# Preparing Teachers of Statistics in the United States

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**Abstract**

In the later half of the last century, use of statistics by federal/state governments, businesses, and industries led to increased popularity of statistics as a discipline in the higher education. As the educators realized the need for knowledge of statistics early in the education, emphasis on statistics in K-12 curriculum also increased. However, with industries attracting most of the graduates with degrees or training in statistics, K-12 education and to some extend higher education also was left in a dire need of trained statistics teachers. Due to increased enrollment in Advanced Placement statistics, and increased use of statistics in other science subjects for data analysis, the demand for trained statistics teachers has become even greater. Although, teacher preparation programs are available in many different subjects, including mathematics, no such programs were available in statistics until recently. Efforts are made to develop new programs to prepare teachers of statistics to meet this increased demand in the United States. There are many problems that need attentions, but this first step towards teacher preparation in statistics makes the future for statistics teacher preparation look bright.

## Background

After World War II the use of statistics as a tool for decision-making has increased dramatically leading to need of highly trained statisticians for developing new statistical tools and applying existing ones as the situation demands. This led to development of many statistics programs that prepare statisticians to meet the demand of government and industrial job market. Moore, et al. (1995) suggested that strong trends in enrollments indicate that statistics may replace calculus as the capstone mathematical study for many students. The data reported by Albers et al. (1992) shows that statistics enrollment in two-year colleges as a percentage of calculus enrollments increased from 10% in 1966 to 52% in 1990. However, no programs were developed to prepare students to teach statistics. In 1997, the College Board also started offering Advanced Placement (AP) exam in statistics. These exams allow students to take a college level course in high school and get credit for it when they enter college/university. The number of students taking AP-statistics exams increased dramatically from about 8,000 in 1997 to 100,000 in 2007 making it one of the fastest growing subjects. As a result, demand for high school teachers trained in statistics has sky rocketed. Due to lack of trained teachers, often these courses, both in high schools and in colleges/universities are being taught by mathematicians with one or two statistics courses to their credit.

As Moore and Cobb (1997) described, “Statistics is a methodological discipline. It exists not for itself, but rather to offer to other fields of study a coherent set of ideas and tools for dealing with data. The need for such a discipline arises from the *omnipresence of variability*”. This focus on variability sets the discipline of statistics apart from mathematics. It also gives rise to the need for retraining mathematicians to handle variability so that they can become effective teachers of statistics. Although number of statistics programs in business, psychology, and medicine are on the rise in nation, in many colleges and universities, statistics is still a part of mathematics department. Traditionally more statistics has been taught by mathematicians than statisticians. In mathematics, the data tends to be just numbers, whereas in statistics data are numbers with a context. In order to make effective teachers of statistics, mathematics teachers need to be trained in identifying and dealing with many sources of variability, and role of context in problem solving.

The knowledge of statistics required for teaching is quite different from that acquired by college students interested in pursuing non-teaching statistical careers. Prospective teachers need a solid understanding of concepts, strong mathematical foundation and excellent communication skills to convey meaning of results coherently. For improved and effecting teacher preparation, collaboration between statisticians and educators is essential.

## Institutional Efforts

With the advances in technology and communication, in the 1980's, data analysis and probability started becoming part of the K-12 mathematics curriculum. It led to movement for developing curriculum materials for introducing statistical concepts in school mathematics courses. In their standards, the National Council of Teachers of Mathematics (NCTM, 1989) included 'Data analysis and Probability' as one of the five content areas stamping their approval and supporting a growing need for study of statistics. This document and its follower, NCTM (2000) provided foundation for the reform movement of mathematics curricula in many states and development of relevant education materials and pedagogical techniques. NCTM's Quantitative Literacy Project (QLP) also developed and made available new teaching materials for teachers. They provide numerous one-shot lessons in ready-to-use forms.

The Conference Board of the Mathematical Sciences (CBMS, 2001) developed a report on current direction of curriculum development and policies affecting the mathematics (including statistics) education of teachers. This report was to provide a resource for individual institutions interested in teacher training to improve their programs, and to provide a basis for obtaining national incentives to improve teacher training. With the help of funding from ExxonMobile Foundation and the National Science Foundation (NSF), A national Summit on the Mathematical Education of Teachers (MET) was organized in November 2001. This summit served as a platform for launching the MET document and to invite the mathematics community to make mathematics education of teachers a priority item on the education efforts.

Recently, the National Assessment of Educational Progress (NAEP) exams have increased emphasis on questions based on probability and data analysis. The content areas described in NAEP (2004) report in general follow the NCTM standards. However, the results from both NAEP and the Third International Mathematics & Science Study (TIMSS) showed very dismal performance in mathematics & science by students from the United States. A report by the National Commission on Mathematics and Science Teaching for the 21$^{st}$ Century (2001) identified five factors including new college graduates' rising interest in teaching as a profession, that show why the time is right for the United States to act now to improve teaching of mathematics and science.

The associations such as the Mathematical Association of America (MAA) and the American Statistical Association also took lead in teacher preparation. In response to the national report card, with the help of funding from NSF, the MAA developed a project titled Preparing Mathematicians to Educate Teachers (PMET) to nurture and support the growing interest among college and university mathematicians to extend their help in improving school mathematics teaching (Katz and Tucker, 2003). Acting similarly, the ASA formed an Advisory Committee on Teacher Enhancement (ACTE) and charged it with advising the ASA board on matters involving teaching and statistics education. A report by Gould (2006) reflects ACTE's concern that the ASA, unlike the MAA, was not invited to endorse a trio of bills designed to strengthen mathematics and science education and felt that given increased coverage of data analysis and probability in K-12, it is important that the ASA have a choice in the design of proposed graduation tests in mathematics. ACTE-sponsored strategic initiative let to development of program INSPIRE. The INSPIRE is a distance-learning course that includes weekend workshops for training first-time AP-statistics teachers. By the Fall of 2006, INSPIRE had taught two cohorts of AP-statistics teachers. Another ACTE sponsored initiative, Statistics Teaching and Education Website (STEW) was developed to disseminate quality lesson plans in statistics for K-12 teachers of mathematics.

The MET report provided an excellent opportunity for statisticians to take a lead in preparing measures

to provide content education for future teachers of statistics. It brought different associations together under the same umbrella to work towards a common goal of preparing teachers to teach statistics. Under the able leadership of Richard Scheaffer, Past President of ASA, Johnny Lott, President of NCTM, Ann Watkins, Former President of MAA, Alan Tucker, CBMS, and Peter Holmes, the Royal Statistical Society Center for Statistical Education, an inaugural conference titled 'Math/Stat Teacher Education: Assessment, Methods, and Strategies (TEAMS)' was held at the University of Georgia, in 2003. Seventeen cross-disciplinary (mathematics, education, and statistics) teams from across the United States participated in this conference.

The TEAMS conference led to the GAISE (2005) project funded by the ASA to develop recommendations for the teaching of introductory statistics. The Guidelines for Assessment and Instruction in Statistics Education (GAISE) project has two parts, one focuses on K-12 education and the other on introductory college courses. The report describes six recommendations developed from the research of studies of teaching and learning statistics. These recommendations are for teaching introductory statistics and they focus on instruction and assessment of important concepts that underline statistical reasoning.

The College Board's AP program is a co-operative effort of secondary schools, colleges, and the College Board which offers about 40 different college level courses and exams for students at secondary level. The College Board (2006) developed standards that list topics central to the knowledge and skills developed in middle-school and high-school. They recommend inclusion of data analysis, probability, and statistics topics at each course level. The College Board also offers and extensive program of workshops at national as well as regional level in teacher preparation and training to teach AP courses, including statistics.

Recognizing that to be a successful teacher, teachers of statistics need the subject knowledge beyond what they teach, the ASA has offered a program Beyond AP-Statistics (BAPS) at the Joint Statistical Meeting (JSM) every year for past ten years. Experts in statistics and statistics education are brought in to train the mathematics and statistics teachers from local area school systems for one day BAPS workshop. Overwhelming responses from local school systems indicate success of these workshops. A new program called Meeting Within a Meeting (MWM) is being developed by ASA under the able leadership of Martha Aliaga. The first MWM will be offered at JSM in Salt Lake City (July-August 2007). The MWM will offer one-day workshops designed to help improve teaching statistics by local K-12 teachers and will further provide opportunities for local chapters to get involved with statistics education at the local level.

University of Minnesota, Department of Psychology is probably the leader in developing degree-awarding program in the United States geared towards training and preparing teachers of statistics. They started offering a Ph.D. minor in educational psychology with an emphasis in statistics education in Fall 2002. It includes coursework on teaching statistics as well as current and classic research on teaching and learning statistics.

## Individual Efforts

Aside from these organizational efforts, there are several institutions where individuals are making a difference. At such institutions, individuals have developed courses for teacher preparation. Pre-service as well as in-service mathematics teachers enroll in these courses and learn to teach introductory statistics in high schools. Due to lack of standard guidelines, each individual has developed courses with different ideas about the teachers' needs in preparing to teach statistics. Christine Franklin, from the Department of Statistics at the University of Georgia has developed three courses in data analysis for preparation of teachers, one for secondary teachers, one for middle school teachers, and one for elementary teachers. Madhuri Mulekar at the Department of Mathematics & Statistics, University of South Alabama developed a course, MA 506, which provides content knowledge as well as introduction to methodology for teaching non-calculus-based introductory statistics course in high school. Joan Garfield from the Department of Educational Psychology at the University of Minnesota has developed a course EPSY 5272 which differs from the courses offered by other institutions in that it includes a practical component requiring students to actual teach under the guidance of an instructor.

Hayden and Kianifard (1992) felt that teachers need to have a deeper knowledge of subject matter in order to teach statistics and designed a course to provide much-needed content background to teachers, an opportunity for teachers to see how high school mathematics is used in statistics, and familiarity with NCTM standards and latest teaching materials. Their experience resulted in a recommendation that "Whatever we may do with *current* mathematics teachers, we have to make sure that future teachers get sound training in statistics as part of their college training".

Due to the impact of the NCTM standards (1989 and 2000), the school statistics curriculum is continually evolving and growing in the United States. Kadar and Perry (2002) describe a content-pedagogy based course that they developed to prepare elementary and middle school teachers to teach statistics in schools. Their course emphasizes the fact that statistical problem solving begins with the notion that data is used to answer questions.

## Conclusions

The need for better trained statistics teachers is evident, it will keep growing and will not be fully addressed by workshops and short-term courses offered to improve knowledge of teachers of statistics. In addition to training current teachers, there is a need for development programs that will generate better trained teachers Bryce (2005) concluded, "… a new paradigm of statistics education is needed that provides for strong undergraduate programs in statistics. Such programs would give the profession wider recognition and provide additional entries into the discipline". In addition to undergraduate programs, more programs in statistics education are needed to prepare statistics teachers with subject-knowledge.

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