WORKSHOP STATISTICS: DISSEMINATION AND ASSESSMENT

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*We describe the **Workshop Statistics** project, which has involved the development of curricular materials for teaching introductory statistics with an emphasis on active learning. The project's goal is to provide instructors with a resource to enable them to implement a learner-centered classroom environment where students can discover statistical concepts, explore statistical principles, and apply statistical techniques. Focuses of the project include stressing students' conceptual understanding, using genuine data from a variety of sources, and implementing technology effectively as a learning tool as well as an aid for data analysis. In addition to giving an overview, we discuss some implementation issues that have been faced by instructors and students. We also present a series of recommendations for successful implementation and conclude by indicating how the materials are being revised in response to feedback from adopters.*

> "Shorn of all subtlety and led naked out of the protective fold of educational research literature, there comes a sheepish little fact: lectures don't work nearly as well as many of us would like to think." - George Cobb (1992)

> "Statistics teaching can be more effective if teachers determine what it is they really want students to know and to do as a result of their course- and then provide activities designed to develop the performance they desire." - Joan Garfield (1995)

Workshop Statistics (Rossman, 1996) aims to provide resources which enable teachers to implement a learner-centered classroom environment in the spirit of the above quotations. In this paper, we first provide an overview of the materials that have been developed: the aim of the course, pedagogical style, content, sequencing of material, use of real data, and incorporation of technology. We then discuss some potential difficulties that instructors could encounter as they implement the materials. Addressing these concerns, we describe how the materials are being revised and provide several recommendations for successfully implementing a learner-centered classroom environment.

OVERVIEW OF MATERIAL

The theme of *Workshop Statistics* is the replacement of lectures with collaborative activities through which students discover statistical concepts, explore statistical principles, and apply statistical techniques. Students work toward these goals

through the analysis of genuine data, interaction with each other, with their instructor, and with technology. These activities require students to collect data, make predictions, read about studies, analyze data, discuss findings, and write explanations. The instructor's responsibilities in this setting are to check students' progress, ask and answer questions, and lead class discussions as appropriate. The essential point is that every student is actively engaged with learning the material through reading, thinking, discussing, computing, interpreting, writing, and reflecting. In this manner students construct their own knowledge of statistical ideas as they work through the activities.

For the most part, the subject matter of *Workshop Statistics* is that traditionally covered in an introductory statistics course. The first two units concern descriptive and exploratory data analysis, the third introduces randomness and probability, the final three delve into statistical inference. Additional material is being developed to better complement the AP Statistics curriculum where *Workshop Statistics* is already in widespread use. Within these units, the focus is on the "big ideas" of statistics, paying less attention to details that often divert students' attention from larger issues. In particular, little emphasis is placed on numeric and symbolic manipulations. Rather, the activities lead students to explore the meaning of concepts such as variability, distribution, outlier, tendency, association, randomness, sampling, sampling distribution, confidence, significance, and experimental design. The activities challenge students to demonstrate their understanding of statistical issues by asking for explanations and interpretations rather than mere calculations. Students record their responses in space provided in the text, as they construct their own understanding and develop their own resource of materials.

In an effort to deepen students' understandings of fundamental ideas, these ideas are presented repetitively. For example, students return to techniques of exploratory data analysis when studying properties of randomness and also in conjunction with inference procedures. They also encounter issues of data collection not just when studying randomness but also when investigating statistical inference. Many data sets are also returned to and analyzed in more depth after additional tools have been developed. This repetition further emphasizes to students the importance of key ideas, and allows them to build upon their previous knowledge.

Within each activity, students are engaged with genuine data. Analyzing genuine data not only introduces students to what the practice of statistics is all about, it also

prompts them to consider the wide applicability of statistical methods and often enhances their enjoyment of the material. Some activities ask students to analyze data that they collect in class about themselves, while most present students with genuine data from a variety of sources. Many questions in the text ask students to make predictions about data before conducting their analyses. This practice motivates students to view data not as naked numbers but as numbers with a context, to identify personally with the data, and to take an interest in the results of their analyses. The data sets do not concentrate in one academic area but come from a variety of fields of application. These fields include law, medicine, economics, psychology, political science, and education. Many examples come not from academic disciplines but from popular culture.

To aid in examining data and exploring concepts, technology plays an integral role. The text assumes that students have access to technology for creating visual displays, performing calculations, and conducting simulations. Roughly half of the activities ask students to use technology; students typically perform small-scale displays, calculations, and simulations by hand before letting the computer or calculator take over those mechanical chores. Activities requiring the use of technology are integrated throughout the text, reinforcing the idea that technology is not to be studied for its own sake but as an indispensable tool for analyzing genuine data and a useful device for exploring statistical phenomena.

IMPLEMENTATION ISSUES

While many instructors share the goals set forth in *Workshop Statistics*, implementation is not necessarily straightforward. Adopters need to be aware of the potential difficulties in employing an approach that can be quite different from prior student experiences.

Many students are quite comfortable with the “lecture to notes” model of learning. They view the instructor as a fountain of knowledge, with their role being to absorb and repeat that knowledge. Such students can have trouble adjusting to the workshop approach, feeling the instructor is not “teaching them”. They may be concerned that they will construct the material incorrectly or not they way the professor wants. Consequently, students often need to be coaxed to take a more active role in their learning process.

Similarly, many professors are comfortable with the “lecture to notes model.” They may feel uncertain about losing autonomy of the course or relying on students to

engage themselves and be responsible for asking questions. They may also allow fears of incomplete student understanding, grade issues, and student evaluations to override their presentation of the course, reducing the impact of many of the goals of *Workshop Statistics*. Some instructors may feel that the emphasis on student discovery reduces their need for prior course preparation. Conversely, they may feel they do not have the time and energy to teach such a course. Thus, use of this approach often requires changes in the approaches of individual instructors.

As technology is an integral part of the course, some institutions may not feel they can supply adequate resources for the students. The materials are designed to allow students to use technology to concurrently explore concepts and work through the material. Use of technology outside the class, or relying on prepared output charts, can cause the information to be disjointed, both from the other materials and from the students.

RECOMMENDATIONS

Based on our own experiences and on those of many instructors who have taught with *Workshop Statistics*, we offer the following recommendations for effective implementation of a learner-centered classroom environment:

Take control of the course

While this may seem obvious, we have also found it to be most important. The "control" needed in the course differs from the traditional lecture setting. Students need to see that the instructor is monitoring and facilitating the progress of the course and that there is a pedagogical purpose behind all of the classroom activities. Instructors can also help students tie concepts together and see what they have accomplished, bringing activities to closure. Instructors also need to be pro-active, continually questioning students and providing quick feedback, instead of waiting for students to pose questions. Another form of control is to keep students roughly together with the material. The instructor needs to keep some groups from getting too far ahead while other lag behind. Instructors can have extension material ready for faster students and can also remind students to be at a certain point in the material by the next class period, maintaining accountability.

Allow students to discover and collaborate

We encourage instructors to resist the temptation to tell students too much. Rather, let them do the work to discover ideas and conduct analyses for themselves. Student also need to be allowed to proceed at their own pace and with their own learning style. This can initially be quite a struggle for both the instructor and the student, but we feel it leads to long term gains in understanding and autonomy on the part of the students. For example, students can be asked to develop their own review sheets and glossaries of terms. Students should also be encouraged to work in groups. This course provides a natural vehicle for allowing students to learn from and to teach each other. Students have shown less fear of the material in this setting, as well as pride for what they have produced. We feel there are appropriate times to interrupt and address the class as a whole, as an important step in enhancing student learning. Still, as a general rule, we advocate lecturing on an idea only after students have begun to grapple with it first themselves.

Encourage students' guessing and development of intuition

We believe that much can be gained by asking students to think and make predictions about issues and data before analyzing them in detail. We urge teachers to give students time to think about and respond to "Preliminaries" questions in the hope that they lead students both to care more about the data they proceed to analyze and also to develop their statistical intuition. New materials are also incorporating a wider range of timely applications and interests in order to further link the data to students' experiences.

Have students do some work by hand prior to working with technology

While we believe strongly in using technology to explore statistical phenomena as well as to analyze genuine data, we think that students have much to gain by first performing small-scale analyses by hand. We feel particularly strongly about this point in the context of simulations, where students can better comprehend the process being simulated through physical simulation before proceeding to computer simulations. The counterbalance to this suggestion is that students should come to regard technology as an invaluable tool both for analyzing data and for studying statistics. After students have had the chance to do some small-scale displays and calculations by hand, they should then be

encouraged to use technology to alleviate their computational burdens. To improve the access to technology, further allowing students to focus on the underlying concepts, materials have been developed that directly lead students to use the TI-83 graphing calculator (Rossman and von Oehsen, 1997) and Minitab statistical software (Rossman and Chance, 1998). Software to facilitate students' explorations of conceptual ideas is also being developed.

Provide sufficient feedback

Students need to be able to assess their own work throughout the course and to receive personalized feedback from the instructor. This feedback should include access to "right answers", as well as immediate monitoring and correction from the instructor as they proceed. We feel such techniques will help students build self-confidence and reduce student worry about incorrect learning.

Stress good writing and reading

Many students will not anticipate reading and writing as crucial components of their statistical education. However, we regard writing-to-learn as an important aspect of *Workshop Statistics*, focusing students' attention and reinforcing their understanding. We urge teachers to insist that students relate their explanations to the context at hand, forcing students to see the implications of their decisions. Students can also do themselves a great service by taking their time and reading carefully. By reading directions and questions well, students can better know what is expected in an activity. Moreover, expository passages interspersed among the activities contain a great deal of information that is essential for students to understand.

Have fun!

We have seen that teachers and students alike enjoy the dynamic and productive learning environment that *Workshop Statistics* can help to produce. To help instructors with the transition to this approach, supplementary materials such as syllabi, solutions, sample exams, and implementation suggestions have been added to *Workshop Statistics* webpages (www.dickinson.edu/~rossman/ws/). Many instructors and students who have

studied with *Workshop Statistics* have expressed a tremendous increase in enjoyment with this approach. Many instructors, contrasting "workshop" and "traditional" sections of the same course, have also documented improved performance on various assessment measures. Thus, we feel that the challenges of adopting this approach can be addressed successfully through careful consideration and planning, with the result of important benefits for students' understanding and appreciation of statistics.

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