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This chapter reports on a mathematics professor's experience leveraging laptops in a required intermediate statistics course with a challenging student population. Use of laptops streamlined course delivery, enhanced classroom interaction, and improved both his students' and his own overall course experience.

Teaching Statistics by Taking Advantage of the Laptop's Ubiquity

Paul Hyden

Laptops have come to play a vital supporting role in managing and delivering my undergraduate courses since I saw them improve my course delivery, my rapport with the class, and the student learning experience. I experimented with laptops and observed the effect of their usage in a required intermediate course in business statistics and probability. The course serves all levels of undergraduates in the College of Business and Behavioral Science at Clemson University. The student population is challenging, with many students openly admitting their predisposed anxiety and hostility toward the subject.

The unique opportunities that laptops afford made it easier for me to reach them. Student access to computers simplified my teaching life, freeing me to focus on and improve my relationship with the class. Laptops also helped me express the best in my own teaching personality. Around-the-clock availability, portability, and personal accessibility make student laptops a unique enabler of powerful instructional techniques.

This chapter describes how I managed my students' use of laptops in class and how the technology advanced my educational goals. It closes with my assessment of the limitations of the technology and the course changes I'm making to take fuller advantage of the laptop's potential to enhance teaching and learning.

My Goals for Technology

Three major goals guide how I implement technology in my classes. First, I strive to create a community of learning among the students and myself. Indeed, students respond positively when they can establish relationships

with peers as well as the instructor, and I have found that laptops can enhance those interactions. Second, I want student input to drive the daily direction of the course, within the confines of my syllabus. Matching what is addressed in class to student needs makes class time productive and relevant to students, and both synchronous and asynchronous online communication enable me to tailor my course content daily. Finally, I want any technology I might use to reinforce and support learning rather than define and control it; I quickly discovered that laptops do this seamlessly, just like textbooks and chalkboards. My hope is that, once the novelty of the laptop wears off, labeling my course a "laptop course" will sound as ridiculous as calling a course with a textbook a "book course."

A course driven by student input and a firm sense of community frees me from the typical patterns of delivering information to students. I can foster two-way communication in the classroom—not just from instructor to student but from student to instructor and from student to student in a fluid and dynamic network, one that mimics how information flows within the Internet. As the instructor, I act simply as a centralized node directing this network of learning, rather than its sole source of knowledge. In this environment, I find that students are less likely to target their frustration at me and more likely to seek out solutions on their own than they are in the traditional classroom hierarchy.

In my mind, a course structured around a learning community and student needs requires high attendance at class, no matter what kind of technology is used. Therefore I keep attendance and enforce a strict attendance policy with serious penalties after a reasonable number of absences.

Discussion Board Postings

Discussion boards, which are now a common virtual environment in course management systems, allow students to submit their own questions and answer the questions of other students. Unlike chat and e-mail, a discussion board makes all postings visible to both the instructor and the entire class. This tool proved useful in inducing my students to do the textbook readings that I assigned for almost every class. With each reading, students were to post either a novel question or an answer to another student's question on the assigned material before the next class.

Before using laptops, I had students turn in a handwritten question that was based on their reading assignment. This served several purposes. First, it motivated students to do the readings when due. Second, it helped them transform their frustration with the material into specific queries and confusions that I could help them address. Finally, it saved class time in taking attendance. But this approach had some negative effects as well. For one, these daily question submissions led students to expect me to compose a specific, individual response for every question, which was not feasible. So when the inevitable frustration with the material surfaced, I was an easy target.

Further, the daily questions generated a stack of papers that absorbed significant time and attention in every class. In addition, the stronger students in the class complained because they didn't always have an honest question to ask about the readings. So even though the initial low-tech approach served its purposes well enough, the class and I both paid a price.

The laptops improved the daily question assignment and added several benefits the paper version couldn't match. First of all, since I could read the student questions before class, I was able to tailor the class time to clear up confusion raised on the discussion board. If students posted their question soon enough, I answered it before class, enabling them to make a higher-quality contribution in class. Second, with all the questions and responses visible to the entire class, struggling students benefited from seeing the answers to more than just their own question. They realized that other students faced the same struggles they did and felt more comfortable with their own difficulty. No doubt, too, students wrote higher-quality postings because they were subject to public scrutiny, and better postings were more likely to get an answer. Third, the stronger students, freed from having to make up a question just to satisfy the assignment, seemed to enjoy the chance to help their peers and apply the material they mastered. In addition, their answers left me with fewer questions to address myself. Fourth, the questions I did answer were rarely unique, and I could broadcast a uniform response to several related questions that students could read at their convenience. As a by-product of all these practical benefits, the traditional hierarchical classroom structure was replaced by a network community of learners.

Daily Online Quizzes

In addition to posting on the discussion board, students were required to complete a daily online quiz based on their reading assignment prior to the next class. Before I began using a course management system that made this online tool available, I conducted daily paper-and-pencil quizzes in class. They induced most students to do the assignment readings, but they took away precious classroom time. They also generated more papers to grade, a tense classroom environment, and a distraction from the business of learning the material.

With the new technology, students completed the online quiz at their convenience before the beginning of the next class. This meant more class time for learning. The course management software instantly graded the quizzes and entered student scores in the course gradebook. To further defuse the stress and downplay the assessment role associated with quizzes, I also allowed students to retake the quiz as many times as they wanted, with the gradebook recording only the highest score. Under these conditions, a quiz served only to motivate students to do the reading and give them feedback about their comprehension of the new material. Many students even said that they enjoyed getting the feedback and felt more comfortable about

the course content as a result. Note this total reversal in student reactions from the pencil-and-paper quiz. Being completed before class, the quiz also informed me how well the students understood the reading and how to best use my precious class time with them.

Even though I didn't administer in-class exams on laptops, I did try to make them a learning experience as well by letting students bring in their own handwritten "cheat sheets." The act of constructing such a sheet generates a lot of learning and helps students focus their studying on mastering concepts and processes rather than memorizing formulas.

With all the exam and quiz results in the gradebook, students also tracked their progress throughout the semester on their own time and followed up with me when their performance fell short of their expectations.

Laptops in Class: A Computer Lab on Demand

Demonstrating mathematical phenomena and problem solutions in class is a basic teaching method in mathematics, and I usually conducted such demonstrations projecting the images from the instructor's classroom computer to the class. Three principles guided my computer demonstrations. First, I wanted to display concepts that I could not simply write on the board. I didn't view the computer just as an electronic archive for a static set of notes. Second, I wanted to concentrate on a few key ideas and not squeeze in too many, or distract students with flashy but shallow content. Third, I wanted to keep the tools of my presentation simple and conceptually focused. So I confined most of my demonstrations to Excel, which was widely available and already familiar to some of my students. The other students at least gained exposure to the spreadsheet program, which they would be learning in their business courses sooner or later.

Laptops in the classroom helped me solve a problem that I had encountered in the past when my demonstrations relied solely on projected images. Just watching the screen, my students couldn't follow what I was doing, in part because of their limited experience with the software I used. But integrating laptop activities into my demonstrations made learning easier for my students.

Making Random Variables Concrete. The challenge of teaching the concept of a random variable immediately suggested using laptops in the classroom. In nontechnical terms, a random variable is a number associated with an occurrence of a random experiment. Hence, it is both a variable in that it can take on many values, and it is random because the actual value it takes on is not known until it is observed. The common notation we use for a particular random variable is X, while the notation x is used to refer to an observation of the random variable X.

Many of my students still struggle with the concept of a variable, and the idea that an unknown value can also be random often generates a lot of confusion. Probability instructors use physical objects such as dice to

describe random variables, but they are limited by the fact that every possible roll of a die has the same probability, and values cannot be customized to an arbitrary probability distribution. Students instinctively pick up on these points where an example is lacking, and they can misapply the concept because of it.

To make this theoretical notion of random variables concrete, I showed the class how to build a simple random variable using functions in Excel. (In an earlier class, I introduced the students to Excel by leading them through some simple exercises.) Specifically, students constructed an arbitrary discrete random variable. They then observed the random variable with each press of a button, getting a feel for what it means for a variable to be random. They continued to play with the variable to see how closely their observations matched the distribution of the random variable.

Laptops helped me make a related key concept concrete as well: the mean of a random variable. If we take a sample of observations of a random variable and compute the average, the resulting value will converge to the mean of the random variable as the sample size increases. The laptops, doing what computers do best, generated samples of thousands of observations of the random variable, allowing the students to observe convergence to the mean in real terms for actual observations of the random variable.

Computing Expected Value and Variance. Students don't appreciate how useful a formula is unless you can show them how much time they can save by using it. However, demonstrating this convincingly at the chalkboard is extremely time-consuming and still fails to show the full power of the result. After I had slowly modeled the computation at the chalkboard, the class and I used Excel to compute the expected value and variance of a random variable. Then we created a new random variable that was a linear transformation of the previous random variable. Again, we went through the steps for computing the expectation and variance of the new random variable. At that point, I demonstrated that the simple laws of expected value and variance produced the same values as the much more taxing work of computing the expected value and variance directly from the random variable. To drive the point home, I changed the values used in constructing the new random variable, demonstrating that the laws of expectation and variance really did work as advertised for arbitrary coefficients on the new random variable. Even though I still used the chalkboard to show the conceptual steps in applying the result, Excel actually demonstrated the powerful applicability of the laws.

Limitations and Improvements Needed

Laptop technology and the human memory being what they are, not all the students had a functioning laptop with them when it was needed. Fortunately, I designed all my in-class laptop activities for small groups, and each group was in charge of ensuring that one member brought a working

laptop to class each day it was needed. But strictly individual in-class exercises would be hampered by reliance on laptops.

Before the laptop class, it didn't occur to me to build graded assessment into the in-class demonstration exercises, but the students questioned their relevance given that they were neither graded nor tested directly on exams. My future course offerings will include a graded element in these exercises.

Some improvements I would like to see are out of my hands. The discussion board in course management software would benefit from a new feature allowing both the instructor and the students to evaluate postings with a numerical score. These ratings would furnish feedback to students and allow the instructor to mark which responses students should note the most. In addition, the tool archiving the postings actually stores responses only in one place, as they first appear, even if they relate directly to later iterations of the topic.

In any case, technology is not a cure-all. I am excited about leveraging it creatively to deliver dynamic, relevant course content, but I do not always use it. Concepts must drive the choice of technology, not the other way around, and some concepts can actually be obscured by computers. During the unit on hypothesis testing, for example, we spend a lot of time working through examples at the board. In fact, whenever I want the students to focus on a thought process and not a computation, I have them put away their laptops. I too still spend plenty of time at the board with chalk in hand, talking with students. However, technology ensures that the time I do spend at the board is more focused and dynamically adjusted to the needs of the students.

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