Fall Technical Conference
Statistics: Powering a Revolution in Quality Improvement
October 4 - 6, 2017 | Philadelphia, PA

ftc

SPES Special Session

Statistics Training for Industry:

Up-to-Date or Out-of-Date?

Panelists

William Myers

Willis Jensen

Ron Snee

Jennifer van Mullekom

Moderator

Kevin White

Statistics Training for Industry: Up-to-Date or Out-of-Date?

William Myers
The Procter & Gamble Company

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A Competitive Advantage? **Yes**

Why Statistics/Analytics Training is Critical to an Organization

➢ Improves innovation, productivity and overall decision-making ability

➢ "Experts cannot be everywhere – it is a big company"

➢ Allows "statistics experts" to focus on the more challenging problems

➢ It is essential for everyone in the organization to have sufficient quantitative skills

P&G

Statistics Training In Industry

Get Support from Upper Management

Nice-to-Have → **Must-Have**

Statistics Training In Industry

"I took a statistics class in college. The course was very dry and I saw no value it in. Now that I am at P&G, it is clear that I need strong statistics/analytics skills to be successful"

-- Typical Engineer at P&G

Best Practices in Developing & Delivering Training

- ➤ Make it very practical

- ➤ Incorporate real company examples/datasets

- ➤ Include statistical software and practice exercises

- ➤ Internal trainers (discuss the advantages)

- ➤ Make it very interactive – not just lecturing from a trainer

- ➤ Leverage MOOC when appropriate

- ➤ Follow-up with coaching/mentoring

Statistics Practitioner Skill Levels
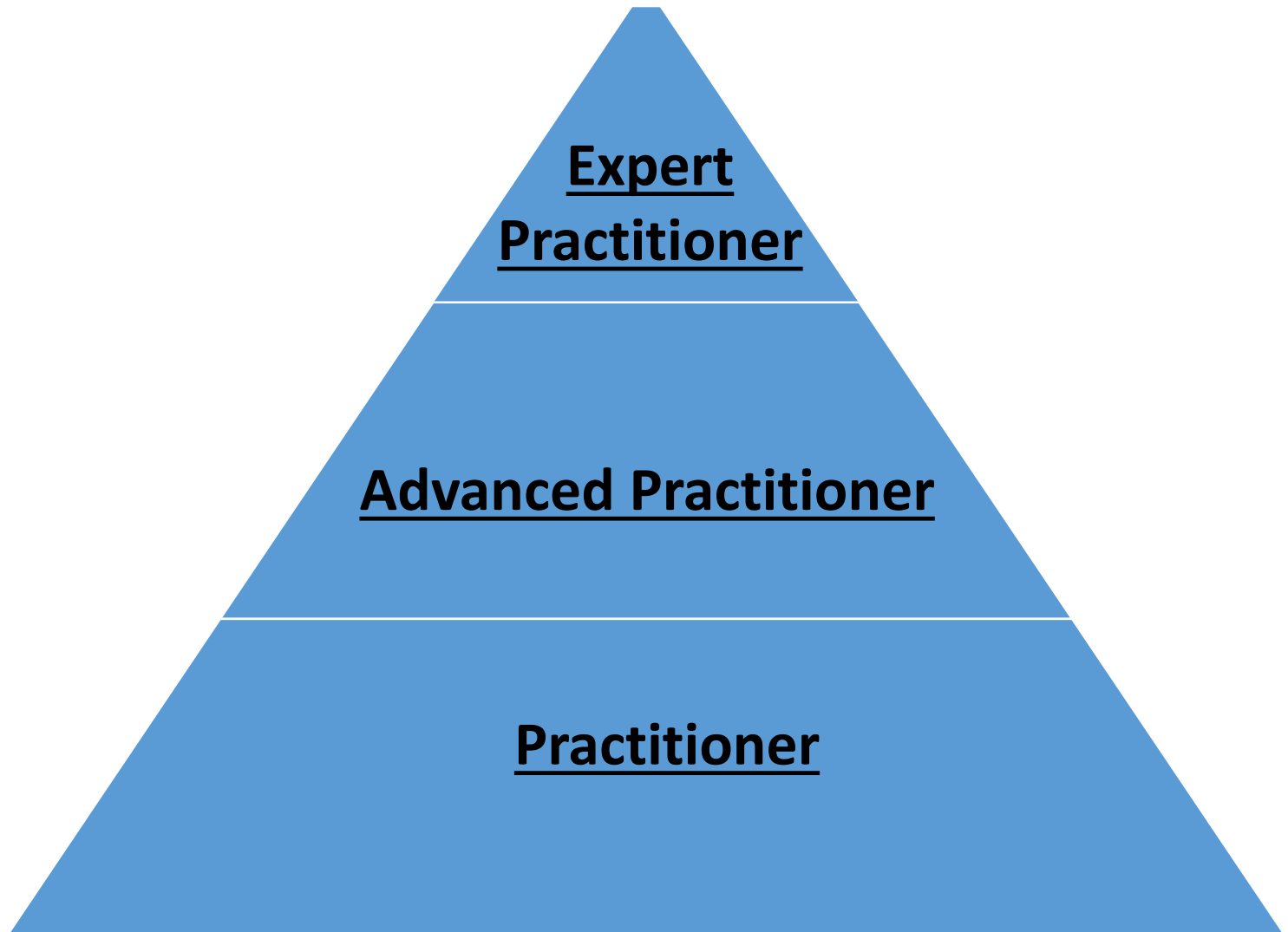
Statistics Courses & Curriculum

- Basic Statistics
- JMP Start
- Design & Analysis of Experiments
- Introduction of Regression Modeling
- Data Mining
- Evaluating Your Measurement System (Gauge R&R)*
- Statistical Process Control*
- Statistical Based Sampling*
- Advanced Topics in DOE
- Design & Analysis of Computer Experiments*
- Basic, Intermediate and Advanced R courses

- Have a course schedule
- Define prerequisites

Best-in-Class Training For Everyone When They Need It!

➢ Not all regions had access to statistics training

➢ Virtual Instructor Led Training Courses
  - o Divide course into modules
  - o Instructor-Led Video
  - o Practice Exercises
  - o Knowledge Checks
  - o Message Board

What Does the Future Look Like?

Statistics Training for Industry: Up-to-Date or Out-of-Date?

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Willis Jensen

Global Statistics Team Leader

W.L. Gore & Associates, Inc.

wjensen@wlgore.com

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What we are not trying to do (Training Myths)

Myth: We need the students to become statisticians
- *They need tools to do their jobs and they must be analytically minded, not become statisticians*

Myth: We have to teach statistics the same way that we learned statistics
- *Training must be adapted to their world, their needs and way of thinking*

Myth: Understanding of the theory is essential to be able to do good statistics
- *Analogy: You don't have to understand how your car engine works to be able to drive*

Myth: Telling the students how to do something will give them the ability to do it
- *Retention is very low when they are told, it is higher when they practice what they are told, and even higher when they practice what they have figured out themselves*

Training Approach for Engineers and Scientists

- 40-60 hours of total training across multiple cours

  - Occurs in a open space where every student has a computer/laptop with JMP statistical software

  - No theory, formulas or hand calculations

  - Large number of hands-on exercises (cookies, paper airplanes, catapults, etc.)

  - Major topics such as Graphical Methods, ANOVA, Regression, Screening Experiments, RSM, Blocking, Split Plots, Optimal Designs, Variance Components, Capability Analysis, Sampling Plans, Control Charts

    - No coverage of central limit theorem, probability concepts, random variables or test statistics

Legend:
○ Factorial design points
● Axial points
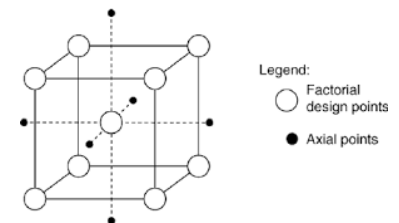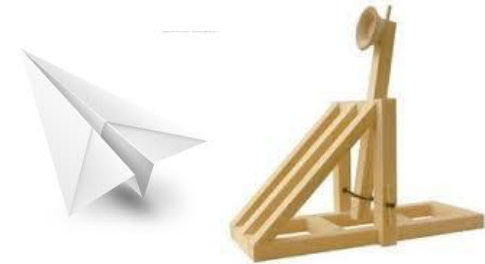
Highly Valued by Students and Leadership!

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Internal vs. External Trainers?

- Internal Training best when
  - Relationship after training matters and you want to create future business for statistical support team
  - And/Or customized content and targeted examples are of value

- External Training best when
  - Knowledge and skills are not available internally
  - And/Or content is standard and not complex

We've used both, depending on the situation at hand

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*Creative Technologies Worldwide*

Some Future Trends Impacting Training

- Globally dispersed organizations

- Increasing comfort with digital content

- More remote and virtual work

- Ease of access to many online resources (eg YouTube videos, MOOCs, Coursera, etc.)
  - Often under the labels of Big Data, Machine Learning or Analytics rather than "Statistics"

- Cost pressures leading to reduction in expensive training programs
  - Increased need to demonstrate a real benefit (ROI) in training programs

- Increasing availability and complexity of tools

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Responses to Future Trends

- ## Digital Content
  - Easier to update and add interactive elements (eg demos, quizzes)
  - Eliminated Powerpoint in some cases

- ## Blended Learning
  - Mix of in-class, e-learning, self-study prework

- ## Modularization of Courses
  - Shorter pieces of content that allows for customization and more "Just In Time" training
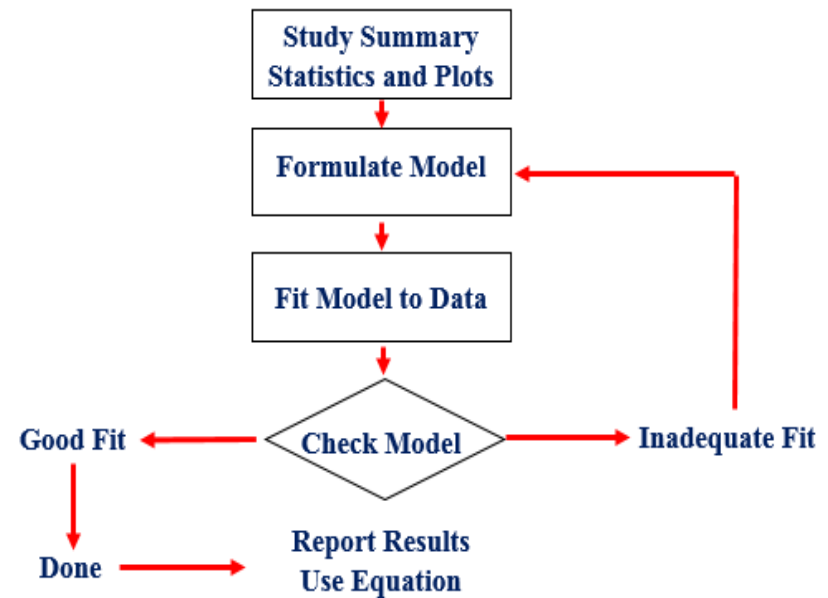
- ## 70/20/10 Model
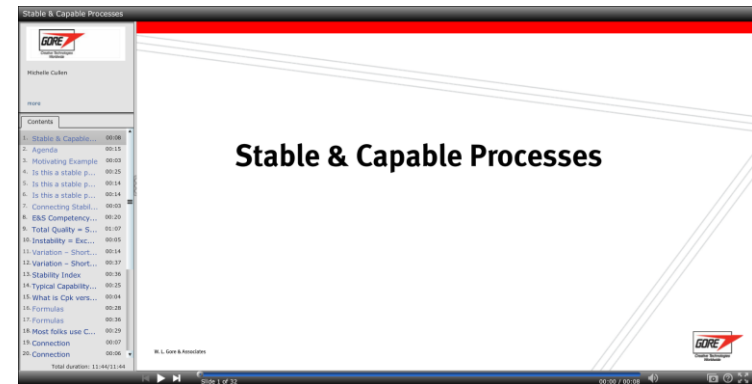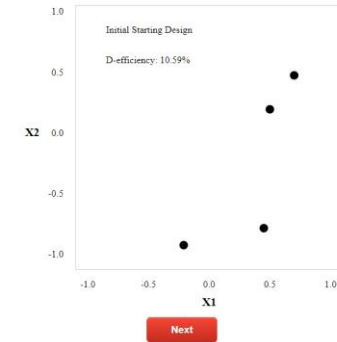
A Take Home Message

The key objective of training courses is not to learn a bunch of tools, it is to learn a fundamental way of thinking about data and developing ability to generate insights the data provide.

The statistical tools and training methods will always be changing, the demand for critical thinking and ability to use the Scientific Method won't.

Strategy of Experimentation

	Screen	Characterize	Optimize
No. Factors	> 6	3-6	2-5
Desired Information	Critical Factors	Understand how System Works	Prediction Optimization Design Space
Model Form	Linear or Main Effects	Linear and Interaction Effects	Linear, Interaction Curvilinear Effects
Experiment Design	Plackett-Burman Fractional-Factorials	Full and Fractional-Factorials	Response Surface

Roadmap Example: Regression Analysis

Study Summary Statistics and Plots → Formulate Model → Fit Model to Data → Check Model

Check Model → Good Fit → Done → Report Results Use Equation

Check Model → Inadequate Fit → Formulate Model

Statistics Training for Industry
Creating a Competitive Advantage

Ronald D. Snee, PhD
Snee Associates, LLC

ASQ-ASA Fall Technical Conference
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Two Aspects of Statistical Training

- **Content – What will be taught?**
  - What concepts, methods, tools?

- **Delivery – How will the content be covered?**
  - Design of learning experience
    - Mixture of presentation, exercises, discussion, projects, tours, …..?
  - Implementation of learning experience
    - Venue, time frame, meeting frequency…… ?

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Content – What Should I Teach?

Guiding Principle - Focus on the Problem

≡ **Problem solving approach defines the needed tools - Not the Reverse!☹**

1. **What's the problem?**
   - ➢ **Context, process, data pedigree, goals and objectives**

2. **What approach and statistical tools should be used?**

3. **What Results? Desired Format?**

Use Systems Approach

≡ **Embed tools in business processes; some examples**

= **Product Quality Management**

= **Continued Process Verification (process control)**

= **Strategy of Experimentation**

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Strategy of Experimentation
Comparison of Experimental Environments

Characteristic	Screening	Characterization	Optimization
No. of Factors	More than 6	3-6	2-5
Desired Information	Critical Factors	Understand how System Works	Prediction Equation, Optimization, Design Space
Model Form	Linear or Main Effects	Linear and Interaction Effects	Linear, Interaction and Curvilinear Effects
Experiment Design	Plackett-Burman Fractional-Factorials	Full and Fractional Factorials	Response Surface

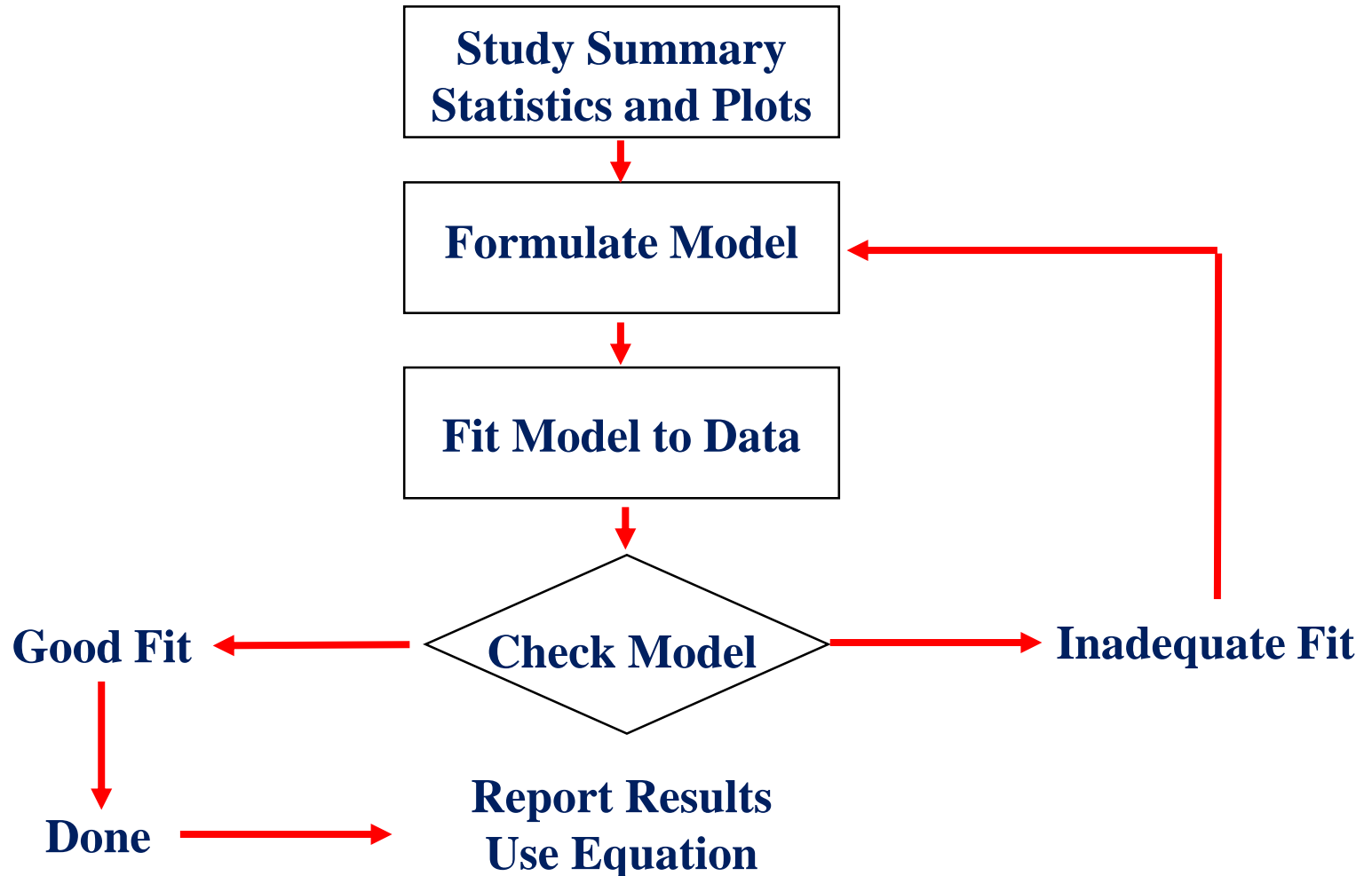Snee Associates, LLC

Content – What Should I Teach? (cont'd)

≡ **Create Corporate Best Practices for use of statistical thinking and methods; for example**

   = **DMAIC for Problem Solving and Process Improvement**

   = **Strategy of Experimentation to guide experimentation**

≡ **Embed statistical thinking and methods in business processes; for example**

   = **Product Quality Management - DuPont**

   = **Collections Process - GE**

≡ **Management Review is the "secret sauce"**

   = **Define Management roles in the approach**

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Delivery

- **Problem based** – **Projects are part of any and all training**
  - **Enhances the learning process**
  - **Results cover the training costs more than 5:1**
- **Software supported**
  - **Software that enables the approaches to be used**
- **Use a variety of learning formats: People learn in different ways**
  - **Lecture, exercises, discussion, video, and PROJECTS**
- **Embed tools in functions used to run the business**
- **Provide Roadmaps**

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Roadmap Example: Regression Analysis

Study Summary Statistics and Plots → Formulate Model → Fit Model to Data → Check Model

Good Fit ← Check Model → Inadequate Fit

Good Fit → Done → Report Results Use Equation

Inadequate Fit → Formulate Model

Hoerl, R. W. and R. D. Snee, *Statistical Thinking – Improving Business Performance***, Wiley (2012)**

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Using Outside Resources for Statistical Training
An Opportunity

Concerns:

- **We don't have enough staff to deliver training**

- **Training not a priority - Management wants us to focus on problem solving and process improvement**

Opportunity:

- **Use Outside Resources to deliver training**

  - **Other functions do it – Engineering, manufacturing, research,…**

  - **Extends your staff – increases capacity**

  - **Content should be consistent the organization's culture**

  - **A Provider-Sponsor partnership works best**

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My Message

- Pay attention to both **content and delivery**

- **Focus on the problem** – Provides context, goals and objectives
  - Helps identify the right statistical tools for the problem at hand
  - **Embed tools** in business processes

- Provide **project-based training and software** that enable users to quickly
  - Learn and use the approaches
  - Generate bottom line results

- Provide **systems and roadmaps** for use of statistical tools

- **Expand capacity** – Use outside resources for training

Statistical Training Should be Problem Focused, Project Based

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References

Hoerl, R. W. and R. D. Snee (2012) *Statistical Thinking – Improving Business Performance,* 2nd Edition, John Wiley and Sons, Hoboken, NJ.

McGurk, T and R. D. Snee (2005) "A Systematic Approach to Deviation Reduction through Six Sigma," <u>Pharma Technology Sourcing and Management</u>, Oct 2005.

Snee, R. D. (2001) "Focus on Improvement, Not Training", <u>Quality Management Forum</u>, Spring 2001, 7,8,16; *Quality Progress*, Nov 2001.

Snee, R. D. (2013) "Statistics: Ask the Right Questions – Once You Know what the Objectives and Needs Are, You Can Figure Out Which Tools Can Help Meet Your Goals", <u>Pharma Manufacturing</u>, January 2013, p 15.

Snee, R. D. (2015) "Management Holds the Key to Continued Process Verification", <u>Pharma Manufacturing</u>, January/February 2015, 33-35.

Snee, R. D. and R. W. Hoerl (2003) *Leading Six Sigma – A Step-by-Step Guide Based on Experience with GE and Other Six Sigma Companies,* Financial Times Prentice Hall, New York, NY.

Snee, R. D. and E. C. Gardner (2008) "Putting It All Together – Continuous Improvement is Better than Postponed Perfection", <u>Quality Progress</u>, Oct 2008.

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Statistics Training for Industry:

Up-to-Date or Out-of-Date?

Jennifer van Mullekom

Director of the Statistical Applications and Innovations Group

Virginia Tech

Revisit the P&G Engineer Comment

"I took my one required Eng. Stats course in college. It was dry and I found little need for it. Now that I am working at P&G, I see why having strong statistics/analytics skills is so critical ".

- How did we get here?

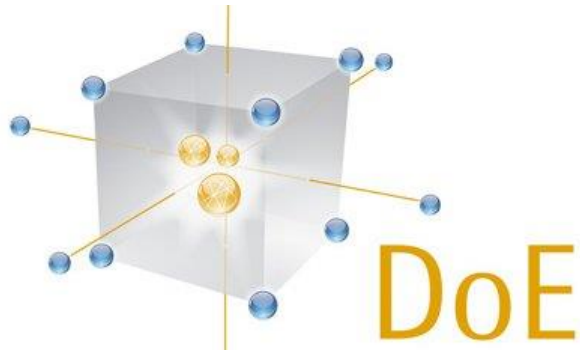- What should we change?

- How can we affect change?

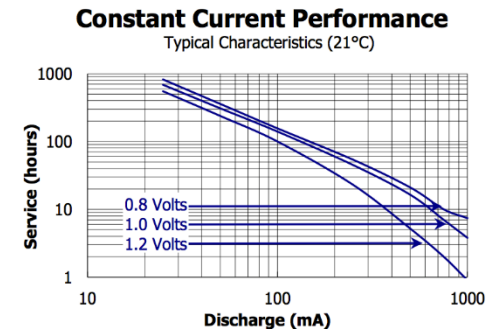# ABETS

Accreditation Board of Engineering and Technology

"With ABET accreditation, students, employers and the society we serve can be confident that a program meets the quality standards that produce graduates prepared to enter a global workforce."

Source: http://www.abet.org/about-abet/

ABETS Student Outcomes for an Engineering Program

Analyze

Interpret

Design   Criteria   Constraints

Source: http://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2016-2017/#objectives
https://www.linkedin.com/pulse/doe-design-experiments-proactive-improvement-driver-sunil-kappal

Statistics in the ABETS Curriculum Statement?

"Engineering design is the process of devising a system, component, or process to meet desired needs. It is a *decision-making process (often iterative),* in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet these stated needs."

- How did we get here?

- What can we change?

- How can we affect change?

Answer: A New Course in Eng Stats!?!
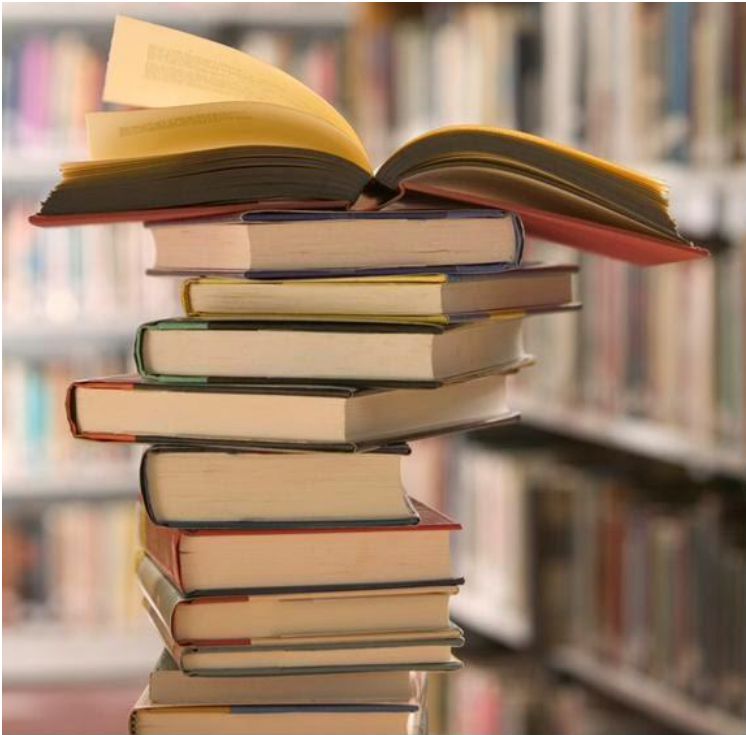
Integrate not Add!

Ideas for Change

- VT DADS (Data Analytics and Decision Sciences) Destination Area
- Conceptual Course: STAT 1984 "Data in Our Lives"
- Flipped Classroom
- Statistical Practice Mini Courses
- Engineering Capstone Integration
- Engineering Design Team Integration
- "Exchange" Program

- How did we get here?

- What can we change?

- How can we affect change?

Literature sparse, not hitting the target stakeholders

Frontiers in Engineering Education Conference

- Jim Rowland at University of Kansas
  - Include ANOVA and DOE
  - Case Studies and Capstone Integration

- Chris Gobulski at UT-Austin
  - POGIL- Process Oriented Guided Inquiry Learning

- Lots of Statistical Thinking Literature, Problem Solving Literature
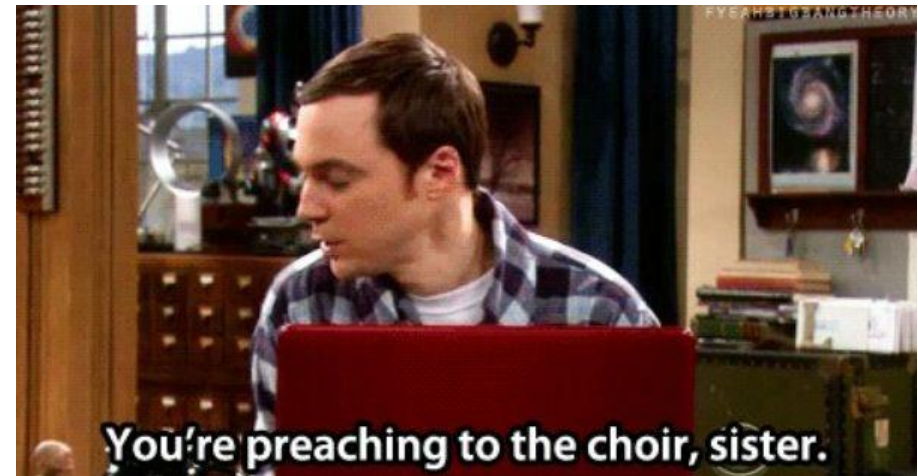
Solution = Collaboration

- Someone should write "101 Engineering Statistics Case Studies with Real Data"

- Summer faculty exchange programs in industry for both Statistics and Engineering Professors

- Campus visits include seminars in Engineering departments

- Engineer testimonials on how statistics has powered their career trajectory

- Collaborate with Engineering Education authors and create publications on how to integrate statistics into the engineering curriculum

End with the Beginning in Mind

ABETS recommendation
on integration of
Statistics and Data Science
into Engineering Curriculum.