DISTANCE EDUCATION OF TEACHERS OF STATISTICS

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A statistically literate citizenry is essential in any society. Teachers play a vital role in developing this expertise so it is very important to continually develop their capacity to teach statistics to the next generation. Teachers, however, are also often place- and time-bound and cannot commute to university cities between 9-5 to take face-to-face coursework. Connections: Statistics and Probability for Teachers, *is an on-line course focused on preparing secondary and community college teachers to effectively teach statistics. This research-based course blends emphases on statistics content and pedagogy, and is part of a program focused on strengthening the depth of content knowledge, instructional strategies, and reflective practice of middle, high school, and community college teachers. This paper describes the structure and format of the course and how it fits into the overall program. Examples from the course and reflections from students are also shared.*

INTRODUCTION

Statistics education is growing in recognition and importance all over the world (ASA/NCTM, 2013; UNESCO, 2013). “The importance of developing the statistical literacy of our future generations is critical...to develop critical thinkers and capable consumers of information that would ultimately benefit social progress.” “This group includes school students as the next cohort of ‘data generators’ and ‘data users’ and also school teachers as the necessary facilitators for this outcome (UNECE, 2012, p. 9).”

Demand for statistics education has seen huge growth in the United States. For example, in 1997 only 7500 students took AP Statistics exams while 15 years later in 2012, 153,000 students took the exam. This growth mirrors the growth in statistics courses being offered at the high school level, which in turn has created a huge demand for the development of teachers who understand the fundamental concepts of statistics and can teach the subject well.

There are numerous recommendations for the types of learning activities that should be utilized in statistics education courses, including an emphasis on thinking, reasoning, and literacy (Garfield, 2002) and the use of real data (Chance, 2002) within an active learning environment (Cobb, 1992). Unfortunately, many mathematics teachers don’t experience this type of learning in their undergraduate education and are not well prepared to teach their own students this way (Stohl, 1995).

The first author of this paper developed a statistics course for teachers of statistics ten years ago and both authors have revised and updated this course over the years. In the upcoming sections of this paper we will share details of the contents, structure, and results of this course.

DISTANCE EDUCATION COURSEWORK IN STATISTICS EDUCATION

When designing the course, we wanted to follow the National Research Council recommendation that to improve teaching and learning “teacher’s need coursework that reflect a serious examination of the nature of mathematics that teachers use in the practice of teaching” (Kilpatrick, Swafford, & Findell, 2001, p. 375). We also wanted to provide these courses via Distance Learning since Arizona is a large state and many teachers cannot travel to university towns to take graduate coursework. We brainstormed ways that we could “connect the major mathematical strands in courses for mathematics teachers with school mathematics” (p. 24). We narrowed in on the idea of “connections” courses (Center for Study of Mathematics Curriculum), which allowed teachers to study the links between, for example, how the concept of variability can be investigated concretely in lower grades and become more formalized in higher grades. This investigation of how concepts build across the grades should, ideally, deepen teachers’ own content understandings and aid their ability to develop important ideas for their students’ learning (Kilpatrick et al, 2001).

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Connections: Probability and Statistics for Teachers is one of these courses and may be taken individually by teachers or as part of a 12 course M.S. in Mathematics Education degree program. All four Connections courses (Probability and Statistics, Algebra, Geometry, Calculus) were co-developed and co-taught by mathematics/mathematics education and statistics/statistics education faculty and aim to support teachers to (1) become more familiar with mathematics content and (2) reflect on how this content knowledge, as well as the pedagogical knowledge gained through readings, discussions, and activities may help them become better mathematics and/or statistics teachers. This goal is actualized via a cohesive focus across the program on the integration of content, pedagogy, and reflective practice. Also noteworthy: in these courses students read, reflect on, and participate in on-line discussions about research-based and practitioner-oriented journal articles addressing issues related to the teaching and learning of mathematics (e.g., various models of mathematics learning trajectories; research on common student misconceptions, and multiple examples of curriculum, instruction, and assessment strategies). Instructional technology is embedded throughout these courses to support teacher content learning and to provide them with resources and practice regarding the effective use of educational technology in their own classrooms. Also, students are encouraged to try out and discuss course tasks with their own students, allowing direct connections between course material and their own instructional practices.

STRUCTURE AND CONTENT OF THE COURSE

Connections: Probability and Statistics for Teachers was developed as a one-semester course, to be offered online within the university supported learning management system (currently BBLearn). The goals of the course are to 1) deepen participants understanding of probability and statistics; 2) broaden participants awareness of, and ability to, apply statistics and probability to their teaching, to education research, and to everyday life; and 3) increase participants use of various technological software (such as *Fathom* and/or *Tinkerplots*), which will in turn increase their ability to use technology as a teaching and learning tool. This course strives to align with the recommendations that Franklin and Kader (2010) outlined regarding the importance of focusing on developing teachers understanding of statistical literacy, thinking, and reasoning while also supporting teachers' ability to prepare to facilitate a cohesive and coherent curriculum to their students.

The content of the course was divided into seven modules, as shown in Table 1 below. Note that each module took approximately two weeks to complete, with the exception of the last module, which took four weeks. Because no textbook existed that covered the content in the detail and/or manner that was necessary for the course, the "text" for the course was created in-house by obtaining copyright permission to combine resources from several areas as a "course pack". Each module in the course pack includes conceptual readings regarding the content "big ideas" for the module, research articles related to the teaching and learning of those big ideas (e.g. Chance, delMas, & Garfield, 2004; NCTM, 2006), AP Statistics and level homework sets (e.g. *Statistics in Action* are supplemented with graduate level proofs from other texts*)*, and technology and/or hands-on investigations so teachers could deepen their own content knowledge and consider ways to support their students interest and understanding as well (e.g. Erickson, 2010; Scheaffer, 1994). During the last offering of the course, the book *Preparing to Teach Mathematics with Technology*: *An Integrated Approach to Data Analysis and Probability* by Stohl Lee, Hollebrands, and Wilson (2012), was added as an additional text.

Every two weeks, usually on Monday, the students were assigned readings, homework problems, and investigations that pertained to the topic(s) in the module under study. They would have the entire modules time period to flexibly work on the assignments and turning them in (usually by emailing the instructor) by the assigned deadlines. Assessment in the course included homework assignments, along with participation in the course discussions, a comprehensive project where they applied the statistical ideas from the course to data that they were interested in interrogating, summarizing, and interpreting, a final proctored exam where they demonstrated their content understandings, and a final paper where they summarized the big teaching, learning, and content ideas from the course and reflected on their own learning and plans for future curriculum and instruction action they would incorporate into their own classrooms.

Table 1: Content Modules of *Connections: Probability and Statistics for Teachers*

Module	Module Content
One	Introduction to the course, Statistics, and *Fathom*: students learn the expectations for the course, *Fathom* software, and begin to investigate types of statistical studies.
Two	Exploratory Data Analysis: Students review exploratory data analysis (EDA) concepts and connections of this topic to teaching and learning.
Three	Probability Distributions: Students investigate probability concepts and connections of this topic to teaching and learning.
Four	Sampling Distributions: Students investigate sampling distribution concepts and connections of this topic to teaching and learning
Five	Inference: Students investigate the mathematical basis, techniques, and considerations for simple hypothesis testing and examine the relationship between confidence intervals and hypothesis tests, and connections of this topic teaching and learning.
Six	Regression: Students investigate many ideas related to deepening understandings of correlation, regression, and statistical modeling, and connections of this topic to teaching and learning.
Seven	Final Assessments: Students summarize their ideas pertaining to the teaching and learning statistics and probability concepts and connections from this course. Students take a content course final exam, and complete a final research-based reading, incorporating these ideas into their final reports and discussions.

One of the drawbacks to any on-line course, from a student perspective, is the perception that they are not an active member of a learning community. This structure develops naturally in a face-to-face course, but not as much in a distance course, where students can feel very isolated from their peers and instructor. Because of this, the instructors of the course used techniques to help develop that community of learners. Two such methods are discussed below.

One technique that was used by both instructors was the weekly discussion topic. Each week, a topic pertaining to the course readings or content would be posted in the bulletin board system. Students were encouraged to post substantive contributions to the online discussions. A contribution was defined as being substantive if it was thoughtful, cited specific aspects of the course materials, and made connections between the course materials and their personal experiences and/or thoughts about teaching, learning, probability, and /or statistics. In addition to making their own posting, students were also required to substantively reply to one or two other students' postings.

Another technique that was used involved putting the students into online small (3-5 member) groups for the express purpose of collaborating on the weekly homework assignments. Every week in the online system, a new homework folder was created for each group. In this folder the members of the group discussed amongst themselves how to solve the problems presented to them in the homework assignments. It is also in these folders where questions to the instructor from each group could be posted, and where the instructor would post his replies. While the expressed purpose was for students to work together on homework, it was through these small groups that the instructor hoped to establish the "classroom" culture of a learning community.

In addition to this, each group was required to meet with the instructor for one hour each week in the chat room for an on-line "office hour" to discuss the homework, the readings, review progress, ask questions, deal with technical/software issues that may have arisen during the week, and other issues. For the students, it was their weekly time to (virtually) get together with their fellow group members and discuss the problems in a real-time format. From the instructor's perspective, this meeting also allowed for a formative assessment "snapshot" of each member of each group, allowing the instructor to determine how each member understood the content for that week. While this can be time intensive (five groups = five extra office hours!), the benefits gained from these meetings were well worth the time. Note that the groups could also meet on-line independent of the instructor in the chat room at other times to discuss their work, and several groups did take advantage of this.

REFLECTIONS FROM STUDENTS

Through anonymous end-of-course surveys, students have shared feedback related to our multiple program goals of deepening teacher content knowledge, instructional strategies, and

reflective practice, which the following two representative quotes (from different students) highlights. “I was not only able to review the fundamental concepts, I was also able to look at the way students learn these ideas. I was learning material that I could use right away in the real world. This also really helped me to keep everything in perspective and keep my focus. As I went through the content, I not only learned the material deeper I also learned how my students would look at the material and their biggest challenges.” “We did case studies where we went and did hands-on type action projects. We took our pedagogy into practice with an action project. That got you right into the content in that regard. That was, to me, the number one thing. I would venture to say that's the most rewarding thing that I got from the classes.”

Students also valued the freedom the online courses provided when they wanted to complete course tasks. One explained, “I like that I don't have to drive [to the university] for every class. I can log on whenever I need to. That's my favorite part.” Another shared, “The main draw for me was the flexibility they provide so that I was able to keep the life that I have with teaching full-time and the other responsibilities that I have. Still another responded “I greatly appreciated the weekly discussions with my group and the instructor. I was able to get a better grasp of the material and understand what was expected of me in the course.”

When prompted, all graduates who responded to offers of anonymous interviews about the program agreed that they would recommend this program to other teachers as summarized by the following response, “Regardless of if it were online or in person, I would recommend this program for a teacher wanting to grow better in their knowledge of math and how to teach it. I think all of my classes helped me think about how I could better teach my students.”

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