Changing the Statistics Curriculum for Future and Current High School Mathematics Teachers: A Case Study

Amy G. Froelich, Department of Statistics
Wolfgang Kliemann, Department of Mathematics
Heather Thompson, Department of Mathematics

Iowa State University, Ames, IA, USA

ICMI/IASE 2008 Roundtable Conference
Monterrey, Mexico
June 30 – July 4, 2008
Iowa State University

- Founded in 1858
  - Land Grant University
  - Strong connection to Agriculture
- Approx. 26,000 students
- Approx. 21,000 undergraduate students
- Research I institution
Statistics at ISU

- Statistical Laboratory – founded in 1933
- Department of Statistics – founded in 1947
- Centralized Instruction of Statistics
- Teach 4,000 students at undergraduate level each year.
- Offer BS, MS, PhD in Statistics
  - 50 Undergraduate Statistics Majors
  - 150 Graduate Students in Statistics
Connection to Mathematics

- Several joint faculty members
- Many research collaborations
- Several teaching collaborations
Mathematics Education at ISU

- Department of Mathematics
  - Controls degree requirements.
- Department of Curriculum and Instruction
  - Assists with courses and student-teacher supervision.
Iowa Core Curriculum (2006)

- All Iowa High School Students should learn elements of
  - Descriptive Statistics
  - Inferential Statistics
  - Data Collection
  - Probability

- Modeled after
  - NCTM Standards
  - GAISE PreK-12 and College Reports
Curriculum for Teachers?

- GAISE Reports and NCTM Standards are focused on:
  - Student learning outcomes
  - Pedagogy
  - Tools
The Mathematical Education of Teachers (MET Report)

- Exploring Data
- Planning a Study
- Anticipating Patterns
- Statistical Inference
- Probability
CUPM Curriculum Guide

“...study of statistics (is) necessary for those preparing for secondary school teaching in mathematics.”

“...study statistics or probability with an approach that is data-driven.”
How should we prepare teachers?

- **Future Teachers – Course Work**
  - Content
  - Pedagogy

- **Current Teachers – Master’s Degree**
  - Content
  - Pedagogy

- **Current Teachers – Professional Development**
  - Pedagogy
How were we preparing teachers at ISU?

- Bachelor’s Degree in Mathematics with Certification (Future Teachers)
- Master of School Mathematics Degree (Current Teachers)
Old Curriculum for Future Teachers

Calculus-Based Probability

– Course Content:
  - Probability
  - Discrete Distributions
  - Continuous Distributions
  - Multivariate Distributions

– More traditional approach
Master of School Mathematics Program

Goals

– Enhance knowledge of Algebra, Geometry, Calculus, Statistics and Discrete Mathematics
– Provide effective strategies for creating student-centered classroom emphasizing problem solving.
– Training in computing technology in learning and teaching school mathematics.
Old Curriculum for MSM Program

Statistical Methods for Research Workers
– Focused on:
  - Statistical methods necessary for graduate students outside of statistics to complete their Master’s or Ph.D. theses.
  - Assumes Introductory Statistics Prerequisite
New Curriculum for Future Teachers

Required:
- Introductory Statistics
- Calculus-Based Probability

Highly Recommended:
- Calculus-Based Mathematical Statistics

Recommended:
- Applied Regression Modeling
- Design of Experiments and ANOVA
Introductory Statistics Course*

Focused on
- Data analysis.
- Interpretations of statistical results in context.
- Investigation and discovery of statistical concepts.

Content Coverage
- Descriptive Statistics
- Data Collection through Sampling and Experimentation
- Basic Probability
- Statistical Inference

*NSF grant #0231322.
Calculus-Based Probability

Focused on
- Data, Simulation, and Mathematical Reasoning
- Differences among Theoretical, Observed and Simulated Probabilities and Distributions
- Properties of Common Discrete and Continuous Distributions

Content Coverage
- Probability
- Probability Distributions
  - Discrete
  - Continuous
  - Multivariate
Calculus-Based Mathematical Statistics

Focused on
- Data, Simulation, and Mathematical Reasoning
- Investigation of Statistical Concepts through both Simulation and Mathematical Proof.
- Connection between Theory and Practice.

Course Content
- Transformations and Sampling Distributions
- Mathematical Statistics
- From Statistical Theory to Practice and Back
Applied Regression Modeling

Focused on
- Data analysis
- Interpretations in context.

Course content:
- Simple linear regression
- Multiple linear regression
- Regression model diagnostics
- Introduction to Analysis of Variance
Design of Experiments and ANOVA

Focused on

- Data Analysis
- Understanding sources of variation in experiments.
- Impact of variability on selection of experimental design.

Course Content

- One-Factor and Two-Factor Designs and Analyses
- Blocking Designs and Analyses
- Latin Square/Split Plot Designs and Analyses
New Curriculum for Current Teachers

Statistical Methods for Mathematics Teachers

- Prerequisite knowledge
  - Calculus-based probability (traditional)
- Content coverage
  - AP Statistics curriculum (without probability emphasis)
  - Multiple regression, design of experiments, analysis of variance, logistic regression
- Pedagogy and tools focus, especially for intro stats curriculum
Statistical Methods for Math Teachers

- Data Collection Through Sampling and Experimentation
- Analyses of One Categorical Variable
- Analyses of One Quantitative Variable
- Analyses of Contingency Tables
- Analyses of Independent Sample Means
- Simple Linear Regression
- Logistic Regression
- Multiple Linear Regression
Statistical Methods for Math Teachers

Structure of each unit

- Descriptive Statistics
- Inferential Statistics
  - Data collection
  - Appropriate conclusions in context
- Mathematical Connections
- Modeling Pedagogy and Tools
Future Work – Current Teachers

- Extend Statistical Methods for Math Teachers
  - Iowa State University, University of Iowa, University of Northern Iowa
  - 4-year Colleges
  - Community Colleges
  - High School Mathematics Teachers
Future Work – Future Teachers

- Changing certification requirements
  - Data-based Introductory Statistics
  - Simulation-driven course in probability
- Endorsement in Statistics?