STATISTICS EDUCATION GRADUATE PROGRAMS

REPORT ON A WORKSHOP FUNDED BY AN ASA MEMBER INITIATIVE GRANT

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1 Executive Summary

Lighting sparks that we hope kindle bright lanterns in the vast sea of statistics education.

THERE IS A STRONG NEED TO DEVELOP and promote high quality interdisciplinary graduate programs in statistics education. As with any emerging discipline, the systematic high quality training of a continual pipeline of young statistics education researchers is needed to create a flow of fresh perspectives that integrate with a deep understanding of what has been learned before. In addition, new faculty positions must arise to fill the need to maintain this on-going training effort and to fuel a cohesive community of scholars supporting a national infrastructure of new methodologies, journals, conferences, and links to professional societies. Further, the transition to this vision must involve the nurturing of national organizations, careful planning by pioneers, and thoughtful input from the broader community.

On October 24 and 25, 2008; a $1\frac{1}{2}$ day workshop brought together a small group of invited participants to develop a shared vision of the key components of a quality statistics education graduate program. Funded by a Member Initiative Grant from ASA, 18 statistics educators from 13 universities, along with 3 ASA staff members, worked in small and large groups to draw up a vision statement defining the need and outlining key components that a quality graduate program in statistics education might have. The small group of participants discussed and examined different models for graduate programs, course and curricular issues, faculty issues, and action plans.

This report offers specific recommendations for the establishment and support of new graduate programs in statistics education, and outlines issues and recommendations related to the placement and support of new Ph.D.s in statistics education and new faculty

hires in the area. While most of this report focuses on doctoral programs, characteristics of master's programs, which may be easier to implement and more feasible for many departments, are also described. Plans are being made to disseminate this report widely through ASA publications, CAUSEweb, and through partnering organizations.

FOR PROGRAMS WE RECOMMEND:

- That graduate programs in statistics education be implemented in an interdisciplinary fashion. Realizing the difficulty in initiating new programs, these interdisciplinary graduate programs may be structured as tracks of existing degrees in Statistics, Educational Psychology, or Mathematics Education.
- That regardless of the department housing the effort, each graduate program in statistics education should include the development of knowledge and expertise in the following areas: statistics, educational and psychological foundations, educational research methods, and statistics education. In particular, doctoral training in statistics education should include:
    - specialized courses in statistics education, covering both practical and pedagogical topics as well as the research literature.
    - developing proficiency in statistics at least at the Master's or Ph.D. qualifier level to ensure fluency with statistical methods and research designs appropriate to education studies and the ability to teach all undergraduate statistics courses.
    - specialized courses in educational research methodologies including both quantitative and qualitative research.
    - courses in psychological foundations of education such as learning theory.
    - practical experiences in data analysis, teaching, and statistics education research.
- That every student earning a graduate degree in statistics education have faculty representing at least two different core disciplines serve on the student's committee.
- That a Ph.D. dissertation in statistics education reflects the unique coursework and research foundations in statistics education. Ideally, the dissertation will be supervised by a faculty member with experience in statistics education research although a paucity of faculty with such experience will make this difficult initially.
- That every Ph.D. program in statistics education have at least one course from each of the following categories: practice of teaching courses (focused on pedagogy and ideas about the content of the introductory course), foundations of statistics education courses (broader focus on teaching and learning statistics at various levels), and statistics education research courses (focusing on the statistics education research literature).
- That statistics education courses be offered and advertised for a wide variety of degree and non-degree statistics and mathematics educators (e.g., current high

school, and two-year college teachers and future college and university instructors) in addition to those students earning degrees in statistics education.

FOR FACULTY SUPPORT, WE RECOMMEND:

- That department and university administrations should:
  - provide collaborative opportunities for statistics education faculty and students to work with the broader STEM education research community on their campus.
  - establish systems that foster the ability of faculty from mathematics and other STEM education disciplines at their institutions, as well as the national community of statistics education research faculty, to help in mentoring new faculty in statistics education research.
  - ensure that tenure track faculty in statistics education have the same research and teaching requirements as other faculty in their department and not be given extra teaching responsibilities because of their expertise in statistics education.
  - ensure that eligible non-tenure track faculty with appropriate training in statistics education be given opportunities to teach, and serve on committees, for graduate students.
  - ensure that new faculty in statistics education who are housed in graduate degree offering departments be given opportunities to develop and teach courses in statistics education in addition to other courses in their department and to advise students interested in pursuing a graduate degree in this area.
  - provide memoranda of understandings detailing the expectations of statistics education faculty positions (see example in appendix from North Carolina State University) and that the type of acceptable scholarship be outlined (e.g., whether scholarship can include publications on curriculum and pedagogy in addition to statistics education research).
- That collaborations be encouraged between universities and liberal arts colleges that provide college faculty who have the requisite expertise in statistics education with appropriate opportunities to serve on dissertation committees for students at graduate institutions.

As actions to help facilitate the development and nurturing of statistics education graduate programs we advise:

- That funding sources be developed for sponsoring statistics education doctoral fellows and postdoctoral fellows, for changing the research focus of some interested faculty, and for organizing summer institutes to bring the community together.

- That a workshop occurs soon to bring researchers and practitioners together to develop a list of targeted statistics education research problems and priorities. Such discussions are likely to help spawn feasible dissertation topics for doctoral students earning a degree in statistics education from different departments.
- That this workshop set the foundations for a close relationship between statistics education researchers and statisticians to promote research that can inform and benefit teaching practice.
- That a regular summer institute and ongoing faculty support system be created to help develop faculty in statistics education to teach courses and supervise dissertation research projects.

Participants at the workshop included:

Martha Aliaga (ASA)
Pam Arroway (North Carolina State University)
Beth Chance (California Polytechnic University)
Keith Crank (ASA)
Amy Froelich (Iowa State University)
Joan Garfield (University of Minnesota)
Robert Gould (UCLA)
Jennifer Kaplan (Michigan State University)
Cliff Konold (University of Massachusetts)
Xiao-Li Meng (Harvard University)
Rebecca Nichols (ASA)
Jennifer Noll (Portland State University)
Sastry Pantula (North Carolina State University)
Dennis Pearl (The Ohio State University)
Michael Posner (Villanova University)
Jaxk Reeves (University of Georgia)
Deborah Rumsey (The Ohio State University)
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2 Background & Significance

2.1 Overview of this Report

THIS REPORT ARTICULATES A VISION of the ingredients of a high caliber statistics education graduate program and addresses issues and recommendations related to placement and support of new Ph.D.s in statistics education as well as for new faculty hires in the area. It is the result of a $1\frac{1}{2}$ day workshop that brought together a small group of invited participants. Funded by a Member Initiative Grant from ASA, 18 statistics educators from 13 institutions and three ASA staff met together to build a consensus defining the need and outlining key components that a quality graduate program in statistics education might have. The participants discussed and examined different models for graduate programs, course and curricular issues, faculty issues, and action plans. This report provides recommendations along with specific examples of model programs, courses, and faculty positions, and associated references and resources. We hope to disseminate this report widely through ASA publications, CAUSE, and through partnering organizations.

The report is organized into five sections. First we demonstrate the need for attention to be paid to developing graduate programs in statistics education as well as to the creation of and support for courses and new faculty positions. The next three sections summarize discussions and offer recommendations for courses, programs, and faculty, respectively. A final section provides a summary and recommendations for next steps and actions needed.

2.2 Terminology

It is important to clarify some easily confused terms that arose in the workshop and that are used in this report. We refer to **Statistics Education** as a discipline that focuses on the teaching and learning of statistics at any level, and in both formal and informal educational settings (see Garfield & Ben-Zvi, 2008). This is distinguished from **Education Statistics**, a discipline and area of graduate study that involves the collection and analysis of education data in general and also includes methodologies used in educational research. These methods are primarily quantitative and statistical. The recently emerging field of **Statistics Education Research** (see http://www.causeweb.org) focuses on both the instruction and learning of statistics at all levels, using any appropriate research methodology (qualitative and/or quantitative) that addresses the question(s) being asked. Statistics education research is typically designed so that the results will offer implications for instruction or future research. A notable characteristic of statistics education research is that it has emerged from several different disciplines (see Garfield, 1995; Garfield & Ben-Zvi, 2007) such as psychology, mathematics education, educational psychology, and statistics. A key recommendation of this report is that graduate programs in statistics education take advantage of, and continually foster, these interdisciplinary roots.

2.3 The Need for the Workshop and for Statistics Education Research Programs

The importance of statistics in today's world is increasingly apparent. There is a need for people to understand and critically evaluate quantitative information in many forms and contexts and in ways that directly impact their lives. This, in turn, has put an increased emphasis on topics in probability and statistics in the elementary curriculum for PreK–12 levels. Every state includes some statistics and probability topics in their curriculum standards (Papaieronymou, 2007) and standards written nationally (College Board, 2006) and internationally (Qualifications and Curriculum Authority, 2007) also include data, statistics, and probability as integral components. Similarly, national reports in the sciences at the college level also recognize statistics as crucial to the core curriculum for their students (see for example, National Research Council, 2003). One result of the recognized centrality of the discipline has been a growth in courses and enrollments at the undergraduate level: combined fall-term statistics enrollments in mathematics and statistics departments grew by 18% between 1995 and 2000 and by an additional 6% between 2000 and 2005 (Lutzer, Rodi, Kirkman, & Maxwell, 2007). While the growth in lower level statistics has slowed at four-year colleges and research universities

— expansive growth continues in two-year colleges and through AP high school teaching. These trends increasingly put the burden for teaching statistics on instructors with little training in the area, while even those well-trained in the discipline have little preparation in the teaching task itself. Thus, there is now a great need to prepare excellent teachers of statistics.

The statistics education community has initiated discussions of how to address challenges in teaching that lead to desired learning outcomes (see GAISE). But there has been little systematic effort to engage in research to determine how to achieve those outcomes, or for that matter, in any aspect of statistics education. In this respect, statistics is well behind some other STEM disciplines such as physics, mathematics and engineering, where subject-based education research is well established. *Thus, there is a clear necessity to train competent statistics education researchers who can conduct scholarship in this area to improve teaching and learning at all levels.*

Statistics education research has provided the underpinning for the identification of best practices that have ignited a vigorous and much broader statistics education community. However, growth of the discipline proceeds at a slow pace with less than a few dozen active researchers nationwide. In 2007 eight graduate students in the US completed Ph.D. dissertations focused on statistics education (see the Table in the Appendix for a summary of Ph.D.'s in the USA whose theses involved statistics education research from 2000 to mid-2008). These students received their degrees from a variety of academic programs, most of which did not even offer graduate coursework specifically in statistics education and often could not provide an advisor with research experience in this area. At this point in time, there is only one graduate program in the US that offers a degree track in statistics education (in the department of Educational Psychology, University of Minnesota), a few that offer areas of concentration in statistics education (as in the Mathematics Education Department at Portland State University) or individually designed, interdisciplinary programs (as at The Ohio State University). A number of Statistics Departments offer a graduate course in teaching statistics, primarily aimed at training graduate teaching assistants, but no graduate degree (examples are at UCLA, Harvard, and Columbia University). In addition, many tenure track or tenured faculty now appear ready to learn how to conduct research in statistics education, as seen in the more than two dozen statistics faculty who indicated their desire to participate in an on-going NSF funded collaborative research program (Hilton et al., 2008).

There is a strong need to help develop and promote high quality interdisciplinary graduate programs in statistics education. As with any emerging discipline, the systematic high quality training of a continual pipeline of young statistics education researchers is needed to create a flow of fresh perspectives that integrate with a deep understanding of what has been learned before. New faculty positions must arise to fill the need to maintain this on-going training effort and to fuel a cohesive community of scholars

supporting a national infrastructure of new methodologies, journals, conferences, and links to professional societies. This community must become competitive for the attention of federal programs of support, fellowship opportunities for graduate students, and post-doctoral training possibilities. Further, the transition to this vision must involve the nurturing of national organizations, careful planning by pioneers, and thoughtful input from the broader community.

A few institutions have had the foresight to seek tenure track faculty in statistics education and, in the past year three jobs have been posted for such positions within statistics departments (at University of Georgia, North Carolina State University, and Michigan State University). We are excited about this new development, anticipate additional postings in the years to come, and want to help these new faculty members succeed in their positions. This discussion also necessarily includes examination of other types of faculty positions that are heavily involved in statistics education, especially non-tenure track positions that may include scholarship in the area, as well as heavy teaching and TA training responsibilities. We also see the importance of having guidance for statistics departments and university administrations who are considering creating new positions (either tenure track or non-tenure track). This points to the importance of the concept of institutional readiness for programs in which institutions and departments provide a solid *teaching infrastructure* much as they now routinely provide research and computational infrastructures.

Finally, for statistics education research to emerge as a vibrant field, we must learn from the successes and the failures of other disciplines — for example, from other STEM disciplines — where graduate programs are found in Mathematics Education, Physics Education Research, and Engineering Education. A summary of some of these STEM education research graduate programs that provide examples for what a statistics education graduate program might resemble can be found in the on-line resources associated with this report (`http://www.CAUSEweb.org/research`). Mathematics Education in particular offers a rich base of knowledge in a sister discipline that can be leveraged to great advantage for statistics education. In addition to these models, we also look to interdisciplinary programs such as Biostatistics that create a specialty area across disciplines and see Statistics Education as having much in common with this type of graduate program.

The Workshop

The workshop funded by the ASA Member Initiative included representative members from a variety of areas: statistics department chairs, faculty teaching statistics and/or mathematics education courses or involved in TA training programs, statistics education researchers, and tenure track statistics education faculty. Three working groups

were formed to discuss issues around courses, programs, and faculty support. The main questions addressed by each of these three groups are detailed below.

Course Issues: statistics education research and seminar courses, other statistics education courses, and practice of teaching/TA training courses

- What are the goals for these courses?
- What should be their structure (including general content, placement in the curriculum, pre-requisite and follow-up activities needed, etc.)?

Program Issues: Ph.D. programs, Master's programs, and minor/supporting field programs

- What should be the goals of a statistics education graduate program?
- What kind of balance is needed in the curriculum (e.g., between statistics and education content)?
- How should programs be structured and linked with other activities such as mentoring/advising, statistics education and STEM education community connections, teaching experience and supervisions, and research experiences for students?

Faculty Issues: tenure track as well as non-tenure track faculty positions

- How do we develop faculty for statistics education positions in the short term? (e.g., consider the role of post doctoral and professional development opportunities)
- How should such positions be structured?
- How should people holding such positions be supported and mentored?

Reports from each working group were discussed by the entire group of participants and additional points were raised and action plans formulated. The following sections provide summaries and recommendations from each of the three working groups.

3 Statistics Education Courses

WE ENVISION GRADUATE TRAINING in statistics education requiring a minimum set of core courses in statistics and foundation areas (see recommendations in the following section on programs). In addition, it is important for graduate programs to have courses in the areas of statistics education. There are already several examples of courses offered to graduate students that are focused on teaching development and training (see associated on-line resources and references), and to a lesser extent, on statistics education research. As the field develops, graduate programs will also create additional courses to build knowledge and research expertise for graduate students specializing in this area.

The discussion of courses resulted in identification of three categories of courses related to statistics education. The first category, **Practice of Teaching Statistics**, addresses a need relevant to any department that teaches statistics, especially at the introductory level — how to foster high quality instruction, especially for new teachers and teaching assistants (see Garfield & Everson, 2009; Harkness & Rosenberger, 2005; Froelich, Duckworth, & Stephenson, 2005; Gelman, 2005; D. Moore, 2005). The second category, **Foundations of Statistics Education**, includes a more in-depth exploration of research findings and pedagogical issues in statistics education, and is appropriate for statistics educators at all levels. The third category, **Statistics Education Research**, is relevant for those who plan to conduct research in statistics education. For category one we present several flavors of a single core (required) course, while categories two and three each have a core course presented with additional types of courses that might be offered in that category depending on departmental interest and resources.

3.1 Category 1: The Practice of Teaching Statistics

GRADUATE COURSE FOR NEW TEACHERS OF INTRODUCTORY STATISTICS (REQUIRED)

The goal of this type of course is to train students and other educators to become excellent teachers of modern introductory statistics. The nature of the course will differ by institution, but should discuss pedagogy, content and extended ideas about how to understand and teach material for a modern introductory statistics course (for example, by following the ASA endorsed GAISE guidelines; Franklin & Garfield, 2007). Students should reflect on their own understanding of the content, and be prepared to address student questions from a conceptual perspective, rather than focusing on formula manipulation. This reflection will encourage a deeper understanding of statistical content that is important for instructors/teachers. Possible texts for this course include Gelman and Nolan (2002) T. L. Moore (2000), and articles from the *Journal of Statistics Education* such as Roseth, Garfield, and Ben-Zvi (2008).

Possible options for teaching such a course include:

- An apprenticeship model in which students sit in on the introductory class, ideally taught by the same instructor as this graduate course, then meet weekly for extended discussion about understanding and pedagogy.
- An extended reflection course where each student sits in on the course for which s/he is a TA, then come together for discussions about content and pedagogy.
- A course geared toward a mixed audience (for example, TAs and local AP teachers), including separate one hour per week breakout groups. For TAs, the added hour might be used for video-taping them giving short presentations. For AP teachers, it might be used to provide some additional content beyond AP statistics, and so on.
- A course exclusively for new TAs, where it is often important to include material on basic issues like institutional misconduct policies, grading exams, holding discussion sections, conducting activities in class, and so on.

This type of course would require only that students have a knowledge of basic introductory statistics content and is intended for people who are interested in teaching statistics.

3.2 Category 2: Foundations of Statistics Education

This category is for graduate courses that provide a more in-depth exploration of teaching and learning statistics.

CORE COURSE: INTRODUCTION TO STATISTICS EDUCATION (REQUIRED)

This course for current and future statistics educators includes more in-depth exploration of issues related to teaching and learning statistics. A possible textbook here, such as Gelman and Nolan (2002) might be supplemented with assigned readings (for example, G. Cobb, 1992; G. W. Cobb & Moore, 1997; Garfield & Ben-Zvi, 2007).

Topics may include:

- Introduction to scholarship and research in statistics education.
- Exploration of individual teaching philosophy, and implementation of it in various aspects of teaching.
- Implementation issues for the recommendations on teaching statistics presented in the Cobb report (G. Cobb, 1992), the GAISE College Report (Franklin & Garfield, 2007) and other sources.
- Exploration of innovations in education in related disciplines, such as mathematics, physics, biology, chemistry, and engineering, where substantial work has been done in developing best practices.
- Technology (software, web resources, etc.) specifically relating to teaching statistics.

GOALS: Introduction to the field of statistics education — the important writings, thinkers, recommendations, research, and resources.

PREREQUISITE: Teaching experience in statistics would be recommended (as instructor or TA).

Examples of additional courses for this category that might be developed and offered:

CATEGORY 2 COURSE: CONNECTING RESEARCH WITH TEACHING PRACTICE

This course is built on reviews and syntheses of research that have been done in statistics education that offer implications and suggestions for teaching practice (see, for example, Garfield & Ben-Zvi, 2008). Students would be encouraged to discuss and explore these implications as they relate to different levels and types of courses.

CATEGORY 2 COURSE: STATISTICS IN OTHER DISCIPLINES

This course is appropriate for educators who plan to teach statistics to students from a variety of specific majors across the university, or a variety of levels from K–12 through graduate programs in other disciplines. Many disciplines have developed their own language and emphases, even regarding their use of statistics. This course explores how

to understand and develop courses for teaching statistics to these various disciplines and audiences, including the psychology and content of teaching and communicating statistics in other disciplines. Students could be assigned to communicate with another department on campus in order to learn about their ideal statistics offerings, learn the history of the development of statistics in that discipline, and design appropriate offerings.

Other Examples of possible courses in Category 2, possibly offered as one-unit seminars, include:

- Outreach to the community — presenting statistics to the public, at science museums, in a middle-school visit, etc.
- Developing a course in statistics — students would jointly develop an actual course, such as a general education course in statistics.
- Teaching statistics as a K–12 teacher.
- Designing assessment instruments for statistics courses that also serve to enhance student learning.

3.3 Category 3: Courses for Researchers in Statistics Education

These courses are designed for students who plan to pursue a career in statistics education research. While we envision most of these people as teachers as well as researchers, it is also possible that an individual might choose a position that is entirely focused on research. Some possible courses include:

CORE COURSE: INTRODUCTION TO RESEARCH IN STATISTICS EDUCATION (REQUIRED)

This course offers a critical reading of the literature related to statistics education research and a discussion of research methodologies employed in that research.

CATEGORY 3 COURSE: TURNING TEACHING PRACTICE INTO RESEARCH

This course is intended to identify fruitful areas of research in statistics education. It includes discussion and exploration of research methods and potential research topics. One possible format for the course is to focus on case studies and how research would be done. For example, how would one study the effectiveness of the AP statistics program? How would one study the effectiveness of on-line learning in statistics? And so on.

OTHER COURSES

In addition to the courses such as those above, other program elements recommended uniquely for statistics education research students include:

- a practicum in statistics education research.
- an ongoing seminar on current statistics education research.
- seminars on advanced topics, such as technology, assessment, etc., which may be repeated for credit.

4 From Curriculum to Programs

THE COURSES DESCRIBED above in section 3 provide key components of the curriculum that can be used to form statistics education concentrations-supporting fields, minors, co-majors, Master's degree programs, and Ph.D. degree programs. This latter type of program is the most unique at this point of time and was the main focus of discussion at the workshop.

We see possible goals of doctoral programs in statistics education, as meeting the important needs outlined below:

- Statistics education needs to be informed by results of research in this area. There is a great need to prepare statistics education researchers to produce this research.
- There is a great need to develop excellent statistics educators at the post-secondary level to meet the increased demand to prepare a statistically literate society.
- There is a great need to prepare K–12 teachers who understand statistics at a reasonably deep level in order to teach ideas of data and chance to their students (see K–12 GAISE guidelines).

Much of the core curriculum envisioned for a Statistics Education Ph.D. program overlaps considerably with the core requirements of existing degree programs at many institutions. Thus, an efficient method for creating Statistics Education programs would be to include them as tracks for earning Statistics, Educational Psychology, or Mathematics Education degrees. In the latter case, those degrees offered within mathematical sciences departments provide the most plausible scenario since the level of statistical training required would be substantially easier to accommodate.

We envision the requirements for a doctoral program to include four important areas of content. First, students should gain statistical content knowledge at least at the Master's

or Ph.D. qualifying level to ensure the ability to teach all undergraduate statistics courses and to design and analyze research studies. Secondly, students should be trained in educational and cognitive science foundations such as pedagogy and learning theory. Next, students must gain an understanding of educational research methodologies including both quantitative and qualitative research and education assessment. Finally, students need a solid foundation in core statistics education and statistics education research content to develop their pedagogical content knowledge specific to teaching statistics (Darling-Hammond & Bransford, 2005; Shulman, 1986). See section 3 for a description of possible courses.

Along with coursework, we recommend additional required experiences as part of the core (these may take place as projects associated with coursework or as part of a separate practicum). These include experiences in:

- Statistical practice, including working with data and interpreting and communicating statistical content in terms of the problem (the data practicum).
- Teaching practice, including a supervised experience which might be built into a teaching practices course (the teaching practicum).
- Statistics education research (the research practicum).

Dissertation research arising from this curriculum may vary when it is conducted in a statistics department vs. an education department, or in an interdisciplinary type of program. Regardless of the departmental context, the thesis should reflect the unique coursework and research foundations in statistics education and be supervised by at least one faculty member who has appropriate expertise in statistics education. To reflect the interdisciplinary nature of the area, we recommend that every student earning a graduate degree in statistics education have faculty representing at least two different disciplines serve on the student's committee. This provides appropriate mentoring expertise to the student and over time should enhance the network of links between the disciplines. In some cases, the most effective method of accomplishing this may require mentoring from outside the institution.

While developing statistics education as a dynamic productive field into the future will rely most directly on vibrant Ph.D. programs, we also see a potential national need to develop Master's degree programs. We envision a Master's serving either as a terminal degree, where students will be prepared to teach AP statistics or undergraduate statistics at two-year colleges (but not expected to do research in statistics education), or as a Master's degree in statistics education taken in conjunction with a Statistics Ph.D., as an added component to make graduates more marketable.

We see the core of a Master's program including the following areas:

- Statistics knowledge: Less than a Master's in statistics — but able to be effective in the introductory statistics class.
- Statistics education knowledge: including a pedagogy class with some learning theory, such as the core courses from categories 1 and 2.

In addition to Master's and Ph.D. degree programs, we encourage institutions to provide the opportunity for students to earn a minor in statistics education to strengthen their preparation for a career involving teaching.

It appears that an optimal long-term model for a graduate program in statistics education is likely to be an integrated multidisciplinary approach that includes faculty and courses from different departments. However, the obstacles to initiating new degree programs can be formidable. Thus, in the near term, we expect statistics education degrees to be instituted as tracks in existing Ph.D. programs in Educational Psychology, Statistics, or Mathematics Education departments. Such programs should be designed as flexibly as possible to allow broader training and strong interdisciplinary input — including on dissertation committees. Distance learning approaches and courses shared across institutions may also be necessary in order to facilitate broad training and development not always available at a single institution.

4.1 Example of Core Curriculum for a Ph.D. in Statistics Education

STATISTICS AND/OR EDUCATIONAL STATISTICS CORE:

- Mathematical statistics & probability sequence (one year)
- Applied statistics core
  - Design & Analysis of Experiments (includes ANOVA and linear models for experimental designs)
  - Regression
  - Survey research
  - Computational statistics and statistical programming
  - Other per strengths of program emphasizing value to education research (longitudinal data, Bayesian statistics, meta-analysis, latent variable modeling, hierarchical linear modeling)

STATISTICS EDUCATION CORE:

- Statistics Teaching Practice (category 1)
- Statistics Education Overview (category 2)
- Statistics Education Research Seminars (category 3)

- Other per strengths of program

EDUCATION FOUNDATIONS CORE:

- Learning theory
- Measurement (student assessment)
- Education research methods (e.g., quasi-experimental designs)
- Qualitative Research and data analysis
- Other per strengths of program (e.g., courses in educational psychology and mathematics education that offer topics such as social psychology of learning, epistemology, problem solving, program evaluation, instructional design, technology in the classroom)

Graduate students in statistics education completing a track in a Mathematics Education or Educational Psychology department typically complete these education foundation core courses as part of their program requirements. For example, they study research methods either in a general educational research course or in a course in research methods in mathematics education. It is especially crucial for students earning a statistics education degree in a Statistics Department to take courses such as these to learn the practical and logistical issues of designing educational research studies. This includes posing research questions, selecting appropriate methodologies, consideration of relevant statistical issues, and the writing of literature reviews and research results. A particularly useful resource for students is the ASA sponsored report *Using Statistics Effectively in Mathematics Education Research*, 2007 (http://www.amstat.org/education/pdfs/UsingStatisticsEffectivelyinMathEdResearch.pdf). Students also need to learn about how to deal with implementation issues such as getting cooperation from schools and getting approval from Institutional Review Boards.

In addition to the recommended coursework and practical experiences, we see the need to have students study statistics education early in their program so they can begin to explore connections between research and teaching practice, and begin to have ideas for possible research topics. Temporally integrating the different components of the core curriculum, rather then offering them sequentially, should provide for a more effective preparation of these interdisciplinary scientists. We also emphasize the need to have multidisciplinary input into student research, as well as the importance of having administrative support in developing, promoting, and providing resources and infrastructure to such programs.

5 Faculty Issues

TO DEVELOP STATISTICS EDUCATION graduate programs and to meet the challenges ahead, it is important to have a short-term and a long-term faculty development plan. At present, the number of doctoral degrees awarded in statistics education research is minimal (two have been awarded at the University of Minnesota, which is the only such program, although a handful of others have crafted individualized programs at other universities). University administrations, the national funding agencies, and the statistical associations should collaborate in developing a pipeline of statistics education researchers in the near future. Crucial to these transitional endeavors is addressing the need for support and mentoring of statistics education faculty.

Faculty in statistics education may be classified into three main categories with overlapping responsibilities:

- Instructors/Lecturers/Senior Lecturers/Adjunct faculty
- Teaching Professors/Education Specialists/Professors of Practice (may be promoted, advise students, have longer contracts)
- Tenure track faculty with an interest in statistics education.

The first two categories are non-tenure track positions with a fixed term appointment. Some statistics (and mathematics) departments may have instructors, lecturers, and senior lecturers who are outstanding teachers and generally, have a teaching load of 3-4 courses per semester. Their primary responsibility is to teach a number of introductory service courses and/or other undergraduate courses. Some of them may be involved with other duties, such as training graduate instructors or coordinating graders in their department.

Over the last decade, some statistics departments have hired Teaching (Assistant/Associate/Full)

Professors (TAPs for short), Statistics Education Specialists, and Professors of Practice (PoPs) (Arroway, 2008; Bush et al., 2008). They are typically appointed on a five-year renewable contract and are considered as a part of the graduate faculty. Their teaching load is generally about twice that of a tenure track faculty member. They are involved with several aspects of scholarship in statistics education - including undergraduate course and curriculum development; developing courses and workshops for graduate instructors, postdoctoral fellows and junior faculty on how to teach introductory statistics courses; teaching both service courses and courses for majors at all levels; participation in statistics education conferences; providing professional service to statistics education journals and societies; service on graduate committees; preparing proposals for NSF-CCLI and training grants; and publishing pedagogy related articles and books. There is not usually a specific expectation for them to be involved with statistics education research, though there are some examples of such faculty who are clearly involved.

More recently, a few statistics departments at Research I Universities have advertised for tenure track faculty positions with an emphasis in statistics education research. These positions seem to have different expectations in different departments. In some departments, the expectations of teaching, research, and service for a statistics education research position are exactly the same as those of any other tenure track faculty position, except that for this faculty member, the research focus will be on statistics education. Thus, the expectations are for the same teaching load (typically three courses per year), publication in peer-reviewed journals (related to statistics education), presentations at conferences and other universities, seeking and securing grant funding for research, directing doctoral dissertations, and providing professional service. In other departments, there seems to be more emphasis on the scholarship of statistics education while demanding higher teaching loads and downplaying research. Also, a number of liberal arts colleges hire faculty with a strong interest in the scholarship of statistics education, and in addition to a higher teaching load, some of these faculty are expected to do statistics education research as well as professional service. These latter models should be discouraged if they diverge too far from the expectations for other peer faculty.

All of these positions are very important and make very valuable contributions to statistics education in general. It is important that no matter which type of position a person is in, the expectations are realistic and clear to everyone in the department, in the college, and in the university. A congruence of expectations among all who are involved up-front is critical. Since there are several areas of statistics education scholarship, the percentage of effort in teaching, research and service should be clear from the beginning. We focus here primarily on positions involving statistics education research and developing graduate programs in statistics education. Statistics education research positions in statistics departments are in their fledgling stage and require additional attention and support from departmental faculty and each level of university administration. A strong commitment from everyone involved is a necessity. Subject based education research

is well established in some other STEM disciplines such as physics, chemistry, biology, mathematics, and engineering. Statistics education research faculty may be able to take advantage of the community of faculty in various STEM disciplines with similar education research interests. Members of such a community can also serve as mentors and research collaborators.

Mentoring is required for any junior faculty, and it is even more important for statistics education research faculty since they may be the only member of the department with such an interest. As with any junior faculty, senior faculty members should provide help with seeking grant funding and collaborations. Collaborations with faculty in education departments and with STEM education research faculty in other departments may be needed, especially in the first several years. TAPs/PoPs in the department may also be helpful in serving on graduate committees together with statistics education research faculty. Given the limited number of faculty in statistics education research, mentoring at a distance with other statistics education research faculty will be important. This may be accomplished electronically, as well as by having regular extended meetings such as a summer institute or retreat of researchers with common interests. Statistics education research faculty at other institutions (and faculty from other departments) may be encouraged to serve on graduate committees that are chaired by junior faculty, as external members. As another example, CAUSE has formed a number of research clusters with 3-4 researchers in each cluster. These are excellent opportunities for collaborations and networking for junior faculty in statistics education research.

We have observed that some recent doctoral graduates in statistics and related fields have shown a passion for teaching and have expressed an interest in statistics education research. However, they do not yet have an appropriate background to conduct such research effectively. A postdoctoral experience for such graduates would be ideal, and will help in increasing the pipeline into the future. At present, such postdoctoral opportunities are exceedingly rare. It is important to find funding sources and an appropriate mentoring structure for a number of postdoctoral fellows. A postdoctoral program that spans across institutions with a cohort that comes together for a summer institute and for virtual meetings such as webinars would be very helpful in this regard.

It will be beneficial also to find funding sources to give established faculty the opportunity to switch their research focus to statistics education research. A multi-level summer institute to connect the community of postdoctoral fellows, junior and senior faculty, and graduate students with an interest in statistics education research will be beneficial. At the institute, current research topics as well as short courses on statistics education may be presented and discussed. The institute can also play a role in making statistics education research efforts more cumulative by drawing out salient themes with an eye toward building generalizable knowledge (http://www.ed.gov/MathPanel).

Creating a supportive environment for faculty also involves educating department heads/chairs

about statistics education research. It may be difficult for chairs to understand the importance and impact of a faculty member's work in statistics education research if their own expertise is far removed. Chairs, in turn, must educate departmental colleagues and administrators, so that research in statistics education is not seen as less important or rigorous than more traditional research in statistics. Chairs must also become comfortable with methods that may deviate from typical "in-house" systems for providing mentoring and connecting junior faculty with other educational researchers to establish early collaborations (discussed above). Patience is required before statistics education research can bear fruit in situations where experiments and data collection methods are developed by the individual researcher. Thus, early collaborative research, while individual experiments may be under way, is needed to help alleviate concerns about publications during the first few years of a junior faculty member's career.

New tenure track faculty members in statistics education should be provided a clear and realistic set of expectations leading to tenure and promotion — and these expectations should be made explicit in a memorandum of understanding at the time of hire. A straightforward approach making the research, teaching and service loads the same as for other tenure track faculty in the department would be appropriate in most cases. A concern is that statistics education faculty members might be given more teaching and TA supervision because of their interest and strength in teaching. However, that type of assignment seems more appropriate for one of the other types of non-tenure track faculty positions described earlier; one that does not demand a research component for success. It is also important to clarify the different types of scholarship that will count toward tenure and promotion, especially how scholarship that does not result in research publications is to be factored into the tenure decision. As another example, a faculty member might have a mixture of research articles as well as research-based articles on teaching practice.

It is important that new faculty in statistics education have the opportunity to develop and teach one or more courses in this area, in particular, courses from the second and third categories listed in section 3 of this report. There should also be opportunities to work with and advise graduate students interested in studying and pursuing research in statistics education. While statistics faculty with a degree in statistics may have an interest in pursuing statistics educational research or advising students, few have studied the foundational areas of learning theory, student assessment, and educational research methods. Therefore, we see the need both for multidisciplinary dissertation committees, as well as for supporting these faculty with national programs such as the summer institutes described above.

6 Discussion — Conclusions — Summary of Recommendations — Actions (strategies for departments, institutions, consortia, professional societies)

THE ASA WORKSHOP outlined issues, needs, and recommendations for the development of graduate programs in statistics education to meet the demand for excellent teachers at all educational levels and for research to inform and improve the teaching and learning of statistics. We highlight the need for such programs to be viewed as interdisciplinary, to draw on the strengths of faculty across departments, to include specialized (and newly developed) courses in statistics education. We also see the need to include practical experiences as well as coursework, and to promote high quality dissertation research studies supervised by a multidisciplinary team of faculty. We see the need to create and support new tenure track faculty positions in statistics education and to also support and utilize non-tenure track faculty who can make important contributions to the new graduate programs in statistics education.

Our specific recommendations are organized around the three main sections of this report: programs, courses, and faculty support.

FOR PROGRAMS, WE RECOMMEND:

- That graduate programs in statistics education be implemented in an interdisciplinary fashion. Realizing the difficulty in initiating new programs, these interdisciplinary graduate programs may be structured as tracks of existing degrees in Statistics, Educational Psychology, or Mathematics Education.
- That regardless of the department housing the effort, each graduate program in statistics education should include the development of knowledge and expertise

in the following areas: statistics, educational and psychological foundations, educational research methods, and statistics education. In particular, doctoral training in statistics education should include:

    - specialized courses in statistics education, covering both practical and pedagogical topics as well as the research literature.
    - developing proficiency in statistics, at least at the Master's or Ph.D. qualifier level, to ensure fluency with statistical methods and research designs appropriate to education studies and the ability to teach all undergraduate statistics courses.
    - specialized courses in educational research methodologies including both quantitative and qualitative research.
    - courses in psychological foundations of education such as learning theory.
    - practical experiences in data, teaching, and statistics education research.

- That every student earning a graduate degree in statistics education have faculty representing at least two different core disciplines serve on the student's committee.
- That a Ph.D. dissertation in statistics education reflects the unique coursework and research foundations in statistics education. Ideally, the dissertation will be supervised by a faculty member with experience in statistics education research, although a paucity of faculty with such experience will make this difficult initially.

FOR COURSES, WE RECOMMEND:

- That every Ph.D. program in statistics education have at least one course from each of the following categories: practice of teaching courses (focused on pedagogy and ideas about the content of the introductory statistics course), foundations of statistics education courses (broader focus on teaching and learning statistics at various levels), and statistics education research courses (focusing on the statistics education research literature). Other statistics degree-granting programs should offer courses from the first and second categories as appropriate.
- That statistics education courses be offered and advertised for a wide variety of degree and non degree students (e.g., current high school, and two-year college teachers and future college and university instructors), in addition to those students earning degrees in statistics and mathematics education.
- A summary of recommended statistics education courses for various audiences is shown in Table 6.1.

Table 6.1: A summary of recommended statistics education courses for various audiences.

Audiences	Courses	Appropriate Departments
Teachers of introductory undergraduate statistics, including TAs (who may or may not go on to careers that involve teaching statistics)	Practice of Teaching (Level 1)	Any department producing future teachers of statistics
Statistics educators (people interested in careers that focus on any level of statistics education)	Practice of Teaching (Level 1) recommended Foundations of Statistics Education (Level 2)	Mathematical science departments, possibly co-taught with education
Statistics education researchers (people preparing for tenure track or research only positions)	Practice of Teaching recommended Foundations of Statistics Education (level 2) Statistics Education Research (level 3)	Statistics education Ph.D. programs with a multi-disciplinary faculty

FOR FACULTY SUPPORT, WE RECOMMEND:

- That department and university administrations should:
  - provide collaborative opportunities for statistics education faculty and students to work with the broader STEM education research community on their campus.
  - establish systems that foster the ability of faculty from mathematics and other STEM education disciplines at their institutions, as well as the national community of statistics education research faculty, to help in mentoring new faculty in statistics education research.
  - ensure that tenure track faculty in statistics education have the same research and teaching requirements as other faculty in their department and not be given extra teaching responsibilities because of their expertise in statistics education.
  - ensure that non-tenure track faculty with appropriate training in statistics education be given opportunities to teach, train and serve on committees for graduate students.
  - ensure that new faculty in statistics education who are housed in graduate degree offering departments be given opportunities to develop and teach

courses in statistics education in addition to other courses in their department and to advise students interested in pursuing a graduate degree in this area.
    - provide memoranda of understanding detailing the expectations of statistics education faculty positions (see example in appendix from North Carolina State University) and that the type of acceptable scholarship be outlined (e.g., whether scholarship can include publications on curriculum and pedagogy in addition to statistics education research).
- that collaborations be encouraged between universities and liberal arts colleges that provide college faculty who have the requisite expertise in statistics education with appropriate opportunities to serve on dissertation committees for students at graduate institutions.
- To help facilitate the development and nurturing of statistics education graduate programs we advise:
    - That funding sources be developed for sponsoring statistics education doctoral fellows and postdoctoral fellows and for changing the research focus of some interested faculty, and for organizing summer institutes to bring the community together.
    - That a workshop occurs soon to bring researchers and practitioners together to develop a list of targeted statistics education research problems and priorities. Such discussions are likely to help spawn feasible dissertation topics for doctoral students earning a degree in statistics education from different departments.
    - That this workshop set the foundations for a close relationship between statistics education researchers and statisticians to promote research that can inform and benefit teaching practice.
    - That a regular summer institute and ongoing faculty support system be created to help develop faculty in statistics education to teach courses and supervise dissertation research projects.

To move forward with these recommendations we propose several near-term actions:

1. **Disseminate the report and recommendations**
    - Present the recommendations to the ASA Board of directors for endorsement.
    - Disseminate the report to departments of statistics, educational psychology, and mathematics education and post it at the CAUSEweb and ASA websites.
    - Present on the report at professional meetings in both the mathematical sciences and education and publish reports in the related professional newsletters and member publications.
    - Present to the Caucus of Statistics Department Chairs and educate the heads/chairs

about the opportunities and needs as they relate to statistics education training programs and mentoring of faculty and postdocs in statistics education research.

2. **Develop a list of research priorities to guide statistics education researchers.**
    - Seek a second ASA Member Initiative grant to host a workshop on statistics education research priorities that will include both researchers and statistics teachers to make sure research priorities are directly linked to teaching practice and questions educators care about.
3. **Organize professional development opportunities for statistics educators.**
    - Apply for funding to host one or more professional development institutes for graduate students, post-doctoral fellows, and faculty to develop expertise in the foundational areas of educational research, cognition, and statistics education to prepare them to develop courses and programs and better graduate students in these new programs.
    - Utilize and publicize existing programs such as CAUSEmos to develop and support statistics education researchers.
4. **Organize national coordination of courses and mentoring.**
    - Develop and offer courses in statistics education that serve graduate students from multiple institutions.
    - Establish mentoring programs across institutions and disciplines to support newly developing graduate programs.
5. **Build strong connections with Mathematics and other STEM education programs and research faculty.**
    - Encourage joint meetings to build on recent developments in methods, in theoretical models, in ways of thinking about and assessing students' learning as well as their research on teaching.
    - Leverage existing opportunities for students in STEM education by developing and incorporating statistics education components.

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Appendices

A1 Statistics Education Position at North Carolina State University

The Department of Statistics at North Carolina State University is seeking to fill a junior level tenure track position in Statistics Education for Fall 2008. Applicants should have a Ph.D degree in statistics and a strong interest in teaching statistics at the University level. The successful candidate is expected to establish a nationally and internationally recognized research program in Statistics Education, to raise external funding and direct doctoral students, and to demonstrate excellence in teaching at both the undergraduate and graduate levels.

NC State has begun a focused STEM (Science, Technology, Engineering, and Mathematics) Education Initiative. This Statistics Education position is one of six new STEM discipline-based tenure track positions that will complement the current half-dozen STEM faculty conducting research on teaching and learning in their disciplines. The Initiative can share new qualitative research facilities, will offer collegial support, provide some travel, and offer the possibility of funding research assistantships.

The NC State Department of Statistics is one of the nation's oldest and largest statistics departments and encourages research in a wide range of theory and applications. The Department has a strong commitment to quality teaching. Many of its faculty belong to the NCSU Academy of Outstanding Teachers, and the Journal of Statistics Education was founded in the department. For more information about the department, see `http://www.stat.ncsu.edu`.

Applicants should send a letter of application, curriculum vita, copies of transcripts, and a statement of teaching philosophy and research plan, and arrange for three letters of reference to be sent directly to the Department. All materials may be submitted electronically to `stat_ed_search@stat.ncsu.edu` or as hard copy to Chair, Statistics Education Faculty

Statement of Mutual Expectation

Appointment Information

Name: xxxxxxxxxx (Tenure Track position in Discipline based education research)

Rank/Position: Appointment Type: 9-month

Time in Current Rank/Position: Assistant Professor (Associate Professor?)

Date Filed:

Statement Horizon:

The following Statement outlines the mutually agreed-upon expectations of YOU in the position of Assistant (Associate) Professor in the Department of Statistics at North Carolina State University. The Statement is prepared in accordance with Reg 05.20.28 of the guidelines for EPA employees.

Areas of Responsibility (percent time)

Consulting:	5%
Research:	40%
Service:	5%
Teaching/Mentoring:	45%
Other (specify):	5%
Total	100%

Consulting

As a member of the Department of Statistics I understand that I have a general obligation to engage in collegial consulting with members of the University community (students and faculty), and more generally to the State of North Carolina via the department's obligation to the Institute of Statistics. In addition, as a faculty member I have a general responsibility as a possible mentor to the Department's consulting class. Areas of consulting interest may include education and psychology, among others. I would be interested in collaborations on the statistical analysis of general education research on campus, for example the use of electronic media versus personalized instruction in computer science.

Research

I understand that research is an integral major component of the mission of NC State University. I am committed to engaging in research and establishing a research program consistent with the mission of the university and the Department of Statistics in particular. Although my research is not restricted to any particular area, I recognize that my research should make original contributions to the field of statistics and bring recognition to the Department. A particular interest of my research will be in statistics education.

1. *Anticipated Future Research/Publishing Activities and Accomplishments:*
   I plan to do research and publish in the broad area of statistics pedagogy. That might include activities such as:

   a) Exploring innovative teaching strategies in the classroom and assessing their success. Access to the large number of ST311 sections would even make it possible to compare alternative strategies using designed experiments.
   b) Designing and testing teaching resource material, including web-based materials.
   c) Writing on the application of learning theory and other aspects of the education literature to statistics pedagogy.
   d) Combining the above in writing one or more textbooks.

   I would expect to be active in statistics education circles nationally and perhaps internationally (e.g., through ICOTSs). Publication could be in the statistics literature (including JSE, Amer. Statistician, Stats, and Chance, as well as perhaps "teaching corners" of more traditional Stat journals) as well as in the broader education literature.

2. *Criteria for Research Evaluation:* My research will be evaluated by the usual criteria used in promotion and tenure decisions, including publications (in refereed journals, books and book chapters, proceedings) that bring recognition to the Department; presentations at other departments and universities, and national and international meetings; innovation in statistics education; internal/external funding sought and awarded; supervision of graduate student research (MS and Ph.D.); honors received; mentoring of undergraduate research and graduate consulting; and scientific collaborations with scientists in other fields.

   I understand that I would be expected to gain stature and become well recognized in statistics education circles that extended far beyond the walls of NC State.

Service

Service to the Department, the University, and the profession will be to an extent, and on a level, consistent with other faculty in the first three years of their appointments. These may include, but are not limited to: service on Departmental committees; service on University committees; service in professional societies; service as reviewer for peer reviewed journals; and service to students in a mentoring capacity.

1. *Anticipated Future Service Responsibilities and Accomplishments:*
   I currently serve onÉ I will continue my service in the above committees and serve in other departmental and university committees as well. In addition, I would like to advise some graduate students for their theses.
2. *Criteria for Service Evaluation:*
   The service component of my responsibilities will be evaluated in terms of the quantity and quality of my service-related activities including: student advising and membership on student committees; mentoring; committee work; refereeing, editorial work and service to professional societies (especially in Statistics Education section of the ASA); and participation in the Department, the University, and professional affairs.

Teaching

I understand that teaching is an integral and major component of the mission of NC State University. I am committed to quality teaching consistent with the mission of the University and the Department of Statistics.

1. *Anticipated Future Teaching Responsibilities and Accomplishments:*

   I expect to broaden the set of courses I teach, including the teaching of . . .
   I understand that the nominal teaching load expected of me will be three courses per year provided I remain active in my other areas of responsibility, especially in my research. I also would like to consider offering . . . (e.g. "Techniques for Teaching an Introductory Statistics Course")
2. *Criteria for Teaching Evaluation:*

   I expect my teaching to be evaluated in a manner consistent with the evaluation of teaching in the University in general and in the Department in particular. My teaching will be evaluated based on: courses taught; student and peer evaluations; service on graduate student committees; special topic courses; mentoring; and other teaching related activities. Given my interest in statistics education, I anticipate that I will be seen as a role model for quality teaching and innovative teaching approaches.

Your Name	Date
Sastry G. Pantula, Head	Date
Daniel L. Solomon, Dean, PAMS	Date

A2

Ph.D. or Ed.D. Dissertations in Statistics Education

Ph.D. or Ed.D. dissertations in statistics education in the U.S. 2000–2008.

Year	Student	Institution	Thesis Title	Advisor	Department	Current Position
2008	Leigh Slauson	The Ohio State University	*Students' Conceptual Understanding of Variability*	Patricia Brosnan	Education-Mathematics Education	Otterbein College, Ohio
2008	Mark Marnich	University of Pittsburgh	A Knowledge Structure for the Arithmetic Mean: Relationships between Statistical Conceptualizations and Mathematical Concepts	Ellen Ansell	Education-Mathematics Education	Assistant Professor of Mathematics at Point Park University , PA
2007	Debbie MacCullough	Penn State University	A Study of Experts' Understanding of Arithmetic Mean	Martin Simon	Department of Curriculum and Instruction	Associate Professor in Department of Art & Science, specialty Math. At Philadelphia Biblical University
2007	Jennifer Noll	Portland State University	Graduate Teaching Assistants' Statistical Knowledge for Teaching	Michael Shaughnessy and Karen Marrongelle	Mathematics Education	Assistant Professor in Math & Statistics - Liberal Arts & Sciences at Portland State University

Ph.D. or Ed.D. dissertations in statistics education in the U.S. 2000–2008 (cntd.)

Year	Student	Institution	Thesis Title	Advisor	Department	Current Position
2007	Mario Antonio Davidson	The Ohio State University	Understanding the Burdens of Race at a Predominantly White University: The Experiences of Underrepresented Students in an Introductory Statistics Course	Patricia Brosnan, Peter Demerath, and William Notz	Education-Mathematics Education	Vanderbilt University, Department of Biostatistics
2007	Matthew Ciancetta	Portland State University	Statistics Students' Reasoning When Comparing Distributions of Data	Michael Shaughnessy	Mathematics Education	Assistant Professor Mathematics and Statistics at California State University, Chico
2007	Morgan Earp	University of Denver, Colorado	Development and Validation of the Statistics Anxiety Measure	Kathy E. Green	Quantitative Methods in Education	Survey Researcher U.S. Department of Agriculture
2007	Rossi Hassad	Touro University International, Cypress, Cal	Development and Validation of a Scale for Measuring Instructors' Attitudes toward	Anthony Coxon	Health Science	Associate Professor Psychology and Behavioral Science Mercy College
2006	Andrew Zieffler	University of Minnesota	A Longitudinal Investigation of the Development of College Students' Reasoning About Bivariate Data During an Introductory Statistics Course	Joan Garfield	Educational Psychology-Quantitative Methods in Education-Statistics Education	Lecturer in QME at the University of Minnesota

Ph.D. or Ed.D. dissertations in statistics education in the U.S. 2000–2008 (cntd.)

Year	Student	Institution	Thesis Title	Advisor	Department	Current Position
2006	David Sears	Stanford University	Effects of Innovation Versus Efficiency Tasks on Collaboration and Learning	Daniel Schwartz	Education-Mathematics Education	Assistant Professor Learning Sciences, Purdue University
2006	Jennifer Julia Kaplan	University of Texas at Austin	Factors in Statistics Learning: Developing a Dispositional Attribution Model to Describe Differences in the Development of Statistical Proficiency	Philip Uri Treisman	Department of Mathematics	Assistant Professor Michigan State University, Department of Statistics and Probability and Division of Science and Mathematics Education
2006	Sibel Kazak	Washington University, St Louis	Investigating Elementary School Students' Reasoning About Distributions in Various Chance Events	Jere Confrey	Education - Mathematics Education	Postdoctoral Research Associate at the University of Massachusetts, Amherst
2005	Birgit Christina Aquilonius	University of California, Santa Barbara	How Do College Students Reason About Hypothesis Testing in Introductory Statistics Courses?	Mary E. Brenner	Education - Mathematics Education	University of Stockholm, Sweden
2005	Yan Liu	Vanderbilt University	Teachers' Understandings of Probability and Statistical Inference and their Implications for Professional Development	Patrick Thompson	Education - Mathematics Education	Nanyang University, Singapore

Ph.D. or Ed.D. dissertations in statistics education in the U.S. 2000–2008 (cntd.)

Year	Student	Institution	Thesis Title	Advisor	Department	Current Position
2004	Daniel Lee Canada	Portland State University	Elementary Pre-service Teachers' Conceptions of Variation	Mike Shaughnessy	Mathematics Education	Associate Professor, Mathematics Education, Eastern Washington State University
2004	Katie M. Makar	University of Texas at Austin	Developing Statistical Inquiry: Prospective Secondary Math and Science Teachers' Investigations of Equity and Fairness through Analysis of Accountability Data.	Jere Confrey and Jill Marshall	Curriculum & Instruction Science & Mathematics Education	Assistant Professor, Mathematics Education, Queensland University, Australia
2004	Luis Saldanha	Vanderbilt University	"Is This Sample Unusual?" An Investigation of Students Exploring Connections Between Sampling Distributions and Statistical Inference	Patrick Thompson	Education - Mathematics Education	Assistant Professor Department of Statistics and Mathematics Portland State University
2004	Maria Alejandra Sorto	Michigan State University	Prospective Middle School Teachers' Knowledge about Data Analysis and its Application to Teaching	Sharon Senk	Education - Mathematics Education	Assistant Professor, Mathematics. Texas State University, San Marcos

Ph.D. or Ed.D. dissertations in statistics education in the U.S. 2000–2008 (cntd.)

Year	Student	Institution	Thesis Title	Advisor	Department	Current Position
2004	Teri Rysz	University of Cincinnati	Metacognition in Learning Elementary Probability and Statistics	Janet C. Bobango and Daniel D. Wheeler	Education - Mathematics Education	Assistant Professor Mathematical Sciences, University of Cincinnati
2003	Jeffrey Hovermill ShaMatha	University of Colorado	Technology-Supported Inquiry Learning in Mathematics and Statistics with Fathom: A Professional Development Project	Dominic Peressini	Curriculum and Instruction Ð Mathematics Education	Assistant Professor of Mathematics Education, Department of Mathematics and Statistics, Northern Arizona University
2003	Randall E. Groth	Illinois State University	Development of a High School Statistical Thinking Framework	Cynthia Langrall and Edward Mooney	Department of Mathematics	Assistant Professor of Mathematics Education, Salisbury University
2002	Felicity Boyd	Johns Hopkins University	Methods of Learning in Statistical Education: Design and Analysis of a Randomized Trial	Marie Diener-West	Public Health - Department of Biostatistics	Mayo Clinic, Division of Biostatistics
2002	Gwendolyn Zimmermann	Illinois State University	Students' Reasoning About Probability Simulations During Instruction	Graham A. Jones and Cynthia Langrall	Department of Mathematics	Adlai Stevenson HS, Chicago

Ph.D. or Ed.D. dissertations in statistics education in the U.S. 2000–2008 (cntd.)

Year	Student	Institution	Thesis Title	Advisor	Department	Current Position
2002	Laurie H. Rubel	Teachers College, Columbia University	Probabilistic Misconceptions: Middle and High School Students' Mechanisms for Judgments Under Uncertainty	Henry Pollak	Department of Mathematics, Science & Technology - Math Education	Assistant Professor, College of Education, Brooklyn College
2001	Mustafa Baloglu	Texas A&M University	An Application of Structural Equation Modeling Techniques in the Prediction of Statistics Anxiety among College Students	Paul F. Zelhart	Department of Psychology and Special Education	Department of Educational Leadership and Counseling at Washington State University
2001	Piotr Bialas	Columbia University Teachers College	Spreadsheet use in an Elementary Statistics Course	Philip J. Smith	Department of Mathematics, Science & Technology - Math Education	No information
2001	James A. Condor	University of South Florida	Effects of Computer Coaching in Metacognitively Cued Elementary Statistics Instruction	James, A. White and Michael F. Chappell	College of Education	Professor of Mathematics at Manatee Community College
2001	Candace L. Gunnarsson	University of Cincinnati	Student Attitude and Achievement in an Online Graduate Statistics Course	Suzanne W. Soled	Educational Foundations	Assistant Professor, Xavier University

Ph.D. or Ed.D. dissertations in statistics education in the U.S. 2000–2008 (cntd.)

Year	Student	Institution	Thesis Title	Advisor	Department	Current Position
2001	Mark Earley	University of Toledo	Investigating the Development of Knowledge Structures in Introductory Statistics	Thomas G. Dunn	Department of Foundations of Education	Associate Professor Educational Foundations and Inquiry, Bowling Green State University
2001	G. F. Miller	Columbia University Teachers College	The Relationship between College Student Learning Styles and Assessment Methods in Elementary Statistics	Philip J. Smith	Department of Mathematics, Science & Technology - Mathematics Education	Division of Numerical Analysis and Computing, National Physical Laboratory, Teddington, Middlesex
2001	H. Phyllis	Columbia University Teachers College	The Effects of using Computer Manipulatives in Teaching Probability Concepts to Elementary School Students	Brice R. Vogelli	Department of Mathematics, Science & Technology - Mathematics Education	Associate Professor of Educational Leadership at San José State University
2001	Janice S. Scott	University of Georgia	Modeling Aspects of Students' Attitudes and Performance in an Undergraduate Introductory Statistics Course	Joseph Wisenbaker	Educational Psychology	Retired, Director of Testing, Atlanta Public Schools, GA

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2001	Charlene K. Sharkey	The American University, Washington, DC	Secondary School Students' Conceptions, Factors Behind Achievement, and Problem Solving Strategies with Stochastic Problems	Virginia Stallings	Department of Mathematics and Statistics	Faculty, Mathematics Mercer Community College, NJ
2000	Hollylynne Stohl Drier	University of Virginia	Children's Probabilistic Reasoning in a Computer Microworld	Joe Garofalo	Curriculum, Instruction and Special Education - Math Education	Assistant Professor of Mathematics Education at North Carolina State University
2000	Jacqueline B. Miller	The Ohio State University	The Quest for the Constructivist Statistics Classroom: Viewing Practice Through Constructivist Theory	Emmalou Norland and William I. Notz	Joint program between Statistics and Education	Auxiliary Associate Professor, Department of Statistics, The Ohio State University
2000	Maggie Back McGatha	Vanderbilt University	Instructional Design in the Context of Classroom-Based Research: Documenting the Learning of a Research Team as it Engaged in a Mathematics Design Experiment	Paul Cobb	Curriculum and Instructional	Assistant Professor in Education, Northern Kentucky University

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Year	Student	Institution	Thesis Title	Advisor	Department	Current Position
2000	Maria Meletiou	University of Texas at Austin	Student Understanding of Variation. An Untapped Well in Statistical Reasoning	Jere Confrey	Science & Mathematics Education	Assistant Professor Department of Computer Science and Engineering, Cyprus College CYPRUS