

## BRIDGING THE STATISTICAL GAP: CREATING SUCCESSFUL SECONDARY/HIGHER EDUCATION PARTNERSHIPS

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*Many school mathematics curricula now include sophisticated statistical content, like randomization-based inference methods and experimental design. Secondary mathematics educators often lack the formal training, and hence the confidence, to help students develop sound statistical reasoning. By networking with college and university statistics educators, secondary school teachers can deepen their statistical understanding and improve their instructional practice. Students benefit directly from these professional partnerships, especially when they participate in statistics-related events sponsored by local colleges and universities. This paper describes several successful statistical partnerships started in the United States that have enhanced student learning and eased students' transition from secondary school to higher education. Opportunities and challenges for launching similar initiatives in other countries are discussed.*

### THE CHALLENGE

Over the last 15 years, statistics has become a more visible component of the secondary school mathematics curriculum in many countries. In the United States, the document *Principles and Standards for School Mathematics* (2000) includes data analysis and probability as one of five main content strands. This document has prompted revision of state and local school mathematics standards, so that many of them now include statistical concepts and methods. Because decisions about education are left to individual states, however, there are great disparities in the statistical content that students learn from one state to another.

But in 2009, the governors and chief school officers of 48 U.S. states agreed to pursue a “common core” curriculum in mathematics. As of January 2014, the new Common Core State Standards for Mathematics (CCSSM) have been adopted by 45 of these states. Beginning in the 2014-15 school year, primary and secondary teachers in those states will be expected to help students master rich mathematical content standards in preparation for computer-based assessments. Standards at each grade level (Kindergarten – Grade 8) and each high school course level (Algebra 1, Geometry, Algebra 2 or Integrated Math 1, 2, and 3) are grouped into clusters by content domain.

From Kindergarten through Grade 5, statistics content standards are part of the Measurement & Data domain. A separate Statistics & Probability domain is included in the standards for Grade 7 on. These standards involve all aspects of the statistical problem solving process: asking a statistical question, collecting data, analyzing data, and interpreting results. Most secondary mathematics teachers should be fairly comfortable providing instruction related to the probability standards at their respective grade/course levels. The same cannot be said for the statistics standards.

According to CCSSM (2010), by the time students have completed an Algebra 2 or Integrated Math 3 course in Grade 11, they will be expected to:

- Recognize the purposes of and differences among sample surveys, experiments, and observational studies; explain how randomization relates to each.
- Use data from a sample survey to estimate a population mean or proportion; develop a margin of error through the use of simulation models for random sampling.
- Use data from a randomized experiment to compare two treatments; use simulations to decide if differences ... are significant.
- Evaluate reports based on data.

Many secondary mathematics teachers lack sufficient background knowledge and experience to provide high-quality instruction in CCSSM's statistical content. Additional teacher training may eventually help bridge the gap. In the meantime, however, secondary teachers would benefit from support offered by statistics educators in their local or global communities.

How might such networks be created and sustained? To answer this question, let's look at some examples of successful secondary/higher education partnerships involving statistics education in the United States.

#### AP STATISTICS: BUILDING A COMMUNITY

The College Board officially launched its Advanced Placement (AP) Statistics course in 1996-97. According to the AP Statistics Course Description (2010), the course was designed to be equivalent to a one-semester, algebra-based, introductory statistics course at U.S. colleges and universities. Students who earn a passing score on the AP Statistics exam may earn credit or placement from the institution of higher education in which they enroll. According to the College Board's AP Central website over 7,500 students took the first AP Statistics exam in May 1997. The number of exam takers has grown at a fairly steady rate to nearly 170,000 in 2013. About 60% of students who took the exam in 1997 to 2013 earned passing scores (College Board, 2014). This is a rather remarkable result considering that many secondary school AP Statistics teachers began with limited statistics content knowledge and minimal experience in teaching statistics. Some of this success may have stemmed from the exam grading process, workshops and conferences, an electronic community, and local support groups.

##### *AP Exam Grading*

Collaboration between higher education and secondary statistics teachers is a fundamental design principle for the AP Statistics exam. A development committee consisting of three college/university faculty and three high school statistics teachers, with guidance from the Chief Reader (currently Allan Rossman, California Polytechnic State University, San Luis Obispo), is responsible for constructing the exams. The Chief Reader drafts scoring rubrics for the free response questions on the exams, which are then reviewed and approved by the development committee. These draft rubrics are further refined in the days prior to exam scoring by individual question teams, composed of experienced exam readers from both higher education institutions and secondary schools.

The AP Reading takes place over a seven-day period at a single site. Approximately equal numbers of secondary and higher education faculty are invited to help grade all of the free response questions as consistently as possible according to the scoring rubrics. Every exam reader is assigned a partner with whom they can consult throughout the week. New readers are paired with experienced readers; college/university readers are usually paired with high school readers. Discussions that take place between reading partners frequently help clarify subtle statistical issues for both individuals.

Outside grading hours, readers often engage in informal dialogue about classroom pedagogy, including effective use of technology. A "best practices" night provides opportunities for high school and college/university educators to present a favorite statistics lesson, project, or resource. College Board forums give readers a venue for expressing their views about the current and future direction of the AP Statistics program. An email list is maintained so that readers can stay in contact after the grading ends.

In 1997, about 50 readers graded over 7,600 AP Statistics exams. By 2013, those numbers had grown to roughly 700 readers and almost 170,000 exams. With the continued growth in AP Statistics enrollment, the network of current and former exam readers keeps expanding.

##### *Workshops and Conferences*

Since before the AP Statistics course was first offered, the College Board has sponsored one-day, two-day, and weeklong training sessions for secondary teachers. Many of these workshops are hosted on college and university campuses, often with instructional support from faculty at those institutions. The workshops are led by consultants who have been endorsed by the College Board for their expertise in teaching introductory statistics at the secondary or higher

education levels. Some sessions are designed specifically for new AP Statistics teachers, others are targeted at more experienced teachers, and the remainder are open to teachers with varying amounts of experience. All workshops aim to deepen participants' understanding of important statistical concepts, to promote effective instructional and assessment practices, and to provide resources for AP exam preparation.

National, regional, and local mathematics education conferences have been another vital source of support and network building for high school and college/university statistics teachers. Some of these conferences offer dedicated statistics strands, extended sessions about AP exam performance and scoring rubrics, and invited gatherings for statistics educators. Here are a few examples. For the past 18 years, an AP Statistics panel discussion has been held one evening during the National Council of Teachers of Mathematics (NCTM) annual meeting. Every July, the AP Annual Conference program includes one statistics session in every time slot. The same holds true at the California Mathematics Council—South Fall Conference each November in Palm Springs. In 2012 and 2013, Texas Instruments' Teachers Teaching with Technology (T3) International Conference featured a Statistics Day conference-within-a-conference. Not surprisingly, many of the presenters at these conferences are experienced AP Statistics teachers, exam readers, and workshop consultants.

### *An Electronic Community*

Teaching a statistics course at the secondary level can be a lonely endeavor. At many U.S. high schools, there is only one statistics teacher. With no colleagues to talk to at their schools, these isolated teachers are eager to forge meaningful connections with other statistics educators. An electronic community can provide a much-needed support network for these teachers.

As the AP Statistics course was about to be offered for the first time, the College Board invited high school and college/university statistics educators to join an electronic discussion group. This "listserv" quickly developed into the primary location for exchanging information about AP Statistics. Secondary teachers could post a question related to course content, pedagogy, technology, the AP exam, and more and receive several thoughtful replies in a matter of hours. From 1994 to 2012, over 100,000 messages were posted to the electronic discussion group, all of which are now archived as part of the Math Forum at Drexel University.

In 2012, the College Board created an AP Statistics Teacher Community to replace the electronic discussion group. Two big advantages of this change included the ability to attach files to individual messages and to upload files for community access. By January 2014, the community had expanded to a professional network of over 4,000 high school and college/university members.

### *Local Support Groups*

When there is a high concentration of statistics educators in a relatively small geographic area, it is possible to form a local support group that is open to both secondary and higher education teachers. One of the earliest such groups (MCSTATS) was organized in Charlotte, North Carolina in 1997 by two AP Statistics teachers. The MCSTATS group met two or three times a year at different secondary schools in the Charlotte area to share instructional resources, AP exam preparation strategies, and best practices for teaching and assessing statistical concepts. With additional support from the local school district and the University of North Carolina—Charlotte, this group has expanded its program to include guest lectures in recent years.

The Philadelphia Area Statistics Teachers Association (PASTA) is another long-running support group that has benefitted from the regular contributions of higher education faculty, many of whom have served as AP exam readers. This group meets three or four times per year at a local high school. Some teachers drive two hours or more each way for the five- to ten-minute best practices presentations at PASTA meetings.

Many similar groups have been created in other U.S. states, but few have endured. It takes considerable time and energy to plan worthwhile meetings, and to communicate with current and prospective members. Both MCSTATS and PASTA enjoy active participation from numerous AP exam readers and question team members. Consequently, less experienced teachers are eager to come and learn valuable information that will help their students achieve success on the AP exam.

## COLLEGE AND UNIVERSITY OUTREACH

Higher education institutions often have access to resources that enable them to host statistics-related activities for secondary school students and their teachers. Such events can help ease students' transition from high school to college/university by giving them a better feel for what campus life is like. Participating teachers also benefit from interactions with their colleagues and with higher education faculty during the event. Some examples of statistics-themed activities that have been held on U.S. college and university campuses include AP exam practice sessions and statistics career days.

Beth Johnson from George Mason University and Ellen Breazel from Clemson University have each organized AP Statistics practice exams on college/university campuses for the past few years. These events have followed a consistent schedule. After registering, students take a 90-minute free response test that is modeled after previous AP Statistics exams. While students work on the open-ended questions, their high school teachers gather to share resources and strategies for exam preparation. Students and teachers then reunite during a short break. Next, the students complete a 90-minute multiple-choice test while their teachers and the college/university faculty score the free response questions. Following a catered lunch, everyone convenes for detailed presentations of the free response scoring rubrics. By the end of the day, students have gained valuable exposure to the format, style, and difficulty level of the AP exam, as well as useful feedback about their statistical understanding. Teachers are able to take away practical resources and information to use in their classrooms.

Several higher education institutions have hosted statistics career days in the past few years. Grand Valley State University (2011) sponsored an event that attracted over 250 secondary and undergraduate students, educators, and business professionals. American Statistical Association (ASA) President Nancy Geller gave the keynote address about why she became a biostatistician. Students then attended two breakout sessions of their choosing, led by practicing statisticians in business and industry. That same year, the ASA's Boston Chapter welcomed students and teachers from five local high schools to its career day at the University of Massachusetts Boston. According to a subsequent report in *AMSTAT News* (2011), "This event was planned to nurture interest in statistics and its use in fields such as public health, finance, sports, and marketing, as well as to inform students how to prepare for a career in statistics." The day consisted of a keynote session followed by two different panel discussions. In a survey after the event, one high school student said, "What I liked most about the program was how they were able to explain [that] statistics is all around us."

## THE AMERICAN STATISTICAL ASSOCIATION (ASA)

As part of its commitment to advancing statistics education in Grades K through 16, the ASA sponsors a variety of workshops for statistics teachers, as well as annual poster and project competitions for primary and secondary school students. In addition, the ASA supports the development of online and print resources for statistics teaching. Educational outreach is a vital part of the organization's mission, as demonstrated by the presence of a full-time Director of Education on staff. With its regional chapter structure, the ASA is uniquely positioned to facilitate partnerships between secondary and higher education statistics educators.

For many years, the ASA has provided financial support for Beyond AP Statistics (BAPS) workshops aimed at experienced AP teachers. Some of these full-day workshops have been held on college/university campuses. Others have taken place as part of NCTM's Annual Meetings or ASA's Joint Statistical Meetings. Whatever the location, BAPS sessions are led by higher education statistics educators who are very familiar with the AP Statistics program.

Since 2007, the ASA has organized a daylong Meeting Within a Meeting (MWM) for secondary school mathematics and science teachers at its annual Joint Statistical Meetings. Originally conceived by Martha Aliaga, ASA's former Director of Education, MWM is designed to "Enhance understanding and teaching of statistics within the mathematics/science curriculum through conceptual understanding, active learning, real-world data applications, and appropriate technology." Presenters include past and present members of the ASA/NCTM Joint Committee on the Curriculum in Statistics and Probability, as well as authors of the *Guidelines for Assessment and Instruction in Statistics Education (GAISE) Report*. MWM sessions focus on the statistical

problem solving process, and are targeted at appropriate state mathematics and science standards (American Statistical Association, 2014).

The ASA/NCTM Joint Committee sponsors annual project and poster competitions. Students compete within grade-level categories for prizes and recognition based on the quality of their statistical work. The finished projects and posters are judged by a volunteer group consisting of secondary and higher education statistics teachers, most of whom are ASA members. Some ASA chapters host regional poster competitions to encourage local student participation.

All of these ASA initiatives strengthen relationships between secondary school and higher education statistics teachers. They also promote high-quality statistical education for all students in Grades K through 16.

## CONCLUSION

With the implementation of the Common Core State Standards in Mathematics, many secondary school mathematics teachers in the United States are faced with a serious challenge: how to help students understand complex statistical concepts in spite of their own lack of background knowledge and experience. This situation mirrors the one faced by most new AP Statistics teachers every year. The big difference is that AP teachers can count on a well-developed network of support that includes both higher education and secondary statistics colleagues. Perhaps some of the same strategies that were used to build a strong AP Statistics teacher community can be employed to bridge the statistical gap that exists for secondary mathematics teachers who are focused on CCSSM.

Because CCSSM assessments will be computer-based, it isn't possible to replicate the AP Exam grading system. However, it is definitely feasible to hold intensive training sessions in the relevant statistics standards for secondary teachers at workshops and conferences. College and university statistics educators have a vital role to play in assisting with these teacher training sessions. Due to political complexities in the United States, it may be challenging to create a national electronic community devoted to CCSSM for secondary mathematics teachers. Each participating state is permitted to add additional math standards (up to 15 percent), so individual states could vary considerably in terms of what students are expected to know and be able to do on culminating assessments. Moreover, two different government-funded consortia—the Partnership for Assessment of Readiness for College and Careers (PARCC) and the Smarter Balanced Assessment Consortium—are each building separate assessments for about half of the states that have adopted CCSSM. Local support groups may be easier to form than for AP Statistics teachers because there will be many more secondary mathematics teachers in an area who are interested in talking about standards in the CCSSM statistics and probability domain.

Outreach activities by higher education statistics educators could prove extremely beneficial for secondary school students and their teachers. Colleges and universities would provide a tremendous service by offering practice exams or review sessions targeted at CCSSM statistics standards.

The American Statistical Association can continue to assist with the statistical training of secondary mathematics teachers through its MWM program. Two ASA publications, *Making Sense of Statistical Studies* and *Bridging the Gap Between Common Core State Standards and Teaching Statistics*, will give inexperienced teachers a better sense of the statistical thinking that is described in the CCSSM. With additional submissions from high school and college/university statistics teachers, ASA's STatistics Education Web (STEW) repository will expand to include peer-reviewed lesson plans on all of the CCSSM statistics standards.

Curriculum efforts that incorporate statistics are underway in many countries. In some of those countries, there is a long tradition of teaching statistics as part of the secondary school mathematics curriculum. Other countries are more like the United States, which has only recently committed to integrating statistics content into its core mathematics standards. This paper has offered some ideas for establishing partnerships between secondary and higher education statistics educators with a view towards improving statistics teaching at the school level.

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