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Comment: Focusing on Learning

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Comment: The future of textbooks – Focusing on learning (Rossman and Chance)

We thank these authors for their interesting and provocative articles about the future of textbooks for introductory statistics. We agree that this is an extremely important topic and that the evolution of textbooks in the next decade has the potential to effect a fundamental change in learning and teaching. In our discussion we highlight ten issues raised in these articles that we find compelling and deserving of more attention.

1. Alignment with learning goals

   West notes that instructors have traditionally adopted textbooks "based on how well they match the course material to be covered and their gauge of the clarity of the exposition." Cetinkaya-Rundel et al. state the textbook is "an excellent tool for self- or directed-study." Zieffler et al. argue that the most important criterion in selecting a textbook is "the extent to which the textbook (and supplementary instructional materials) is aligned with the student learning goals for the course." The goal is for the textbook to assist students in learning the course material. Alignment between the textbook and the course goals greatly enhances this process. We especially commend Zieffler et al.'s focus on supporting materials, recognizing that students learn from more than just the textbook. In fact, we question whether many current students learn much from the textbook as compared to other resources provided in a course.

   We certainly urge instructors to look for more than mere alignment between the book's table of contents and the catalog description of the course. For example, seeing that the text "covers" two-sample t-tests is not very informative, but assessing how well the text explains and asks questions about the concepts surrounding two-sample t-tests is critical. We also note that recent trends that encourage customizable publishing empower instructors to produce even closer agreement between their textbook and learning goals. We believe future textbooks have much potential to move from being perceived by students as a nuisance required by instructors to an integral component of their overall learning process.

2. Immediate and personalized feedback

   Equally important as alignment between textbook and learning goals is alignment of both with how student learning is assessed. For this reason we think it's crucial for textbooks of tomorrow (and today!) to include high-quality assessments of various types. We subscribe wholeheartedly to Cobb's admonition, cited by Zieffler et al. but with a question about its narrow focus, to "judge a textbook by its exercises." Moreover, electronic exercises can be even more effective learning tools by providing immediate and personalized feedback.

   However, we disagree with West's admittedly controversial suggestion to that "exercises may find a better home than within the text itself," and we take issue with his apparent emphasis on automated exercises. We contend that exercises should be well-integrated throughout the course materials, enabling them to efficiently assess the student's understanding of what he/she has just read or experienced. For instance,

suppose that an expository example presents the idea of using a coin-tossing simulation to assess whether an observed sample proportion is significantly larger than one-half. That example could be followed immediately with questions that assess whether students understood what the simulation was doing, what the coin tosses represented, and how a decision was reached about statistical significance, all in the context of the example that students would have just read. These questions could be objective (e.g., multiple choice) format that provide immediate feedback, perhaps just-in-time feedback that can motivate class discussion the following day. Or these could be more open-ended questions to assess whether students can apply their understanding to new problems. We believe this type of contextual and reinforcing exercise is more valuable than a large number of algorithmically generated exercises.

Moreover, an e-book can be even more helpful by providing immediate feedback on the student's responses, indicating the correct responses and explaining likely reasons behind incorrect ones, and even sending students directly back to the example illustrating the correct answers. Online materials can even indicate whether the student is prepared to move on to the next section of material, requiring a sufficient demonstration of understanding before making the next section available. Based on students' responses, online exercises could point to additional questions, tailored to the individual student misconception being demonstrated, for students to obtain more practice.

We believe these goals are best achieved with exercises that are based on authentic data and exercises, engaging students with data from genuine applications of statistics to everyday life and to scientific inquiry. Students can learn much through writing about and interpreting statistical results, in addition to answering more standard multiple choice or short answer questions.

3. Interactivity between learner and textbook

West points out that "the most important feature of the e-book that I adopted was its search facility." We agree that this search capability, along with hyperlinks and pop-up definitions, is a very nice and helpful feature of e-books. But if the e-book is otherwise a verbatim copy of the static textbook, why bother? Interactivity strikes us as the primary advantage of e-books, so we regard creating an interactive learning experience between the student and the textbook as the most important direction to move in as textbooks evolve.

We consider this interactivity to be important for two reasons. One is that learning occurs through active engagement, and interactivity can engage students' minds much more than passive reading or listening to a lecture can. The second reason is that the prevailing wisdom is that students simply do not read static textbooks, regarding them as an expensive and heavy repository of exercises, which students attempt to answer by searching for an example to mimic. Interactivity can encourage students to engage with the text in more meaningful ways.

West provides a good example of the kind of interactivity we have in mind: Students can use an applet to explore the meaning of confidence level in terms of the long-run proportion of confidence intervals that succeed in capturing the unknown parameter value. Students can also use such an applet to explore the effects of sample size and confidence level on confidence intervals, and then describe those properties for themselves. Granted, these applets already exist and may even be widely used, but we believe that the applet alone is not enough. The applet needs to be closely tied to learning activities that guide students to use the applet to answer questions that produce the understanding that is sought. We believe that having students directly interact with the applet and learning activity, constructing their own knowledge, is more beneficial than having them passively watch a video or an instructor demonstration. Also, as we indicated with our previous point, the applet and activity need to be closely connected with assessment items that allow students to test whether they have understood what the applet revealed and what they were to have learned from the activity. We have tried to achieve these goals with the print textbooks *Workshop Statistics* (Rossman and Chance, 2012) and *Investigating Statistical Concepts, Applications, and Methods* (Chance and Rossman, 2012), but we think e-books offer great potential for generating more interactivity and active learning.

4. Re-thinking best use of class time
   Re-imagined textbooks can stimulate substantial rethinking about the optimal use of class time. West points out that "it is quite odd that we continue to congregate in the classroom environment for the primary purpose of the instructor conveying material." The CATALST course described by Zieffler et al. puts the emphasis on student activities and discussion during class time. This rethinking of how to use class time is consistent with the pedagogical model of the "flipped classroom" or "inverted classroom" that has received considerable attention recently (e.g., Bergmann, Overmyer, and Wilie, 2012; see also slides from two breakout sessions at the 2013 U.S. Conference On Teaching Statistics about flipped classrooms: www.causeweb.org/uscots/program/).

   We do note with interest that West and Zieffler et al. seem to have different conceptions of how to use class time and how a new type of textbook can support this. West advocates having the textbook contain videos of an expert lecturer presenting material, with class time spent on answering students' questions, working out more detailed examples, and completing group activities. Zieffler et al. propose a more substantial rethinking of class time so learning activities drive what students do in class and also what they read and explore outside of class.

5. Abundant learning support
   Also important is the opportunity for textbooks of the future to provide abundant learning support that static print textbooks cannot. The ideal is for students to be able to get help as soon as they need it with regard to understanding concepts, using software, performing calculations, analyzing data, and interpreting results.

Types of learning support already mentioned are the search capability of e-books and frequent links that enable students to go immediately to helpful information. For example, links enable students to click on a word that they encounter (such as "skew" or "p-value") to go to a definition and perhaps the first instance of that term in the text. West refers to such links as supporting a "just in time" approach to learning that is familiar to many of today's students. We want our students using these links rather than going to separate, unrelated resources such as Wikipedia because we agree with West that "a single voice and narrative is essential to the student learning process." We also concur with Zieffler et al. that a good textbook provides students with necessary structure, "coherence and repeated summarization," and "purposeful connections." These metagoals are harder to obtain without the guidance of a common textbook.

West and Zieffler et al. appear to disagree with regard to where support for using statistical software should appear. West advocates removing software-specific instructions from the text "so that it does not interrupt the flow of material." Zieffler et al. recommend including detailed software-specific instructions in line with text activities and also in sidebars. We favor the ability of a reconceived textbook to allow instructors to customize many aspects for their own choices. For example, with electronic materials an instructor could choose the software package for which to show instructions and output. Rather than have students sift through instructions and output for, say, Minitab and JMP and StatCrunch and R, the instructor or student could choose which one would appear. We think the best way to avoid having software instructions become a distraction is to integrate those instructions seamlessly into the materials (e.g., with a scrolling sidebar), allowing the student to use the technology while maintaining focus on statistical issue.

6. Dynamic capabilities and customization

Similarly to customizing software options, even such mundane choices as notation (e.g., whether to use p or π for a population proportion, whether to say "null hypothesis" or "H_0") could be controlled by the instructor with one click that would then produce the entire text with those choices.

Instructors could even enter data collected on the class in an online form and have the text produce graphics and text to reflect the class-generated data. For example, we like to use an activity that asks students to classify colors of Reese's Pieces candies and then analyze the distribution of colors. Our preferred approach is to use dynamic materials in which an instructor (or students) could enter the class results for the number of each color, and then have accompanying graphs and calculations be updated automatically to reflect the class results.

7. Appeal to diversity of learning styles, interests

Cetinkaya-Rundel et al. make the important point that "we should be mindful of diversity in the way students learn." We agree that new textbooks can do a better job of appealing to students with different learning styles. One example of this is giving students the option between reading text or watching video, or both, in either order.

Also, whereas print textbooks often provide a variety of examples from different disciplines, an e-book can provide even more flexibility, enabling students to select examples primarily from business or from psychology or from sports or wherever their interests lie. Multimedia generally offers the ability to appeal to, and hopefully motivate, today's generation of students that have grown up in an e-connected world.

8. Embody all aspects of course

   We strongly endorse Zieffler et al.'s conclusion that "the appropriate textbook … is not one that supplements the class, but rather one that embodies the course." West also makes this point by citing "a tremendous opportunity for integrating the e-book content with other course materials." We applaud the list that Zieffler et al. provide in section 6 of their article, describing desirable resources for including in a CATALST textbook. We are especially pleased that the first item in this list is not exposition but rather "a place to collect the daily in-class activities." We like to think that by developing a textbook that is so integrally related to all aspects of the course, students would have no choice but to use the textbooks extensively and productively.

9. All else being equal, cheaper is better.

   All three articles make the point that textbook costs have become prohibitively expensive. We especially commend the efforts of Cetinkaya-Rundel et al. to produce an alternative that is free to students and available to a more diverse audience. Among many other options, we also point out the free introductory statistics text developed as part of Carnegie Mellon's Open Learning Initiative. An evaluation of the effectiveness of this product (Lovett, M., Meyer, O., and Thille, C., 2008 and 2010) indicated that student learning gains were completely comparable to a traditional course/textbook with a 50% savings in amount of time that students invested.

   We note that West and Cetinkaya-Rundel et al. seem to disagree about whether publishing companies play an essential role. West argues that they do, partly for technology infrastructure, partly for providing resources to develop high-quality materials, and partly for importance of campus representatives to spread the word about available products. Cetinkaya-Rundel et al. counter by emphasizing that by working together, the scholarly community can produce high-quality resources that can be disseminated successfully without the need for a traditional publisher. Indeed, they then contend that "technological innovation has facilitated an era in which the community can be leveraged to produce high quality educational materials without a traditional publisher." Frankly, we are not sure which of these arguments will carry the day in the coming decades. We doubt that the role of traditional publishers will be diminished much, but we are also hesitant to doubt the potential influence of an open source community.

10. Readiness of students and faculty to adopt and use innovative textbooks

    We share the authors' concerns about how ready instructors are to adopt textbooks of the type they have described and also how ready students are to use such textbooks to their potential. West mentions CyberStats (Utts, 1999), and Zieffler et al. refer to

ActivStats (Velleman, 1997), both innovative and high-quality products developed more than a decade ago that incorporated many of the desirable features that the authors and we have described. These products have certainly enjoyed some commercial success, but frankly not as much as we would have expected. Why did/do these excellent products not enjoy more success? Were they too far ahead of their time, and are instructors now ready to adopt such materials with less "start-up" time required? Or was instructor reluctance or dissatisfaction tied to a more fundamental concern (or inertia) that remains a hurdle now? West points out one possible reason for reluctance: Many teachers of statistics do not have training in statistics and so might prefer traditional textbooks and resources that cover conventional content with conventional pedagogy.

On similar lines, we worry that enticing students to embrace such textbooks is also a stumbling block. Students seem to naturally gravitate to using Wikipedia and google to find information. Perhaps the onus is on us to produce textbooks that appeal to today's diverse students and that provide genuine learning support that is so helpful that students can't help but use it well.

We again thank the authors for their timely and thought-provoking articles, and we look forward to their exciting textbooks projects. We anticipate that substantial evolution of the idea of textbook in the coming decade could greatly enhance students' learning of statistics.

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