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Teaching Statistics with Laptops in the Classroom: Reflections on Successes and Missteps

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INTRODUCTION

For many students, learning statistics is a challenge, so it is not surprising that those teaching statistics are continually looking for new and better ways to teach statistical concepts to students. The statistics education "reform" movement was acknowledged as early as 1995 (Rossman & Short, 1995). Within this movement, educators have been promoting the re-conceptualization of statistics courses to emphasize statistical reasoning, student-centered learning, and the use of technology to allow students to analyze and interact with real data sets (Cobb, 1993; Garfield, 1995; Garfield, Hogg, Schau & Whittinghill, 2002). In 2005, the American Statistical Association's GAISE (Guidelines for Assessment and Instruction in Statistics Education) College Report formalized these ideas, making six recommendations for statistics instruction, including utilizing "technology for developing conceptual understanding and analyzing data" (GAISE, 2005). Recent studies have suggested these reforms lead to increased levels of statistical reasoning and satisfaction among students (Everson, Zieffler, & Garfield, 2008) and are possible even in large classroom sections (Woodard & McGowan, 2012).

The GAISE report suggested that technology could be used effectively in statistics courses for analysis of large, realistic datasets; automation of calculations; simulations to illustrate concepts; and "what-if" analyses, and also discussed benefits from the use of technology, including ease of data entry, interactivity, availability and portability (GAISE, 2005). Chance, Ben-Zvi, Garfield & Medina (2007) gave an overview of the types of technology that can be used in teaching statistics, including statistical software, spreadsheets, applets, and multimedia materials. To instructors planning to utilize these tools, the authors recommended a focus on concepts rather than calculations (Chance et al., 2007).

Several authors reflected on their experiences with technology in teaching statistics, most reporting positive effects. Loch, Galligan, Hobohm, and McDonald (2011) reported improved active learning experiences and Hyden (2005), reported enhanced course delivery, classroom interaction, and student experiences. Other authors reported increased levels of student motivation, self-efficacy in analyzing real data (Su & Liang, 2000), satisfaction level, final test scores (Gorman, 2008), enjoyment, and appreciation for the role of technology (Meletiou-Mavrotheris, Lee & Fouladi, 2007).

In more recent years, some focus turned from "inclusion" of technology to "infusion" of technology, emphasizing that technology has become part of everyday education of students in all subjects (Riddle, 2010). Sites such as "The 21 things for the 21st century educator" (2012) are now available as resources for teachers to learn about and incorporate technology into their classrooms.

The focus of this paper is the redesign of undergraduate business statistics courses taught at a college of business at a public Midwestern university. The courses are presented as a two-course sequence, the first covering descriptive statistics, random variables, sampling, confidence intervals and hypothesis tests for one and two populations; and the second dealing with ANOVA, chi-square tests, regression, and forecasting. Both courses are required for all business majors and typically consist of sections of 25-50 students. As in many statistics courses, students sometimes approached these experiences with anxiety.

In 2008, the Indiana State University implemented a laptop requirement for all undergraduate students. For instructors of these statistics courses, this ready availability of technology in the classroom provided vast opportunities for course redesign that would allow students to interact with applications, do immediate calculations, explore what-if analyses, and generally take a more active role in their learning. The instructor, motivated in part by GAISE guidelines, wished to leverage student laptops and move away from the traditional format that included lectures supplemented by practice, computer demonstrations by the instructor, and occasional trips to the computer lab.

The goal was to implement a student-centered learning environment in which students work hands-on with data and use computers to immediately perform calculations and visualize concepts. With student-centered learning, students are in "command" of their own learning and learn to solve problems without depending on the instructor (Nanney, 2004). When the student-centered environment is combined with technology, students have ". . . ability (through new technologies) to experience abstract concepts in applicable and often easily accessible formats," (Ryan 2008, para 8). Students gain deeper knowledge and skills by manipulating the learning objects (Ryan, 2008).

In the discussion that follows, the experiences with the redesigned statistics courses are detailed. Topics addressed include pedagogy and student feedback, followed by a section on lessons learned.

PEDAGOGY

With the GAISE recommendations in mind, the introductory business statistics courses were redesigned to be technology-centered, application centered, and learner focused. Students were required to bring laptops to class every day and to use them for in-class conceptual exploration, data analysis, assignments, and exams. Students brought their laptops with surprising consistency. Blackboard was used for course management. Several different aspects of the pedagogy used in the redesigned courses are explored, including online materials and classroom technology; classroom activities; homework and projects; and exams.

Online materials and classroom technology. The classrooms were equipped with Sympodium and Smart Board technology. These resources allowed the instructor to project images and to write on the screen with a stylus. Notes were written (in a Smart Board Notebook file) and Excel files. Web pages, applets and PowerPoint could be annotated and posted to Blackboard.

Class periods were generally run as follows. Before class, Excel spreadsheets, worksheets, applets, online resources and/or PowerPoint slides were posted on Blackboard and students were notified of their location. After the first three weeks, emails and announcements were no longer needed. Students generally would have their laptops already "booted up" with links and files open when class started. The PowerPoint notes were available for students who desired structured information. Students were at times directed to websites that used (or misused) a particular statistical technique, for example, a high-profile instance of confusion of correlation with causation. Any solutions to problems done in class were also posted to Blackboard.

Classroom activities. Classroom activities were generally presented in one of two formats. At times, the instructor would demonstrate calculations or processes and students could follow along on their own computers. These were more along the lines of enhanced lectures. At other times, students would work on their own, guided by worksheets or instructions and collaborating with other students. In these cases the instructor served as a facilitator. Instead of hearing passively about how these concepts worked, the students "discovered" concepts for themselves using applets and manipulating data.

Technology-based classroom activities came in several forms. For example, large, realistic data sets in Excel were provided for students to create graphs or calculate statistics. Online probability calculators were used extensively in place of traditional statistical tables. Java applets and simulations were used to demonstrate statistical concepts, such as sampling distributions, confidence intervals, processes for hypothesis tests and properties of regression lines. Once students were confident with procedures and calculations, they used statistical software, online calculators, or applets to do calculations, though they still had to determine the appropriate analysis and how to interpret results.

Homework and projects. Students were evaluated based on online homework and projects. Students were given about 10 graded assignments on an online homework system. These assignments generally consisted of 5-8 multi-step problems in which students applied concepts, calculated statistics, and/or interpreted results. For example, a hypothesis testing problem might consist of determining the correct hypotheses, calculating a test statistic, arriving at a decision, and finally making a conclusion based on results.

The instructor felt online homework was consistent with the philosophy of the course. Benefits included automatic grading and multiple attempts so students could learn from their mistakes. The instructor found significant issues with the system originally chosen and after a review of available online statistics homework software switched to MyStatLab.

Students were also evaluated on several projects, all of which involved analysis and interpretation of real data. For example, students analyzed data generated from a café run by fellow undergraduate business students (DePaolo & Robinson, 2011). For the first statistics course, students analyzed customer satisfaction data generated by a survey.

For the second statistics course, students worked with sales data for café products to forecast and identify trends and seasonality. In all projects, students analyzed data sets, created graphical displays, calculated and interpreted appropriate statistics, and wrote professional reports to summarize findings and make recommendations based on the data.

Exams. For the first midterm exam, covering data types, graphical displays and descriptive statistics, a traditional paper and pen, closed book, closed note exam was used. Students were given printouts of computer output to analyze and interpret. They were also asked to specify Excel functions to calculate statistics (e.g. mean and standard deviation), but laptops were not used.

While covering material for the second exam covering probability, random variables, and binomial, normal and uniform distributions, technology was heavily used during class for calculations. As a result, the instructor felt it was unfair to "take away" the laptops for this exam. Instead, students wrote responses on paper but could use laptops to do calculations with Excel or applets. If they used Excel, they had to indicate what function they used; and if they used an applet, they had to specify which one.

After the second midterm exam on which the students performed poorly, the instructor began providing additional reference materials. Students were surveyed about their poor performance; results suggested that while students understood the hands-on activities during class, they struggled with the larger picture or the "take-aways" from the lessons. This was partly because there were not many lecture notes for this unit heavily focused on computer applications. The instructor's remedy was to post at the end of every topic a "Summary of Important Points" from the activities and material. This was generally a 3-5 page PowerPoint with high-level points and directions to more detailed information. The students later indicated these summaries were very helpful in identifying the important aspects of the lessons.

The third midterm exam was largely like the second, but corrected for earlier mistakes. For example, students were told ahead of time which applets were recommended and were given instructions regarding their use. By reducing the number of questions and better informing students about expected tasks, some problems that occurred on the second exam were alleviated. Also, an open book, open note, open Internet format was used beginning at this point (and has been used ever since). The exam, with multiple test forms, was written with the anticipation that students would use any materials they wanted, but recommending that they have important notes on one sheet of paper and all computer resources easily accessible. Students were required to sign an honor statement indicating they did not communicate with any other individuals about the exam. The final exam was comprehensive and largely used the format of the third midterm.

STUDENT FEEDBACK

At the end of the first semester, students were surveyed about their perceptions of the course. Aspects of course satisfaction were measured on a 5-point Likert scale, with 5 being the most positive response. Out of 24 enrolled students, 18 attended class the last week when the survey was administered, resulting in a 75% response rate. Tables that follow summarize student perceptions of the course. Specific detail is presented related to students' perceived effort, workload and challenge; effectiveness of instructional methods and student activities; and student engagement and attitudes.

Perceived effort, workload and challenge. Survey results that follow in Table 1 indicate that students needed to put forth significant effort and were challenged by the course. On the other hand, they felt that the material was presented too quickly, which is common for this statistics course.

Table 1: Student Feedback: Effort, Workload and Challenge

Statements	Mean	St Dev
I put forth significant effort to learn the content of this course.	4.50	0.86
I was challenged by the overall amount of material to be learned.	4.47	0.72
I needed significant effort to learn the content in this course.	4.33	0.69
Course material was presented at a pace that helped me understand it.	3.56	1.34

Note: Rating scale: 5 = Strongly Agree; 4 = Agree; 3 = Neutral; 2 = Disagree; 1 = Strongly Disagree

Perceived effectiveness of instructional methods and student activities. Students generally felt that instructional methods and course activities were effective in helping them learn course material. However, students were quite negative about the online homework system; see Table 2.

Student engagement and attitudes. The approach fulfilled the instructor's expectations of an engaging and motivating environment. Students

Table 2: Student Feedback: Effectiveness of Methods and Activities

Methods	Mean	St Dev
Instructor's lectures	4.67	0.59
Instructor's use of examples	4.56	0.51
Instructor's use of technology, in general	4.39	0.78
Instructor's use of applets, calculators, demos	4.33	1.14
Instructor's lecture notes written in class	4.33	0.97
Study materials and worksheet solutions posted on Blackboard	4.33	1.08
Summaries of important points posted after class	4.28	1.07
Instructor's use of Excel	4.22	0.94
Your use of laptops, in general	4.56	0.70
Your use of Excel	4.22	0.94
Worksheets, in-class activities	4.17	1.10
Your use of applets, calculators	4.11	1.41
Online homework	2.17	1.54

Note: 5 = Very Helpful; 4 = Somewhat Helpful; 3 = Neutral; 4 = Not Very Helpful; 5 = Not At All Helpful

generally brought their laptops and actively participated in learning activities. They also agreed that the environment was engaging and had a positive influence on their performance; however, when students were asked if they liked and enjoyed the course, results were somewhat less positive. As shown in Table 3, this feedback is generally as good as, or perhaps slightly better than, is usually received with this required introductory class.

Table 3: Student Feedback: Student Engagement and Attitudes

Statements	Mean	St Dev
I brought my laptop every day.	4.39	1.09
The learning environment created by the instructor had a positive influence on my class performance.	4.33	0.91
I attended class every day.	4.22	1.06
The teaching strategies actively engaged me in learning the content.	4.17	0.99
I participated actively in the class learning experiences.	4.17	0.86
I liked the way this course was run.	3.94	1.21
I learned a lot in this course.	3.72	1.18
I enjoyed learning the course content.	3.33	1.33

Note: Rating scale: 5 = Strongly Agree; 4 = Agree; 3 = Neutral; 2 = Disagree; 1 = Strongly Disagree

LESSONS LEARNED

There were several successes and missteps that occurred during this first iteration of the course. Below is a summary of some important take-aways related to pedagogy and classroom management.

It takes more time. Teaching with laptops, applets, Excel and other technology takes more time for both preparation and in class. For a veteran instructor, traditional lectures can be easily prepared, but preparing hands-on activities with technology takes planning, at least initially. Allowing more time than a lecture would take for students to explore concepts is recommended.

Summaries are vital. Instructors must provide sufficient guidance and documentation if students are to benefit fully from active learning activities. Activities should guide students pretty closely through important steps of an exploration and then either summarize important points or lead students to correctly conclude what the important points were. Without this culminating step, students tend to lose focus of what they were doing and why.

Rethink exams. In general, allowing any and all resources on exams was the approach that ultimately best aligned with the philosophy of this course. If technology is to be used for in-class analyses and assignments, it is unfair to expect students to do without it on exams. It is also difficult to prevent them from using whatever materials are available online and on their own machines. In addition, using technology tools seems to take students more time, so exams should not be as long or have as many questions. However, this forces the instructor to design exams that emphasize what is really important for students to know and be able to do.

Choose online homework systems carefully. The students strongly disliked the online software package initially used in this course. While online homework may be valuable because of its capabilities in allowing students to see their mistakes and practice methods, it is recommended that instructors carefully review alternatives.

Be clear about expectations. Instructors should be clear and consistent in informing students about what they are expected to do and not do, publicizing steps that students should take before class (e.g. charge batteries, download files or updates for their computers), at the beginning of class (e.g. open appropriate links and files), and during class (e.g. follow along, stay on task, do not Facebook, chat or email). Consistency prompted most students to adjust well to the rhythm of the course after a couple of weeks.

Address up-front possible problems with technology to avoid extensive problems. During this course, there were only occasional issues with power, hardware and software. Instructors should make clear that students should charge batteries before class and have required software already installed. Additionally, the instructor should check any applets or websites beforehand to ensure they will work with recommended browsers.

Consider the physical environment. Many traditional classrooms may not be amenable to laptops, either because of limited desk space or power outlets. It is recommended that an instructor personally examine any space well before beginning a class in the event changes are needed.

Classroom management may not be an issue. Only very few problems with off-task behavior occurred, and the instructor found no evidence of cheating. Making expectations clear and regularly and closely monitoring student activities during class is recommended to help minimize these issues.

SUMMARY

During initial iterations of these business statistics courses taught with laptops daily, many things were learned. Overall, the pedagogy appeared to be effective, with students reporting that they were engaged with and enjoyed the technology and active learning environment and that they believed it was helpful in learning statistical concepts. However, some early mistakes were made by not summarizing important points for students and by giving exams that were too long for them to complete using technology. Problems with technology and classroom management were not nearly as troublesome as anticipated. Instructors should make expectations very clear and consistent. For this course, daily use of laptops continues to be required to engage students in using technology to learn statistical concepts.

REFERENCES

Chance, B., Ben-Zvi, D., Garfield, J., & Medina, E. (2007). The role of technology in improving student learning of statistics. *Technology Innovations in Statistics Education, 1*(1).

Cobb, G. W. (1993). Reconsidering statistics education: A national science foundation conference. *Journal of Statistics Education* [online], *1*(1). Retrieved from https://www.amstat.org/publications/jse/v1n1/cobb.html

DePaolo, C. A., & Robinson, D. F. (2011) Café data. *Journal of Statistics Education* [online], *19*(1). Retrieved from http://www.amstat.org/publications jse/v19n1/depaolo.pdf

Everson, M., Zieffler, A., & Garfield, J. (2008). Implementing new reform guidelines in teaching introductory college statistics courses. *Teaching Statistics, 30*(3), 66–70.

GAISE. (2005). Guidelines for assessment and instruction in statistics education (GAISE) college report. Retrieved from The American Statistical Association (ASA): http://www.amstat.org/education/gaise/GAISECollege.htm

Garfield, J. (1995). How students learn statistics. *International Statistical Review, 63*(1), 25–34.

Garfield, J., Hogg, B., Schau, C., & Whittinghill, D. (2002). First courses in statistical science: The status of educational reform efforts. *Journal of Statistics Education, 10*(2). Retrieved from http://www.amstat.org/publications/jse/v10n2/garfield.html

Gorman, M. F. (2008). Evaluating the integration of technology into business statistics. INFORMS *Transactions on Education, 9*(1), 10–19. Retrieved from http://www.informs.org/site/ITE/article.php?id=73

Hyden, P. (2005). Teaching statistics by taking advantage of the laptop's ubiquity. *New Directions for Teaching & Learning,* (101), 37–42.

Loch, B., Galligan, L., Hobohm, C., & McDonald, C. (2011). Learner-centered mathematics and statistics education using netbook tablet PCs. *International Journal of Mathematical Education in Science & Technology, 42*(7), 939–949.

Meletiou-Mavrotheris, M., Lee, C., & Fouladi, R. T. (2007). Introductory statistics, college student attitudes and knowledge—a qualitative analysis of the impact of technology-based instruction. *International Journal of Mathematical Education in Science and Technology, 38*(1), 65–83.

Nanney, B. (2004). Student-centered learning. Retrieved from http://jtp.ipgkti.edu.my/ppy/resosbestari/PENDEKATAN/scl/7%20SCL-Nanney.pdf

Riddle, J. (2010). 21 things: Kinder, gentler tips for effective technology Infusion. *MultiMedia & Internet@Schools, 17*(2), 25–27.

Rossman, A. J., & Short, T. H. (1995). Conditional probability and education reform: Are they compatible? *Journal of Statistics Education*

[online], *3*(2). Retrieved from https://www.amstat.org/publications/jse/v3n2/rossman.html

Ryan, D. (2008). Technology enhanced learning environments. Retrieved from http://sites.wiki.ubc.ca/etec510/index.php?title=Technology_Enhanced_Learning_Environments&oldid=38739

Su, Y.-T., & Liang, C.-L. (2000). Using multivariate rank sum tests to evaluate effectiveness of computer applications in teaching business statistics. *Journal of Applied Statistics, 27*(3), 337–345.

The 21 things for the 21st century educator. (2012). Retrieved from http://www.21things4teachers.net/index.html

Woodard, R., & McGowan, H. (2012). Redesigning a large introductory course to incorporate the GAISE guidelines. *Journal of Statistics Education* [online], *20*(3). Retrieved from http://www.amstat.org/publications/jse/v20n3/woodard.pdf

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