Improving the Teaching of Statistics Online: A Multi-faceted Approach

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Abstract:

Teaching an online statistics course poses significant challenges to the facilitator and the learners alike because of varying student preparedness levels, complexity of the course content, the difficulty in assessing learner outcomes, and determining the frequency of visibility of the facilitators in the online classroom. In this paper, the author suggests a teaching model that presents difficulties in the facilitation of an online statistics course and provides some remedies for overcoming these difficulties.

Introduction

In the last decade, the use of computer-mediated communication (CMC) has been widely adopted as a primary delivery method for online education (Heroism et al., 1995; Hiltz, 1995). In practice, asynchronous-based[1] CMC allows learners to engage in the course material from any location and at their own convenience without having to attend their courses in a regular classroom setting. Asynchronous text-based CMC has become one of the predominant tools used by many colleges and universities to deliver online educational programs. Online education fulfills a need for students who cannot attend traditional classrooms in order to complete a degree or a certification program. In this environment, where facilitators and students do not see each other, teaching effectively becomes a challenge and requires extensive preparation of appropriate course materials for the learners for effective instruction (Smith, 2001). A college statistics course is a particular challenge since it often requires the "show and tell" of a classroom in real time. However, in an online environment, this showing and telling about statistical methods is absent, and the mode of delivery is often asynchronous. Another problem that exacerbates effective online instruction is that an online class may contain students whose logical reasoning and mathematically abilities range from well prepared to no preparation at all.

Facilitators of statistics courses often present the material in an abstract lecture format, followed by illustrations of the concepts of the lecture using prototypical examples and textbook exercises. Before the class session is over, the learners are assigned problems to complete to be submitted for the next class. However, the traditional approaches to teaching statistics is not effective in an online environment, so the goal of this paper is to provide an integrative approach for teaching statistics courses. Put in another way, facilitators need to determine how to duplicate the traditional class setting into an online environment. More importantly, the facilitators cannot just observe what is going on in the classroom, but the facilitator needs to be more proactive in an online class. That is, the role of the facilitator needs to be sure that there is an exchange of knowledge between the learners as well as being understood. Larson (2002) argued that whereas traditional course delivery is centered on the facilitator, online education is more student centered. Although the facilitator continues to facilitate the course, the learners actually may take on the responsibility of the learning process.

Showing Statistics

In an online environment, the facilitator should contact the learners before the start of the course. At this introduction, the course syllabus should be distributed, so the learners will have time to review the contents, course requirements, and other relevant issues. The syllabus should be self-contained, so the learners can answer their own questions. The syllabus should include a week-by-week outline of the learning objectives, topics, and the assignments for the week as well as the administrative policies. In typical courses, a standard textbook is assigned, but with the advent of online references and textbooks, some learners would benefit from the additional references supplementing the course material.[2] In fact, facilitators may decide to integrate material from a myriad of these online sources since each of these online sources may provide strengths in a discussion of statistical concept.

The facilitator needs to remember that the course will be delivered in an online environment, so the lectures for the week should be clear and concise. Lectures present new ideas and techniques in understanding the topic. What should occur in an online lecture is an opening that eases the learner into the topic so he or she is engaged in the content. In the first section, it may be useful to list the objectives for the week. The middle section should present all of the statistical concepts for the topic, followed by an example illustrating the concepts. These examples should clearly explain each step. At the midpoint and the end of the lecture, the facilitator should present some problems for the learners to review in order to gauge their level of understanding. At this point he facilitator can provide the solutions to these problems or, to promote greater learning, the facilitator can have the learners post their solutions to the problems. This allows the learners to provide feedback to each other and allows the facilitator to provide additional clarification when necessary. The closing of the lecture should reemphasize the statistical concepts and how they are used in order to recap and reinforce the information.

Also the facilitators can also use the lectures which come with textbook since many textbooks often provide Powerpoint™ presentations which can be used to augment the lectures. The facilitator can use of the all of the accompanying slides or select the more relevant slides. Additionally, the facilitator can also insert their own slides for particular emphasis on a statistical concept which may not be presented or downplayed in the original slides.

It is easy to develop statistics courses which emphasize the formal statistical methods giving the applications the least amount of emphasis. However, most modern statistical work requires analysis of real data. The online statistics course will also need to show how to perform these analyses using a statistical package.[3] If the statistical package is new to the learners, documentation should be provided to show how to use the software for analysis. A useful way is to do an actual problem step by step using the software in which the facilitator can copy each screen and past into MS Word and disseminate to the learners. By providing this document, the learner will see the step-by-step application of the software for data analysis. In fact, the facilitator could provide the data from the example, and the learner to replicate the analysis of the facilitator using the course software.[4] This process of replication will allow the learner to perform the analysis and use the software. Also data analysis will enhance learners' understanding of quantitative data analysis and enable them to become comfortable reading, discussing, and applying statistical concepts to their research as well as assessing results from peer-reviewed studies from their discipline.

However, a special data analysis such as an effect of outliers on regression analysis may appear in the course, but the current course materials may not have an example of data to illustrate such effects. On the other hand, learners may have an interest in environmental issues or a spontaneous interest in the runnings of past Kentucky Derbies. The Internet contains an abundant source of secondary data which could easily be downloaded in a variety of formats[5], and these data can also be used as part of data analysis in the course.

Application of Statistics

To promote understanding of the statistical concepts, the facilitator should post discussion questions based on each lecture, questions which should be presented at the start of the online week. These questions should avoid statistical computations and focus on discussion and applications of the concepts. The responses to the discussion questions should also avoid regurgitating material from the lecture. The point of the discussion questions is to allow learners to master statistical concepts and to integrate and apply them statistical concepts to new applications.

For example, discussion questions pertaining to linear regression can be given as follows:

1. Give an example of where regression analysis can be used. How is regression analysis being used in your workplace, or how should it be used? Can you think of examples specifically related to strategy formulation and implementation?

2. What is correlation analysis? How can correlation analysis be used in a business decision or examples specifically related to strategy formulation and implementation? How can correlation analysis be misused to explain a cause and effect relationship?

The goal of these discussion questions would require the learner to think about applications of linear regression and its use in various applications and decision-making scenarios. Additionally, these questions should promote discussion among the learners and allow them to see the variety of applications of linear regression as well as potential misapplications of the concept. The facilitator should attempt to read all of the responses and replies when necessary, i.e., ask for additional clarification of certain parts of the learner's response. By asking for additional clarification, the facilitator creates an active dialogue with the learner which enhances learning.

As in traditional statistics courses, the learners use textbook exercises in order to practice using the statistical concepts. The facilitator assigns the exercises, and the learner shows the steps of the problem such as outlining all of the steps in a z test. This practice reinforces the statistical concepts and refines the learner's statistical thinking. In addition, the learner would need to provide explanation of the steps in a problem, so the facilitator can fully assess his or her level of understanding. After the assignment due data has passed, the facilitator should provide the solutions. Providing these solutions will allow the learner to assess what was done correctly and incorrectly, and this will also serve as a valuable tool to ask the facilitator any additional questions or clarification of the material.

Integrate the Material

The preceding sections focused on learning and applying various statistical methods. The online facilitator can also enhance the level of mastery of the statistical concepts by assigning case

studies and/or a major research project that requires analysis--using data.[6] Regardless of the approach, the goal is to encourage further mastery of statistical concepts as applied to data analysis. Cases provide a chance for the learner to practice the concepts of statistics. Also cases allow for the learners to defend his/her position concerning the results of the cases which further develops critical thinking skills. In fact, since authors often incorporate case studies into their textbooks, these can easily be integrated into an online course. In the past, this author has used case studies from textbooks but did not use the questions which often accompanied them. The learner was required to solve the issues of the case study and present findings to non statisticians. Case studies that use the appropriate data would enhance the understanding of statistics in various applications.[7]

Another method for the integration approach would be using Java applets of statistical methods, which can be retrieved from various Web sites.[8] In an online course, it can be difficult for a learner to grasp statistical concepts based on only readings or lectures. Java computing language now makes it possible to add interactive components to aid understanding of a concept and stimulate student interest by providing a "hands on" learning experience. These applets that can be shipped over the Internet[9] and provide a step-by-step guide to some important statistical concepts and allow the learner to actively explore and experiment with a single concept.[10] The learner can experiment with each applet, change some parameter such as those in a confidence interval, and see how the results are affected. This level of experimentation would allow the learner to understand and retain these statistical concepts. For more suggestions on the integration of statistical applets into a statistics course, the reader should consult West and Ogden (1998).

Learning teams, cooperative groups of 3-5 students who work together during an online course, share talents, experiences, and resources to achieve greater self-direction and responsibility for their own learning. The purpose of a learning team is to allow for an assimilation of information more efficiently than an individual learner could achieve on his or her own. The learning team attempts to simulate the work environment and provides a safe environment to express new ideas without fear of negative reactions from other learners. In these learning teams, the facilitator could assign problems from the course text to allow learners to discuss the course material. In

fact, the facilitator can assign a case study that the learning team would be required to solve and present a coherent solution to non-statisticians.

Self-assessment of this Pedagogical Approach

For a facilitator to provide a positive learning environment for the learners the facilitator needs to carefully plan the entire course and be prepared to make changes as needed. As a measure of learning, this learner should post a summary of the course for the week. The summary should contain the following components:

1. The topics learned in the preceding week.
2. The learner's feelings about his or her progress and the facilitation of the course.
3. A statement of what the learner would like to accomplish in the next week of the course.

These weekly summaries allow the facilitator to easily assess the comprehension level of the students and determine what is working or not working. In fact, a common problem from many learners running through a week's summary could result in a reevaluation of the lesson. If any required change is substantial or requires a modification to the course syllabus, the facilitator should inform these revisions to the learners. From an assessment of learner weekly summaries, the author saw the need to reduce the number of discussion questions in the course since the learners felt overwhelmed answering three to four discussion questions. Instead, fewer discussion questions were required, but they required more depth of statistical thinking.

This facilitating approach for teaching statistics is the one employed by this author, and feedback from learners has been favorable which reinforces the assertion that this approach works well in an online environment.

Another measure of teaching effectiveness is to review the end of the course questionnaires as implemented by the college/university. These course evaluations are often presented in a questionnaire format, and this form of evaluation is easy to tabulate results and economical to administer. The purposes of these course evaluations are to assist facilitators in monitoring their

effectiveness as teachers and to assist programs in monitoring the quality of their programs (Marsh and Roche, 1997). These evaluations can provide some useful feedback to the facilitator but care must be taken when reading the results from these questionnaires since responses may be biased. That is, the learners who did not earn the grade they wanted may provide not so constructive feedback about the facilitation of the course. Often these end of course questionnaires contain a space for written comments, and these written comments can provide valuable feedback to the facilitator regarding the facilitator's pedagogical strengths and weaknesses which cannot be assessed through the closed-ended questions. Also if low ratings were received, the learner should provide comments for the assigning of low points. If no explanation is accompanied for the low ratings, these results should not be taken too seriously.

To remedy some of the deficiencies in the use of end of course questionnaires, this author has used mid-term evaluations as a valuable alternative. This midterm evaluation would be comprised of some questions from the end of course questionnaire and several questions which require free responses. If these free responses reveal major pedagogical weaknesses, the facilitator would implement the necessary changes to the course. On the other hand, my experiences reveal that the learners may be uncomfortable about providing negative responses since their grades are not settled. As a remedy, it is suggested that these midterm evaluations be distributed to each of the learners' email account, and these midterm evaluations would be submitted to the Chair of the Department. However, these midterm evaluations would be provide more value-added if they are augmented with interviews, debriefing sessions, and follow-up questionnaires.

Conclusion

The facilitator for an online statistics course will realize quickly there are more obstacles involved in delivering the information in this manner than in the traditional classroom and will need to be cognizant of these obstacles when preparing for the course. The methods above can easily be applied to any online course in statistics, but they may need to be modified to meet the university and college online policies for facilitating a course. In an online environment, the facilitator may feel isolated from administration and other facilitators in statistics. As a remedy, the facilitator should attempt to find out if there are online meetings or lounges for collegial

collaboration among the facilitators. These collaborations would be a great opportunity to share best practices and tips for delivering a course. If the facilitator adopts the techniques presented in this paper, he or she should be able to deliver a more effective course. As with any technique, the approach will require practice and sufficient preparation if the course is to provide value-added to the learners.

Endnotes

[1] Asynchronous communication allows for learners and facilitators to interact but the interaction is not in real time. The interaction is often at the convenience of the learners and facilitators, but the course still follows a structured format to learn the course material.

[2] There are numerous online textbooks and references that can be provided to the learners. The references which I have provided are as follows:

Hyperstat Online Textbook at http://davidmlane.com\hypersat\desc-univ.html;

Introductory Statistics, Concepts, Models, and Applications at http://www.psychstat.smsu.edu/sbkou.htm

Statistics Tools for Internet and Classroom Instruction with Graphical User Interface at http:\\www.stat.berkeley.edu\~stark/sticigui\index\htm.

The following reference is an advanced reference but it provides very intuitive presentation of the statistical concepts: *NIST/SEMATECH e-Handbook of Statistical Methods,* http://www.itl.nist.gov/div898/handbook

[3] In some academic programs the software may be pre-selected because the University has purchased license from SPSS, SAS or other software vendors. However, if the University does not have such licenses, most learners have Office Suite containing EXCEL, which can do some statistical analysis. In fact, some learners have Office Suite containing EXCEL, which can do some statistical analysis. In fact, some textbooks often provide an EXCEL plug-in(s) which can do more advanced statistical analysis. Some of these textbooks with these EXCEL plug-ins: *Managerial Statistics* First Edition S. Christian Albright Wayne L. Winston and Christopher Zappe (the title of the second edition is *Data Analysis for Managers*) which uses plug-ins called StatPro and Solver Table; Bruce Bowerman and Richard T. O'Connell, *Business Statistics in Practice,* Third Edition provides a CD which contains the EXCEL plug-in, Megastat. Also the CD contains Visual Statistics which explores statistical concepts from a graphical perspective.

[4] This practice of replication provides an interesting statement by an econometrician: "Studying this book and working through the exercises could do for economics students what interning in a big city hospital does for medical students – give them a taste of what practice is

really like and get them used to the sight of blood. This is a wonderful education." Robert M. Solow, Massachusetts Institute of Technology, speaking of an econometrics textbook which focuses on replication of earlier analyses.

[5] There is an abundance of data sources available on the Internet, which can be easily integrated into a course. A sampling of these websites include:

U.S. Government Statistical Agencies which can be accessed from www.fedstats.gov. This site serves as a gateway to the government agencies which disseminates statistics from a variety of programs in the federal government;

lib.stat.cmu/DASL, the Data and Story Library which contains data by topic and statistical methods;

lib.stat.cmu\datasets which contains data sources used from a myriad of textbooks in statistical analysis.

[6] The author has utilized case studies primarily in undergraduate and graduate statistics courses and contends that these learners should conduct analyses in a business environment while long papers would be more feasible for research-oriented courses in the social sciences and education.

[7] A good supplementary textbook to assign in a course would be Peter G. Bryant and Marlene Smith, *Practical Data Analysis: Case Studies in Business Statistics Volumes I, II, and III*. This book provides real data analysis problems for the learners to analyze. Each case is provides a brief description of a situation which is accompanied by data. Each situation allows for the learner to define the problem, apply the appropriate statistical method, and provide an interpretation of the results.

[8] There is no dearth of Web sites for statistical applets. A sampling of includes the following:

http://www.stat.duke.edu/sites/java.html;

http://intrepid.mcs.kent.edu/~blewis/stat/;

http://www.stat.sc.edu/rsrch/gasp/;

http://www.intranet.management.mcgill.ca/homepage/profs/smithb/applets.htm;

[9] The only user requirement is a Java-capable Internet browser such as Netscape Navigator, Microsoft Internet Explorer, or Sun Microsystems' HotJava.

[10] Some applets will allow users to input their own data for analysis. This allows the use of learner's own data which can be directly applied to the statistical concept of their interests and evaluate the outcomes of the analysis.

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