Teaching Statistics Online in the Health Sciences

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Abstract

As the demand for internet-based learning increases, so grows the need for knowledgeable instructors comfortable with delivering content online. Panelists were consulting statisticians and experienced educators from three U.S. based universities, who shared their perspectives and insights on teaching graduate level courses in an online format. The experiences presented came from a variety of courses in diverse academic programs where student goals, quantitative preparation, and computer literacy vary considerably. The panel discussed accommodation of degree-specific curriculum requirements, transition from a brick-and-mortar classroom to cyberspace, course implementation considerations when going online, challenges and opportunities of the online experience, and recommendations for success. The goal was to share what worked or did not work to assist educators who are considering new online courses or programs, or who are seeking to modify ongoing offerings.

Key Words: online education; web-based teaching; teaching statistics

Introduction

As the demand for internet-based learning increases, there is an increasing need for knowledgeable statistics instructors comfortable with delivering content online. According to the most recent survey by the Babson Survey Research Group and the College Board, which includes responses from 2,800 academic leaders, 6.7 million students were taking at least one course online in fall 2011. This was an increase of 570,000 students from a year earlier. Survey results showed that in a comparison of learning outcomes between online courses and face-to-face, 75 percent of academic leaders rated online as being the same or superior. Additionally 69.1 percent of chief academic leaders reported that online learning is "critical to their long-term strategy." (Sloan Consortium, 2012) Educators who are considering new online courses or programs, or seeking to modify ongoing offerings, would likely benefit from the experiences and insights of faculty experienced in this arena.

Panelists, consulting statisticians and experienced educators holding appointments at three U.S.-based universities, shared their experiences from teaching courses that are offered completely or substantially in an online format. The perspectives and conclusions presented came from a variety of courses in diverse academic programs where student goals, quantitative preparation, and computer literacy varied considerably. The goal was

to share what worked or did not work to assist educators who are considering new online courses or programs, or who are seeking to modify ongoing offerings.

1. Online Delivery: Master of Public Health Core

1.1. Introductory Biostatistics at the University of Nebraska Medical Center
The Biostatistics I course at the University of Nebraska Medical Center is a professional/graduate level introductory biostatistics course. It serves as the required biostatistics core course for the Master of Public Health (MPH) program, and attracts students from many other programs on campus such as Nursing MS, PhD, and DNP students, as well as PharmD, Basic Science, and other students. The in-class offerings of this course are typically the highest enrollment courses from the College of Public Health each semester. Previously the in-class offering incorporated distance technology, both two-way IP video and live streaming (to a personal computer) to reach distance students. With the increasing demand for this course, as well as the College's initiative to increase availability of courses, an online offering of the course was developed. Online versions of all MPH core courses were developed and offered for the first time beginning in fall 2012, and the other distance technologies began to be phased out. The online introductory biostatistics course is currently in its second offering, and is described in more detail.

1.2. Planning to Teach Online
For those who have never taught online, this type of course can be intimidating. A frequent thought was, "How can this material be taught with no direct student contact?" Students were equally apprehensive with some commenting, "This is a challenging subject, it would be too difficult to learn online." The planning for the online version of the course began almost a full year before the first offering. The online version had to cover the same content and meet the same competencies as the in-class offering, while trying to follow best practices in online education. Additional considerations while planning were student apprehensions of a biostatistics course combined with the apprehensions of an online delivery format, and access, installation, and technical support of statistical software.

To begin planning, training was taken through enrolling in the Certificate in Online Instruction program offered through Central Michigan University. This was a four-week online course about teaching online, and was very helpful in focusing on what to do with the course and not be so overwhelmed by all the preparations needed. By the time the Certificate program was completed, there was a clear plan for the course. Table 1 below gives a comparison of the online version with the in-class version in terms of how "class time" is structured, assessments, and interaction. Table 2 shows the beginning of the semester schedule, with a checklist for students to keep track of what they had completed.

Table 1: Comparison of online class structure to in-class version of same course.

	In-class	Online

"Class Time"	2 hour and 40 minute class
	 • 45-50 minute lecture
	   ○ Content
	   ○ Examples
	 • 20-30 minutes practice
	   ○ Group work
		Everything Asynchronous
		 • Lectures divided by topic
		   ○ 10-20 minutes of content
		   ○ Examples separated
		 • Practice problems
		   ○ Individual/group work

	o Discuss Solutions • Repeat with a new topic	o Auto graded with feedback • 2-4 sets per week
Assessment	• Quizzes/Exams o Quizzes "as needed" o 3 Exams (distance students arranged proctors) • Homework o One per week • Data Analysis Project o Choice of Group or Individual	• Quizzes/Exams o 5 question quizzes each section (2-4 per week) o No Exams • Homework o One per week • Data Analysis Project o Group
Interaction	Student-to-Student • Class time • Online discussion board Student-to-Instructor • Class time • Office hours • Appointments • Phone/email	Student-to-Student • Online discussion board • Group project Student-to-Instructor • Phone/email • Discussion board • Appointments • Virtual office hours

Table 2: Example of weekly schedule

Week	Topic	√	Due
0	Syllabus and SPSS (to be completed prior to week 1 materials)		Read Syllabus Get SPSS Complete SPSS Tutorial Take Syllabus Quiz
1	Introduction to Biostatistics Graphical Summaries Describing Distributions		View Lecture(s) Take Quiz(zes) Participate in Discussion Work on Practice Problems Complete Assignment
2	Categorical Data Numerical Data-Center Numerical Data-Spread		View Lecture(s) Take Quiz(zes) Participate in Discussion Work on Practice Problems Complete Assignment
3	Introduction to Probability Conditional Probability Risk/Odds		View Lecture(s) Take Quiz(zes) Participate in Discussion Work on Practice Problems Complete Assignment

1.3 Student responses

Despite early apprehensions, students tended to like the course format and delivery. On end of course evaluations, over 91% of students agreed or strongly agreed with "The

course was effective in helping me gain the competencies" and 100% responded with good, very good, or excellent when asked their overall opinion of the course. Similar positive responses were received on questions regarding instructor effectiveness and preparation. Direct quotes from student evaluations included:

- "As an economic major and mathematic minor in my undergraduate I have taken statistics course in the past. However, I can honestly argue that I have learned a great deal in this course. The materials used and the way the course was structured were both really helpful."
- "The way Dr. Schmid structured this course was really helpful. For each chapter, I like how she assigned an interactive discussion board, examples to problems and assignment. Plus, her lectures are easy to follow as well. She is also there when we need help."
- "Well informed, organized, and structured class schedule."

1.4. Tips for Success

Keys to a successful online course are careful planning, clearly outlining expectations and policies, and consistency in the layout of the course materials, due dates, and tasks to be completed each week. Below are some additional tips for anyone who will be developing or teaching an online course.

- Don't be intimidated by the online format, practice with the system in advance.
- Be consistent.
- Take advantage of a training program if possible.
- Have a communication policy and all other policies and expectations clearly outlined in the syllabus.
- If you want students to engage with one another (i.e., discussion board), grade it
- Proofread, or have someone proofread for you.
- Edit the videos, or have someone edit for you.
- Be careful of default settings in auto grading systems (i.e. default correct answer on multiple choice questions).
- Be patient with yourself and your students.

2. Asynchronous Online Delivery: Doctor of Nursing Practice Core

2.1. Doctor of Nursing program at the Medical University of South Carolina

The mission of the Doctor of Nursing Practice (DNP) program, the newest of three programs offered by the College of Nursing at the Medical University of South Carolina (MUSC), is to prepare graduates who will practice nursing at highest clinical level. This is in contrast to the PhD in Nursing program, which educates researchers. Both programs use a totally online instructional format while the third program offered, the accelerated Bachelor of Science in Nursing (BSN), is taught on campus. This discussion will focus on the DNP program, which has been offered since 2010 in response to the changing requirements for nurses practicing at this level. The DNP program combines expert clinical practice with knowledge and experience in leadership, health systems design/evaluation, and evidence-based practice. It awards the Master of Science in Nursing (MSN) and terminal professional DNP degrees.

The three-year DNP curriculum includes academic coursework, clinical rotations, and a capstone quality intervention project conducted at students' clinical rotation or work site (many are practicing nurses). A curricular emphasis in the DNP program is evidence-

based practice. Sackett, et al (1996, 71) define evidence-based practice to be the "conscientious, explicit & judicious use of current best evidence in making decisions about care of individual patients."

2.2. Statistics course characteristics

Students take statistics as a combined introductory biostatistics and epidemiology four-hour course during their first semester in the program. The core course provides instruction in basic statistical and epidemiological concepts that nurses would need to affect change in clinical practice in their new roles as problem solvers. It demonstrates the benefits of integrating both disciplines to conduct risk assessment. The introductory statistics component equips learners with statistical reasoning and basic statistics skills to understand statistical information presented in the literature, and to assess patient and health agency data in an evidence-based practice. At the end of the semester learners will be able to calculate descriptive statistics and create graphs proficiently, and apply and interpret basic inferential methods. This expertise will subsequently be applied by students in their capstone evidence-based improvement projects the final two semesters in the program.

The ideological perspective of student as a consumer-of-statistics in nursing practice, adopted with the advent of the DNP program, differs from the researcher-targeted approach of the prior masters level statistics course. An assessment of statistics needed by the advanced practice nurse to achieve the best possible clinical outcomes resulted in a redesign of the content. The change included a reduction in the scope of statistical methods and techniques, and less emphasis on the actual computation of statistical tests. The new focus is on the instruction of statistics for making reasoned, data-informed decisions in clinical nursing practice.

Enrollment in the fall course is generally around 60 students, most in their first semester and a few part-timers taking it a year later. The students are of mixed age groups and they learn differently. For example millenniums like lots of activity and find the use of different media appealing. Their attention span could be short. Baby boomers include some empty nesters returning to work and long-time employees seeking to advance in their careers, who are sometimes fearful of returning to school. This could be particularly so when the content is online and requires new technology skills. Many also juggle work and family responsibilities. Nurses have differing work schedules – days, nights or rotating shifts. Residency is geographically scattered, with the majority of students living in mostly rural South Carolina and the remainder generally residing within the southeast. The nurses enter graduate school with varying practice experience. Some come soon after graduating with a BSN and have limited or no experience, while others have been employed many years. Although an undergraduate statistics course is required for acceptance into the program, learners' backgrounds are variable.

2.3. Asynchronous module format

The course is taught in an asynchronous module format, which is helpful to accommodate nurses' diverse work and personal life schedules. Each module is self contained and available for two to three weeks for completion. Some students take the entire period of time while others complete everything over the first few days. Each module's content is accessible in the learning management system (MUSC uses Moodle) when the module opens. There is an identical content structure for modules throughout the course that includes the following components. 1. A short podcast (Tegrity) introduces the module material and learning activities. 2. Topic-specific videos (Adobe Connect or Tegrity) and

accompanying slides explain important concepts and show examples. 3. "How-to" podcasts demonstrate statistical computations in Microsoft Excel, with separate recordings/slides for the PC and Mac to accommodate differences. 4. Learners complete assigned textbook readings, short-answer comprehensive questions, and problem sets. 5.They take a short-answer quiz to show mastery.

2.4. Student evaluation
Anonymous student evaluations completed electronically (MUSC uses e-Value) at the end of the semester help identify what worked and where to improve in subsequent course offerings. At the conclusion of the initial offering of the new DNP course, learners reported good satisfaction with the course and educator performance. Summary evaluation scores in fall 2012 were 2.3 for course activities and 2.4 for faculty performance (scale: 1.0 to 5.0, with higher scores indicating increased satisfaction). These scores were above the somewhat stringent 4.2 cutpoint defined by the MUSC College of Nursing to be a good level of satisfaction. Students commented favorably about the online format. "I liked the completely web based class. I also enjoyed the low-pressure environment. I found the tests and assignments to be very conducive to learning and being able to retain the information."

2.5. Challenges and opportunities
While the online format accommodates nurses' busy schedules and many responsibilities, there are some challenges.
- Because this course is offered first semester in program, the learning management system itself is new for students. Online training is provided to help get students started.
- While a brick-and-mortar classroom provides an immediate sense of community, the internet does not necessarily promote the same degree of connectedness. To encourage camaraderie students are assigned to groups of six, remaining with their same peers the entire semester. All are encouraged to post introductions the first week and share some information about themselves. Continued involvement is facilitated throughout the semester with group assignments and availability of group discussion forums.
- No single text was identified to adequately cover statistics & epidemiology. Statistics for Nursing: A Practical Approach, by Elizabeth Heavey, was chosen as the statistics textbook. It is written at an appropriate level for DNPs and includes a chapter on statistical topics in epidemiology. The CDC offers a self-paced course over the internet, which was selected for the epidemiology content. Lessons are comprised of readings, problems, and quizzes on topics in public health. The CDC awards a certification for successful completion.
- Statistics material from the first semester course is often forgotten by the time students begin their capstone project. A statistics toolbox was created in the learning management system in response to student concerns. Selected content from this course plus examples of actual projects completed by past graduates are posted, with student access throughout the program.
- Teaching online can be time-consuming. There are five faculty in the course, including one course coordinator, with varying time commitments of participation.

2.6. Advantages
The advantages of an online course outweigh any limitations. Learners can complete all module components at their own pace from any location with internet. They can access and utilize all learning materials as often and as many times as desired. Question and

Answer topic-focused discussion boards are "open 24 hours" for new posts and replies by students and faculty. The learning management system offers a two-tries quiz completion option, which encourages students to "think again" about a question to successfully identify a solution. Online course delivery permits faculty to post additional resources that are immediate available to students even after a module has opened. It provides continued access to pertinent first semester statistics content to students as they progress through the program and complete their capstone projects.

3. Asynchronous Online Delivery: PhD in Nursing Advanced Course

3.1. Target audience
The audience for this distance-based survey applied statistics course is composed of nursing and health administration PhD students, typically at the beginning of their second year of graduate studies. The majority of the nursing PhD students are non-traditional graduate students, i.e., they are established clinicians who are distance students and may reside anywhere in the country. In contrast, the health administration students are mostly traditional graduate students who study and work on campus. The prerequisites for the course consist of two mandatory core courses: a course on basic Frequentist inferential statistics and basic data manipulation; and a course on linear models (focusing on the general linear model). The prerequisite courses are provided separately to nursing and health administration students. At time of enrollment in the advanced course, the students are already proficient at navigating the university's platform for online instruction (Blackboard; Blackboard Inc., Washington, DC), and have been instructed on netiquette. Also, the students have some basic familiarity with a statistical software package, typically IBM SPSS (IBM Corp., Armonk, NY) or SAS (SAS Institute Inc., Cary, NC). The expected course size is 9 to 10 students.

3.2. Course Implementation
The main objective of the course is to provide exposure and basic working knowledge for: general and common generalized linear models, linear models under non-independence (GEE, linear mixed model), dimension reduction (principal components analysis and exploratory factor analysis), and path analytic and structural equation models. At the course design stage, a total of 11 textbooks in advanced statistical analysis or multivariate analyses were inspected. A decision was made to utilize the classical textbook by Tabachnick and Fidell (2007), an applied statistics textbook commonly used in social and behavioral science graduate programs. Further detail on the courses' schedule of lectures and activities can be found in Azuero et al. (2013). The first implementation of the course was offered in the summer 2010 term. Computer tutorials for IBM SPSS and SAS were developed to accompany each topic. In order to avoid schedule conflicts for the nursing students, a decision was made to provide asynchronous lectures; thus, all lectures and computer tutorials were recorded using Adobe Captivate (Adobe Systems Inc., Seattle, WA) and posted as Flash videos to download and play on web browsers. The lectures were split in parts so that no single part was longer than one hour. Because a major objective of the course was to provide practice in data analysis in preparation for dissertation work, rather than timed exams, evaluation consisted of four 'take-home' individual assignments that included analysis of datasets. Discussion boards were available, but discussion was not made mandatory. Questions asked individually to the instructor that could benefit the class were shared in the discussion boards. Each week, the lectures and other course materials were posted typically on Mondays or

Tuesdays. A to-do list of specific tasks and their suggested order was posted along with the materials.

The two first iterations of the course did not include group activities or group assignments. In order to increase student communication and interaction, an activity that is a combination of individual work and group interaction was implemented in the third offering of the course. This activity builds upon two ideas. First, data analyses provide natural settings for discussion, since different strategies can be employed to analyze the same dataset, and even if the same strategy is employed, then there are different ways to present analysis results. Second, students can benefit from examining and critiquing how their peers approached the same analytical problem they did, as opposed to passively observing how the instructor solved the analytical problem. The activity resembles peer reviewing; it consists of de-identifying the data analyses from the assignments, then splitting the course into two groups in order to have two separate discussion boards, where in each board the members of one group critique and discuss each individual analysis from the members of the other group. Then the comments for each individual analysis are de-identified and given to its respective student. After conclusion of the activity, the instructor presents also his/her solution to the analytical problem, noting commonalities and differences with the students' solutions and comments.

3.3 Student evaluation
Anonymous feedback from students is requested typically during the last three weeks of the course using the services and forms of the IDEA center (www.theideacenter.org). Most of the feedback from students has been positive, acknowledging the instructor's effort developing the course materials, especially the computer tutorials, and stating agreement with the format and timing of the assessments. The adjusted IDEA summary evaluation scores for the three iterations of the course have been 4.1, 4.2, and 4.3 respectively, on a scale from 1 to 5, where higher scores indicate higher student rating of instruction. Although summary evaluation scores over 4.0 indicated good levels of satisfaction with the instruction, some concerns and suggestions have also been expressed. Some students have suggested less emphasis on the mathematics and instead more examples and applications of the techniques. This is a valid suggestion. Because the course materials were prepared by a statistician, some lectures might have been focused on methodology rather than application.

3.4 Instructor's experience with the course
The instructor's experience has been similar to experiences described by others cited in the review by Mills & Raju (2011) and the textbook by Ko & Rossen (2010). Compared to a traditional classroom course, the online course needed a large amount of time upfront to plan and prepare course materials. Preparation required creating timed scripts for lectures and tutorials, as well as learning new software tools to record lectures and edit sound and images. Communication with students via written word was time consuming; online chats and office hours may be helpful in addressing this problem. Because the assignments were take-home and solutions were presented, questions and datasets could not be reused. A challenging aspect was the implementation of meaningful discussions that allow interaction among students. The peer-review activity implemented in the third offering of the course partially addressed this challenge.

4. Blended Delivery: Executive Doctor of Science in Health Administration Advanced Course

4.1 Academic Program

The Executive Doctor of Science Degree (DSc) in Administration-Health Services offered at the University of Alabama at Birmingham (UAB) is designed to meet the needs of experienced healthcare executives holding high-ranking leadership positions at their respective institutions. These senior leaders enter the program to develop and improve their analytical and strategic management skills in an increasingly complex and continually changing healthcare landscape.

Students in the program are both full-time employees and full-time students for the duration of the intensive three-year program. The first two years of the program are exclusively coursework. Following the successful completion of the coursework and the comprehensive exam, the last year of the program is devoted to dissertation research, the proposal, and the defense. All courses are delivered in a blended format with students working online and spending one week (20 contact hours) of the semester on-campus. The program features four courses in quantitative methods and statistics. The course discussed here, Applied Multivariate Statistics for Health Administration, is the final course in the quantitative sequence.

4.2 Course description

Applied Multivariate Statistics for Health Administration provides an introduction to multivariate statistical analysis methods including factor analysis, discriminant analysis, and repeated measures analysis. In addition, it provides a review of essential and more frequently used statistical methods like multiple regression, logistic regression, nominal and ordinal logistic regression, Breslow-Day and Cochran-Mantel-Haenszel methods. Primary data collection, survey design, power, and sample size are also covered.

As these students prepare to enter the dissertation phase of their doctoral training, high importance is placed not only on their analytic abilities, but also their writing skills. Essential writing skills include the ability to appropriately describe the methods applied, describe the results obtained, and interpret the results obtained. To this end assignments are selected to allow for practice of the statistical methods covered in the assigned reading. For each assignment a formal write-up is required, similar to what one would expect in the methods and results sections of a practice-based journal. Extensive feedback is provided to critique the completeness of data inspection, appropriateness of the analysis, correctness of the interpretations, brevity/length of the presentation, and even style of presentation. Timely feedback is needed for students to implement recommendations into subsequent work.

The purpose of the program is not to train statistical analysts or academic researchers. Residential PhD programs are offered for students pursuing those career paths. However students are required to perform their own analyses for their dissertation work and therefore must be proficient in all aspects of the core statistical methods. Furthermore these students will be active consumers of research, and it is extremely important that they be able to recognize, understand, and critically evaluate results and findings presented to them as they consider proposals to modify or change practice. Incorporating critical reviews of published material helps to achieve this training goal.

4.3 Content delivery

As the course is offered in a blended format, materials are provided both online and on-campus. Several texts are required for the course, including Tabachnick and Fidell

(2013) for detailed yet approachable presentation of multivariate methods, and Field (2009) for supplementary presentation of the statistical methods and illustration of the analyses using IBM SPSS. Assignments are selected from these sources.

Online course materials are provided through Blackboard Learn. These resources include weekly session listings, assignments, and the course reserve. The weekly session listings are used to list assigned readings (both textbook and articles), optional readings, assignments due, and assignments upcoming. The assignment materials include the assignment itself, the accompanying data set, any supplementary notes for the topic covered, and links to any supplementary pre-recorded WebEx sessions. The course reserve, provided by the Lister Hill Library at UAB, provides a 1-stop location for all assigned and recommended journal articles. This course reserve allows the students to easily attain the readings and download them at their own convenience.

The intensive one-week on-campus session occurs early in the semester and allows for traditional didactic classroom instruction, as well as supervised instruction and hands-on use of the statistical software and resource materials. Because the on-campus session occurs early in the semester, new multivariate topics are introduced during that week so that questions may be more easily addressed face to face.

Conference calls and/or live WebEx sessions can be arranged as needed. However, even though class sizes are small (typically 7-12 students), scheduling any synchronous sessions is extremely difficult. Thus, the WebEx session is recorded and link provided on Blackboard Learn so that others can watch the discussion at their own convenience.

4.4 Effective strategies

The unique composition of the students in this doctoral program requires a tailored educational approach. While the students are both highly interested and motivated, all are working professionals and the vast majority have long-established careers meaning that, a) it may have been a substantial period of time since the last collegiate course in math or statistics, b) computer literacy should not be assumed, and c) adult learning strategies are more appropriate than adolescent or young adult approaches. It is important to consider these and other factors when tailoring the teaching approach for a course like this. Some additional strategies that have been effective include:

- If possible, meet the students before the semester starts. This helps to break down any teacher/student barriers, identify any needs of the class, and provides an opportunity to address any concerns, questions, or fears before the course begins.
- Meet with the other instructors, administrators, and dissertation advisors in the program. This allows for continual modification and improvement of the course, and allows the group to agree upon collective goals of the course(s).
- Provide web content up front. While this involves a tremendous initial investment into preparation, it expedites preparation in subsequent course offerings and assists students to work at their own pace.
- Use only one statistical analysis package, preferably menu driven.
- Clearly express expectations and be consistent.
- Avoid synchronous sessions. But if they are done, plan to record them and make the videos available.

Above all, the instructor should know his or her audience and be willing to adapt to the learning styles of the class.

Discussion

Statistics is a challenging subject to both teach and learn, and it could be more so in a non-traditional online environment. Mills & Raju (2011) provided a review of 10 years of literature on teaching statistics primarily online across a variety of disciplines and levels. Although their study acknowledged that there is still much to learn about how to effectively implement online courses in statistics, it provided some general comments and recommendations regarding teaching practices in an online environment. The review included eight articles that specifically discussed graduate-level courses; however none of these articles referred to advanced doctoral-level courses. Nevertheless across these studies, general recommendations from the authors included: 1) use an established pedagogical model or rubric for online course design; 2) assess students' prior knowledge; 3) have a clear and detailed week-by-week outline of learning objectives, topics, and assignments; 4) offer a standard textbook that students can refer to; 5) encourage active engagement with discussions or group activities that allow students to interact, discuss course materials, and avoid isolation; 6) split lectures and tutorials into 30-minute sections; 7) provide practical examples and computing activities for the statistical concepts presented in the lectures; 8) offer quizzes that provide immediate feedback; and 9) incorporate formative feedback to monitor and evaluate teaching along the way.

Most of these general recommendations may apply to any course, not just a statistics course. These general recommendations are also in agreement with the Quality Matters Rubric, as well as with more comprehensive discussions on teaching online, such as Zhu & Kaplan (2011), or the textbook by Ko & Rossen (2010) solely devoted to the topic. In an online course, as in any course, there should be clearly defined course goals and measurable learning objectives, and the instruction and learning activities should be conducted to match these course goals. Further there should be effective means of communication and interaction between students and instructor, and among students themselves. Finally there should be clear expectations and standards for assessment, aligned with the learning objectives.

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