$. This effect was also found when comparing Year 2 students in Fall 04 students with laptops to Fall 03 students without laptops on the same assignment (mean hours = 25.25 vs. 5.92, respectively), $F_{(1, 28)} = 30.9$, $p < .0001$. No difference was found in time spent on assignments comparing Spring 04 students with laptops in Typography II with Fall 04 students with laptops in Typography I, $p > .05$. (See Figure 1). Thus for these two groups of students, having laptops was associated with spending more time working on assignments, regardless of the course (Typography I vs. II). Furthermore, preliminary data suggests that there is no relationship between time spent on assignments and overall rating of the assignment by the instructor.

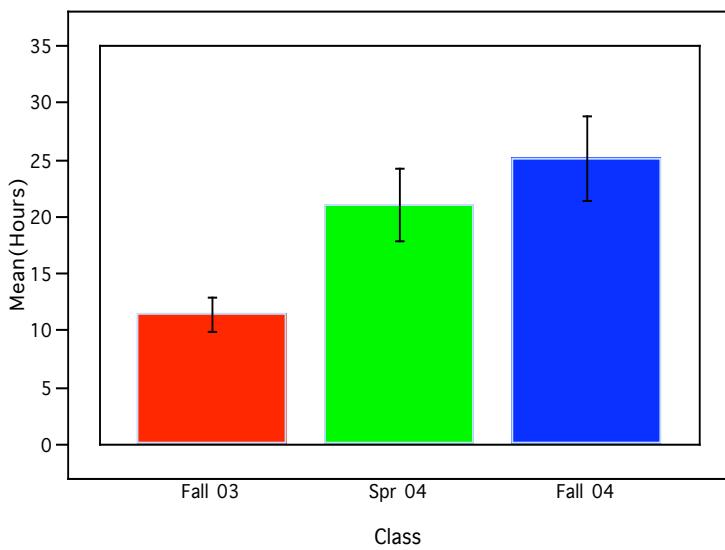


Figure 1. Mean hours spent on assignments for No-laptop (Fall 03) vs. Laptop classes.

Did laptops affect how students distributed their work time?

The first set of analyses showed that students spent more time on their assignments when they had laptops but didn't address how students spent that time. Additional analyses examined how often and how long students spent working on assignments. On

average, Fall 03 students engaged in fewer work sessions per assignment without laptops than during Spring 04 with laptops (Mean = 6.9 vs. 8.7), $t_{(df=8)} = 4.49$, $p < .002$ and Fall 04 students (with laptops) also engaged in significantly more work sessions than the Fall 03 no laptop group for the same assignment (mean = 10.8 vs. 3.9), $F_{(1,28)} = 28.14$, $p < .0001$.

The duration of work sessions also differed between the classes. The mean work session duration on the same assignment in Fall 03 (No laptop) vs. Fall 04 (Laptop) was 1.57 hrs vs. 2.39 hrs, respectively, $F_{(1,28)} = 5.31$, $p < .03$. The two groups did not differ on the minimum duration of a work session (means = 49 vs. 51 minutes) but the maximum duration of a work session was longer for students with laptops compared to those without, 5.1 hrs vs. 2.36 hrs, respectively, $F_{(1,28)} = 9.37$, $p < .005$. Thus students with laptops worked more frequently and had longer work sessions than when they didn't have laptops. These longer work sessions can be explained in part by where students worked and the characteristics of those spaces, which will be discussed in the following section.

When students worked also varied as a function of having laptops. Comparing the Fall 03 (No laptop) vs. Fall 04 (Laptop) on the same assignment revealed a significant difference in the tendency for students to work after midnight: 58% of the laptop group reported working after midnight compared to only 5.5% of the no laptop group, $\chi^2 = 9.7$, $p < .002$. In comparing the same group of students across the two semesters, when they did not have laptops only 33% worked after midnight during the semester whereas 67% worked after midnight when they did have laptops.

In sum, students with laptops spent more time on assignments, worked for longer

durations, and more of them tended to work after midnight compared to when they did not have laptops.

Why did students spend more time on assignments?

Although students reported spending significantly more time on their assignments when they had laptops, there was no relationship between time spent and grades. Focus groups and classroom observations suggest that the time reported included non-work activities that were interspersed with work, such as checking and sending email, instant messaging, reading news and announcements from clubs and organizations, etc. Students reported that it was more difficult to track their time on task when they had laptops because they would often multi-task, which they were much less likely to do when they did their work in the computer cluster.

Another factor that may have contributed to the increase time was the tendency for students to limit their exploration and development of ideas and work to the computer, rather than use other tools that were more efficient and appropriate. For example, students reported spending long periods of time searching the web for pictures rather than sketching and then scanning what they needed. This tendency not only increased their time on task, but according to students, it was also contributing to the weakening of their drawing skills. Instructors had to sometimes tell students to use paper rather than their computers to record ideas, in order to give themselves' a larger surface to record and view them. This over-reliance on the computer for doing their work is supported by the logbook data. On average, when working on an assignment, Typography I students without laptops spent a significantly smaller percentage of their work time on computer compared to Typography I students with computers (76% vs. 86%), $t_{(df=20)} = 2.63$,

$p < .02$. Students also voiced their dependence on the laptops in focus groups, with many saying that they “didn’t know how they would survive” when they had to return them.

Did laptops affect where students worked?

One of the often-mentioned advantages of laptops over personal desktop computers or computer clusters is that they provide students with freedom and flexibility in choosing their work locations. Based on their logbooks and their survey responses, we examined where students worked, and their preferences for working in certain locations.

As shown in Figure 2, laptops had a major impact on where students did their work. The graph depicts the percentage of time students spent working in various locations for the same assignment for the Fall 03 (No Laptop) and the Fall 04 (Laptop) classes. The classes differed significantly in work time spent in Reese, in the studio, and at home. The most dramatic change was the shift from Reese to working in the studio and at home, both individually and for the group. Whereas only 12% of no-laptop students reported working at home, 91% of laptop students reported doing so. Conversely, 94% of no-laptop students reported working in Reese compared to only 9% of laptop students.

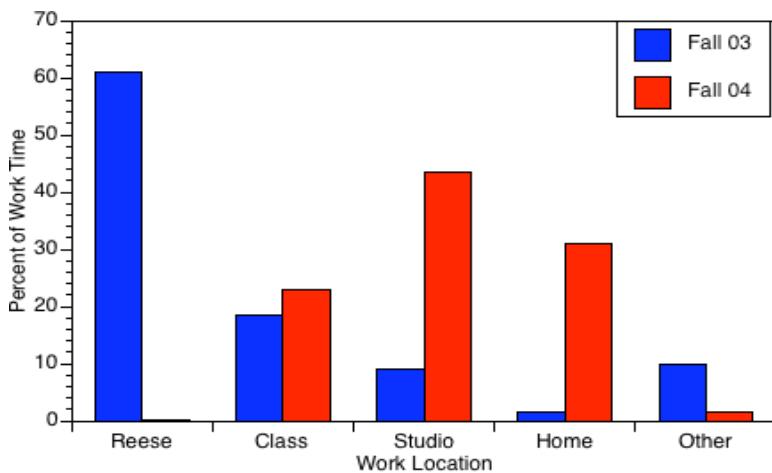


Figure 2. Proportion of time spent working on an assignment in different locations for the no-laptop (Fall 03) and laptop (Fall 04) classes.

Although both classes spent about the same proportion of time working during the class period (regardless of location), the percentage of students working during class time was lower for the no-laptop group (37%) than for the laptop group (64%). Without laptops, students wanting to work on the computer during class time had to go to Reese Cluster, which was reserved for the class during the class time period. However, as we observed and students reported, instead of going to the cluster, many of the students left the class and did work for other classes or did other non-academic activities.

One surprising finding is the very small percentage of time that students spent working in other locations on or off campus. For the No-laptop class, only 18% of the students reported working in some other location, which accounted for about 10% of the group's total work time. With laptops, the percentage of students working in other locations increased (27%) but this accounted for less than 2% of the total time spent working. Thus, despite the portability of the laptop, students continued to work in the same small set of locations but shifted the relative percentage of time spent in those locations.

Survey responses corroborated and expanded on the logbook reports. Students were asked to indicate where they did the most and the least amount of their work. Figure 3 shows the percentage of students indicating the locations where they did most of their work. With laptops significantly more students reported doing most of their work at home or in the studio and no students reported doing most of their work in other locations, either on or off campus.

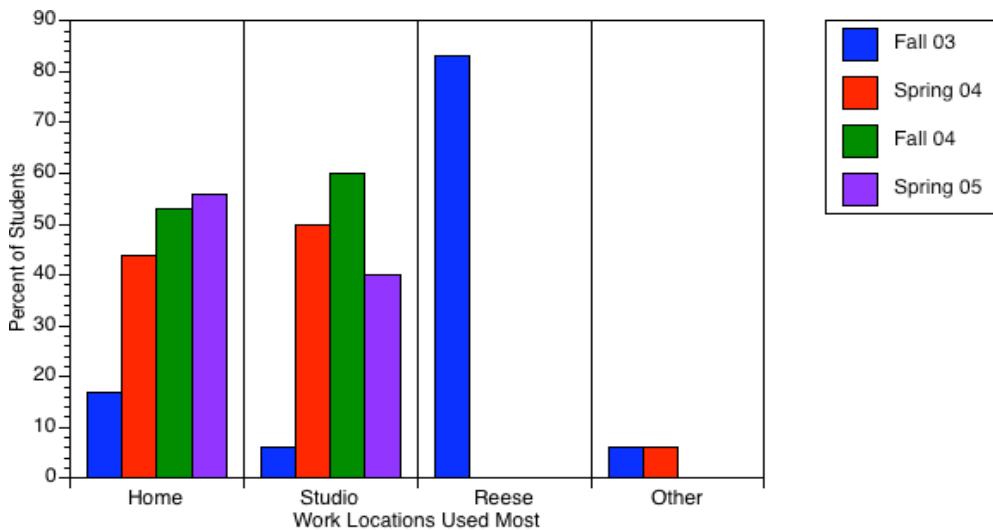


Figure 3. Percent of students indicating different locations as their predominant work location.

Thus with laptops students spent more time working in the studio and at home, and more students made home or the studio their predominant work environment. Without laptops most of the students used class time and Reese to do most of their work.

The shift away from working in the cluster could lead to changes in the type amounts of help that students receive, as the cluster was a common work space for design students of all academic ranks, with a computer support person available. The next set of analyses examine who students interacted with while they worked on their assignments.

Did laptops affect students' interpersonal interactions while working?

Prior to the study, interviews with students and faculty suggested that an important aspect of design education was the community that formed within each class. Students within a given year share a studio space where they have a desk, attend class, and develop and display their work. The common space provides many opportunities for students to share, view, and critique each other's work, and to help each other learn design

techniques and how to use the technology. Reese cluster also served this purpose because it was the only location with all the computer software that students needed for their course work. The following analyses examined how the changes in work location may have affected the sources and quantity of interactions.

Figure 4 depicts the percentage of time students spent interacting with others while working on their assignments as reported in their logbooks. Without laptops, students spent a significantly greater percentage of their work time interacting with the instructor and peers and spent a smaller percentage of their time working alone. In terms of interacting with peers, not only did they interact less when they had laptops, but the peer group changed as well. Without laptops, the peer group was predominantly other students in the design class or other design students. With laptops, students tended to interact more with peers who were not in the design community, such as roommates, other students in the dorm, and friends. This change in the peer group is not necessarily negative. One instructor discussed the value of feedback from non-designers as a way “to see how they read a design”, a sentiment repeated by many students as well.

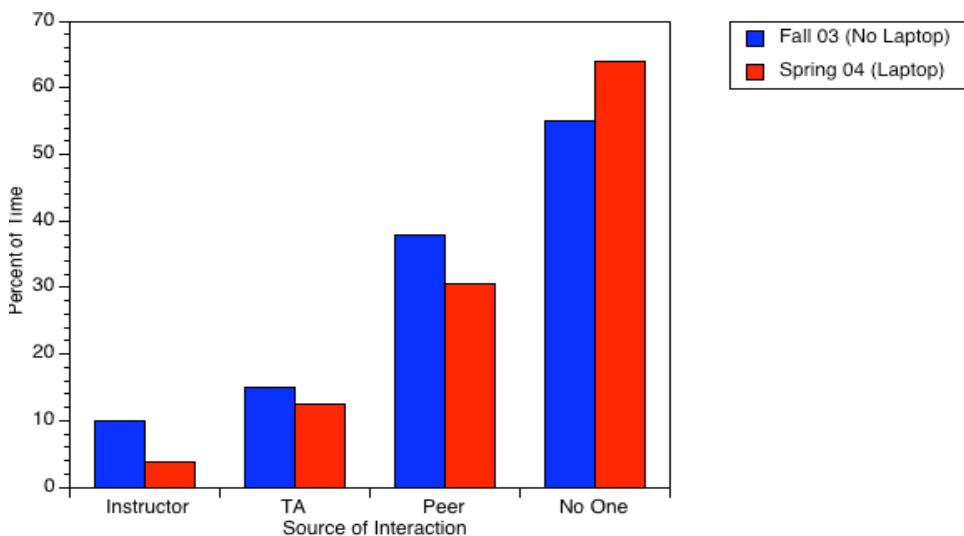


Figure 4. Percentage of time interacting with others while working on assignments

Although the overall interaction patterns showed little change, where students interacted with these various sources did change. In Fall 03 (no laptops), work in Reese cluster (outside of class time) was dominated by peer interaction, which is consistent with reports from the student focus groups and surveys. These interactions often centered on getting help with the software tools, as well as critiquing and sharing ideas. In contrast, no work interactions were reported in Reese in Fall 04. Students reported mostly using Reese to access the printer, not to support creative aspects of their work. As Reese showed a decline in work and interaction use in Fall 04, the studio showed an increase in usage. Outside of class time, peer interaction in the studio dominated work sessions for Fall 04 students, whereas no peer interactions occurred in the studio for Fall 03.

Interaction patterns during class time also shifted slightly with the introduction of laptops. More interactions with the TA were reported in Fall 04 than in Fall 03, and fewer instances of working without any interactions. There was also a slight drop in interactions with peers. This shift toward increased TA interactions can be accounted for by the tendency of the TA and the students to remain in the class throughout the class period. Prior to having laptops, when students were given time to work on their assignments in class, the TA would often go to Reese and the instructor would remain in the class. However, many of the students would neither stay in the class nor go to Reese, and would instead work in Reese outside of class time.

The other major shift was seen in the interactions when working at home. Although the Fall 03 class rarely worked at home, when they did they often interacted with a peer while working. In contrast, the Fall 04 group spent about one-third of their work time at

home and reported having no interactions.

Are there differences between working at home vs. working in Reese?

The shift from working in the cluster to working at home does have a potential impact on the quality of students' work and students' satisfaction. In surveys and focus groups, students without laptops reported both advantages and disadvantages for working at home and in the cluster. For working at home, the advantages centered around comfort issues, such as not having to go out in the cold, more relaxing, access to food, comfortable furniture, better lighting, temperature and noise control, privacy, and ability to work in more causal attire. This greater comfort may be a major factor contributing to the longer and more frequent work sessions that students engaged in when they worked on laptops compared to when they didn't have laptops.

The reported disadvantages of working at home were all learning-related: 30% report the lack of feedback, interaction and help from others, and 23% reported too many distractions (e.g., presence of TV, stereos, people). Ten percent of the students said there was nothing positive about working at home, although they still did it. Students also reported psychological negatives of working at home. "Lonely" was a common description of the disadvantage of working at home. This was also reported as a disadvantage for the studio when they had laptops because students were often the only ones working in the space at a given time.

In contrast, the major advantages of working in the cluster were learning-related. Sixty-six percent identified the availability of help and feedback from other students as advantages of the cluster and 10% also mentioned few distractions. The disadvantages of working in the cluster were predominantly non-work related and focused on the

lack of comfort - cold, poor lighting, uncomfortable furniture, no food, etc. The physical discomfort of working in the cluster may contribute to the shorter and less frequent work sessions that students engaged in when they didn't have laptops.

Without laptops, most students did most of their work in the cluster, thus exposing themselves to the educational advantages of working in that location. In contrast, with laptops students were much more likely to work at home, even though they also recognized home as a poor place to work from a learning perspective. In the survey, 43% of the laptop students reported home as their most frequent work location, 50% reported their studio, and 7% reported other places around campus. The advantages and disadvantages of the studio mirrored those of the computer cluster, with the additional advantage mentioned being a sense of community.

In sum, with access to laptops, students increased their tendency to work in their rooms, an environment that was more physically comfortable but less conducive to learning or working (more distractions, and less feedback and help), and worked less in a communal setting (cluster or studio), that was more conducive for learning and working (feedback, help, community-building, "inspiring" as one student put it), but less physically comfortable. Even though students recognized these advantages and disadvantages, they opted to work in environments that offered physical comfort over better work/learning environment.

The Sense of Community

As described, with laptops more students did more of their work at home or in the studio outside of class hours. This behavior would remove them from each other's

physical presence but the availability of wireless connections on campus may have enabled them to maintain the same level of contact and mutual support as when they worked together in the cluster. To examine this issue, students were asked to report the frequency of obtaining help from the various members of their class and department community. Figures 5 and 6 show the percentage of students reporting getting help often or very often for technical, computer-related issues and for creative help or inspiration. Without laptops, more students reported getting help often from the TA, classmates and other design students compared to when they had laptops. With laptops, more students reported getting help from manuals compared to when they did not have laptops. However, with laptops, more students reported getting help often from the instructor compared to when they didn't have laptops. In terms of creative input or inspiration, without laptops more students reported getting help and inspiration often by seeing the work of classmates and other design students and getting input from other design students compared to when they had laptops. With laptops students got input more often from non-design classmates compared to without laptops.

The introduction of laptops does seem to have changed the interactions and support systems that existed before students had them. The role of the instructor as a source of help increased but the role of the greater design community decreased. Students in the focus groups and in the surveys reported a change in the sense of community. Even though the students liked having the laptops for work, they also saw them as contributing to “the death” of the design community. Several warned against introducing laptops in the freshmen year, because they believed doing so would prevent students from forming a sense of community and attachments to their classmates.

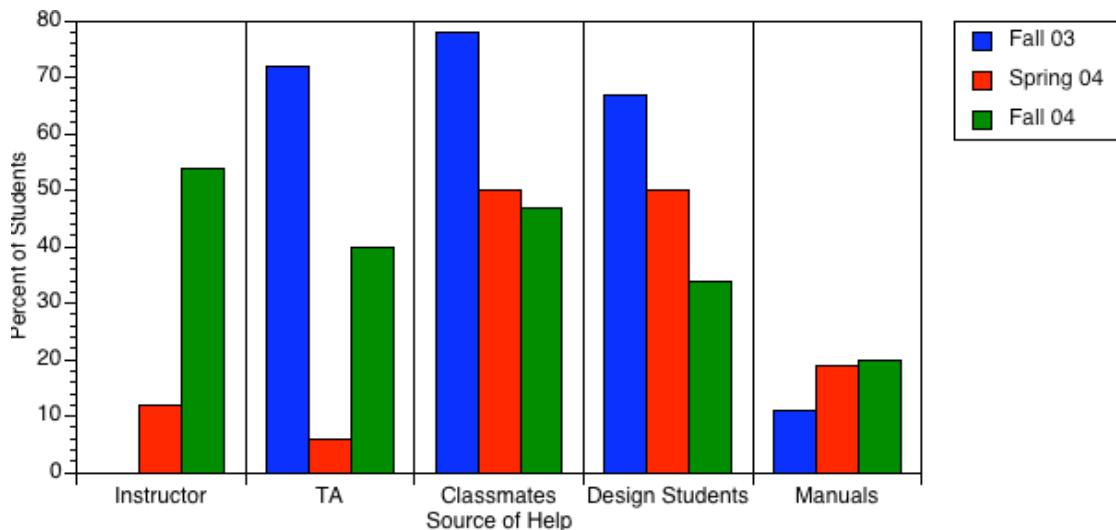


Figure 5. Percentage of students who reported getting technical help often or very often from various sources.

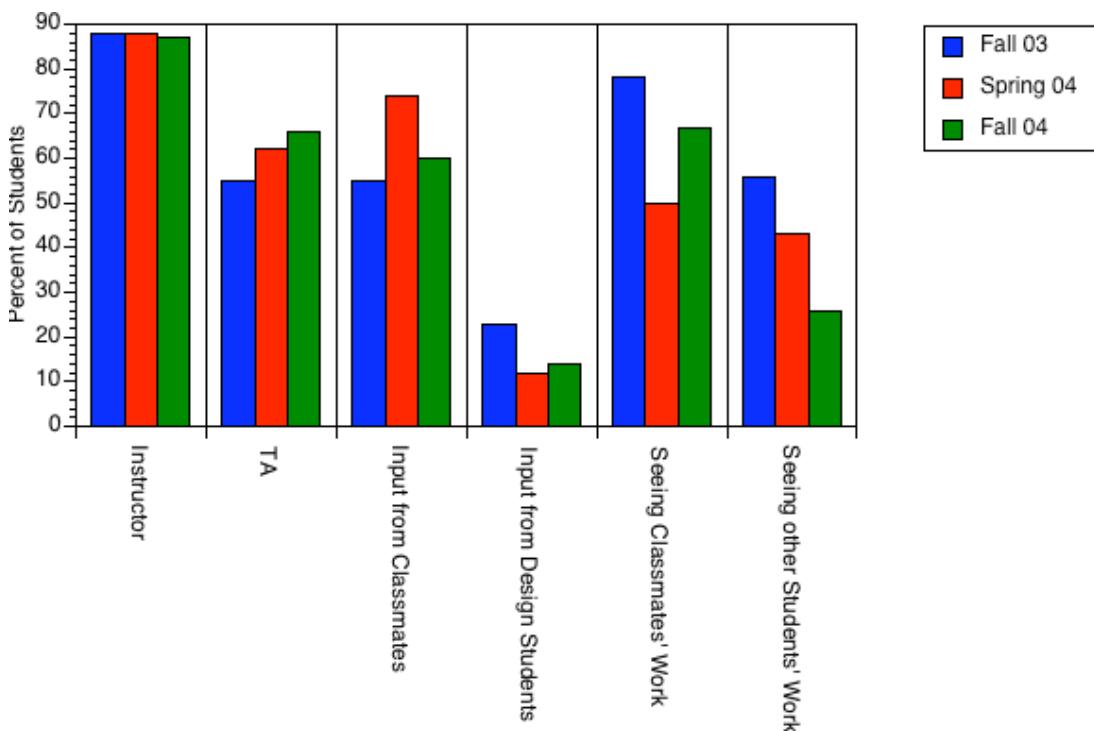


Figure 6. Percentage of students who reported getting creative inspiration or help often or very often from various sources.

Conclusions

Two of the major advantages of laptop computers are that they enable students to engage in their work when and where they want, with few constraints. This study did find that students spent more time on task when they had laptops. They worked more frequently and for longer stretches of time. However, this time was not always productive or efficient. Work was interspersed with other activities, such as checking and writing email, instant messaging, reading news, etc. Furthermore, for some students, the constant availability of the computer served to constrain their thinking, whereby they tried to use the computer for everything even when hand drawing or other sources of creation would have been more appropriate and efficient. This over-reliance on the laptop also led to a perceived weakening of their drawing skills.

Although laptops have been promoted as supporting freedom to work anywhere, students in this study rarely worked in locations other than their rooms or studio. With laptops, students preferred to and were much more likely to work at home. Location was often chosen for its level of physical comfort rather than its support of learning and community. This finding implies that learning spaces that provide the optimal environment for learning must incorporate features that provide physical comfort as well if students are to take advantage of them. The creation or redesign of physical spaces so that they are closer on the comfort scale to students rooms – comfortable furniture, lighting control, flexible (private and public spaces), access to food, etc, may be necessary to pull students from their non-optimal work spaces. Creating comfortable, functional learning spaces could also serve to maintain students' sense of community. If the common working spaces encouraged students to spend most of their work time in

them, it would increase the likelihood that more of them would be working in them at the same time.

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