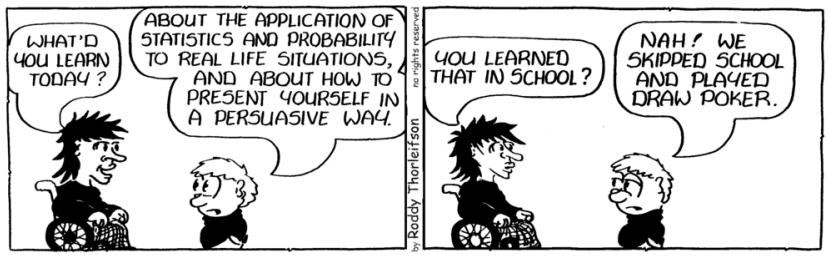
The Art of Teaching and Communicating Design of Experiments to Non-Statisticians

Presented by Shari Kraber,
MS Applied Statistics,
Certified Professional in Learning and Performance



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"Statistics & Quality: Riding the Big Data Wave"
2018 Fall Technical Conference

Take Away:

Aim to educate so that you motivate people to try something new!

Agenda:

Why should you improve your teaching skills?

Teaching statistical concepts via anecdotes and illustrations

Teaching how to communicate

"Education is the kindling of a flame, not the filling of a vessel."
-- Socrates

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Art of Teaching DOE
Agenda

- **Why should you improve your teaching skills?**
- Teaching statistical concepts via anecdotes and illustrations
- Teaching how to communicate

"The mediocre teacher tells. The good teacher explains. The superior teacher demonstrates. The great teacher inspires."
- William Arthur Ward

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Why Improve Teaching Skills?

The hard reality –

Most people hate (or fear) statistics.

Ouch…

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Why Improve Teaching Skills?

If people fear it, they will not use it.

We can help overcome the negativity surrounding statistics classes by getting *creative* with our teaching methods.

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Why Improve Teaching Skills?

Great teachers -

- ✓ Motivate students
- ✓ Are passionate about the topic
- ✓ Bring energy to the classroom
- ✓ Can convey messages in several different ways, to help those who learn: by seeing, by listening, by analogy, by hands-on practice
- ✓ Become the go-to person for others to learn from!

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Art of Teaching DOE
Agenda

- Why should you improve your teaching skills?
- **Teaching statistical concepts via anecdotes and illustrations**
  - **Concept of power**
  - Why factorials don't work for mixtures
- Teaching how to communicate

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Teaching Illustration
Explaining power of a design

First, explain concept of signal and noise, and how to choose these levels.

DOE Process:

1. Identify opportunity and define objective.
2. State objective in terms of measurable responses.
   a. Define the minimal change (Δy^*) that is <u>important</u> to detect for each response (signal).
   b. Estimate experimental error (σ) for each response (noise).
   c. Use the signal to noise ratio ($\Delta y/\sigma$) to estimate power.

*See next slide for tips on defining your signal.

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DOE Process
Defining Your Signal (Δy)

To define your signal, ask this question:

"What is the minimum amount of change in the response that will be recognized as an important improvement?"

The answer is a business decision, not a statistical calculation.

Objective: Improve yield from its current level of 80%. Each percent is worth $100,000 per year in profits.

Signal: What amount of improvement will be valued?

0.1%	1%	10%

A quantitative answer is required!

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DOE Process *(2 of 2)*

3. Select the input factors and ranges to study. (*Remember that the factor levels chosen determine the size of Δy.*)
4. Select a design and:
   - Evaluate aliases.
   - Assess power.
   - Examine the design layout to ensure all the factor combinations are safe to run and likely to result in meaningful information (no disasters).

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What is Power?

No Factor Effect; H_0: $\Delta = 0$

Then, explain concept of power.

Power = (1−β)*100%

Power is the probability of revealing an active effect of size delta (Δ) relative to the noise (σ) as measured by signal to noise ratio (Δ/σ).

It should be high (at least 80%!) for the effect size of interest.

Effect?		ANOVA says:	
		Retain H_0	***Reject H_0***
Truth:	***No***	OK☺	Type I Error (alpha) *False Alarm*
	Yes	Type II Error (beta) *Failure to detect*	OK☺

Power

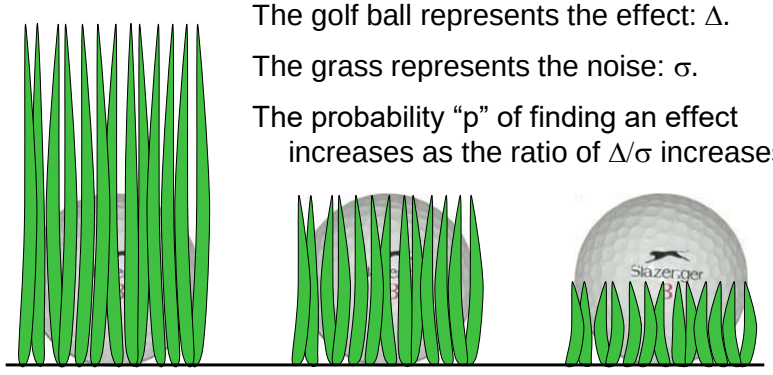
Depends on Signal to Noise Ratio

Finally, relate power to signal/noise via a fun analogy.

The golf ball represents the effect: Δ.

The grass represents the noise: σ.

The probability "p" of finding an effect increases as the ratio of Δ/σ increases.



$\Delta/\sigma = 1/2$ $\Delta/\sigma = 1$ $\Delta/\sigma = 2$

Power
Depends on Signal to Noise Ratio

What's helpful about this illustration?

1. It incorporates a variety of words, symbols, and graphics to convey the concepts.
2. It encourages the student to think about their own process and consider how they would define signal and noise for their responses.
3. The golfing analogy can be understood by all and is fun, leading to better retention of the concept.

Art of Teaching DOE
Agenda

- Why should you update your teaching skills?
- **Teaching statistical concepts via anecdotes and illustrations**
  - Concept of power
  - **Why factorials don't work for mixtures**
- Teaching how to communicate

"The mediocre teacher tells. The good teacher explains. The superior teacher demonstrates. The great teacher inspires."
- William Arthur Ward

Teaching Illustration
Explaining why mixture design is important

Explain the concept of a mixture.

1. Factors are components of a mixture
2. Response is a function of proportions

Given these two conditions, fixing the total (an equality constraint) facilitates modeling of the response as a function of component proportions.

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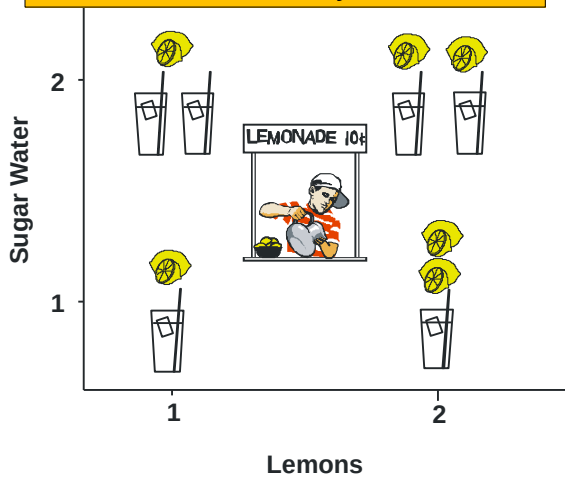
Making Lemonade:
Factorial Not a Good Design: Why Not?

Tell a story!



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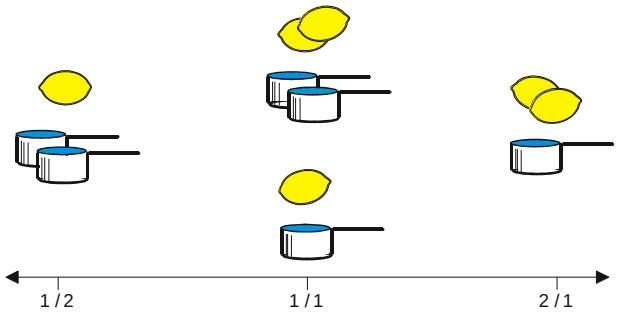
Lemonade
Taste is a function of Proportions



Lemon / Water

To study mixtures you must either use ratios of ingredients or a mixture design.

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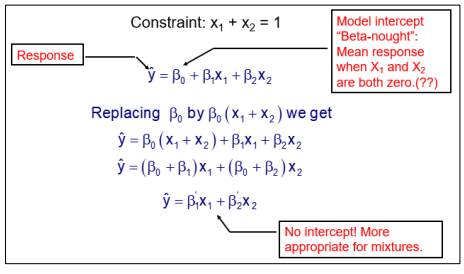
Teaching Illustration
Explaining why mixture design is important

What's helpful about this illustration?

1. It uses a story to help students imagine the situation.
2. An engaging intro MOTIVATES students to learn the statistical details of Scheffe' polynomials.
   Put the story before the theory!



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Art of Teaching DOE
Agenda

- Why should you improve your teaching skills?
- Teaching statistical concepts via anecdotes and illustrations
- **Teaching how to communicate results**
  - **Make your data dance!**

"It's the software's job to record and analyze data but it's the storyteller's job to tell others what that data means and what they're to do with it"
David Pelton, Professional Communicator

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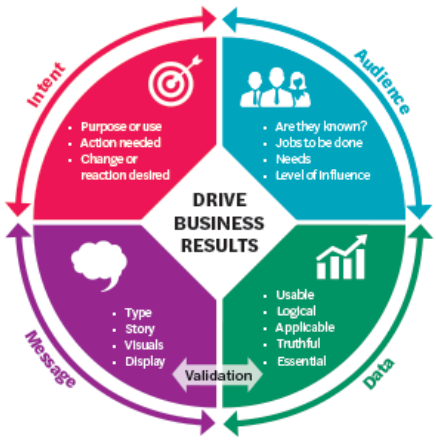
Teaching How to Communicate Results
To the Non-Statistician

Make Your Data Dance!*

- ✓ Determine Intent
- ✓ Understand Audience
- ✓ Create Message
- ✓ Thoughtful Data

Goal: Drive Business Results



**TD Magazine*, March 2018

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Teaching How to Communicate Results
Make Your Data Dance!

- ✓ Determine Intent
  - Why are you gathering data?
  - What is the goal?
  - How will this goal make a difference to the organization?
  - What is the expected ACTION as a result of this communication?

Goal: Drive Business Results

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Teaching How to Communicate Results
Make Your Data Dance!

- ✓ Understand Audience
  - Why should they care about your message?
  - What information will the audience need to make decisions?
  - Understand how much data, and in what form, would the data be most valuable to the audience?

Goal: Drive Business Results

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Teaching How to Communicate Results
Make Your Data Dance!

- ✓ Thoughtful Data
  - Take static data and transform it into dynamic information that can drive business results
  - Present data that shows an ROI, an impact on business, new knowledge
  - Is your data clear, logical, applicable, complete?

Goal: Drive Business Results

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Teaching How to Communicate Results
Make Your Data Dance!

- ✓ Convey Message
  - How to convey your message? In person, document?
  - What story do you want to convey? Making request or sharing information?
  - Appropriate visuals? How can data be displayed effectively?

Goal: Drive Business Results

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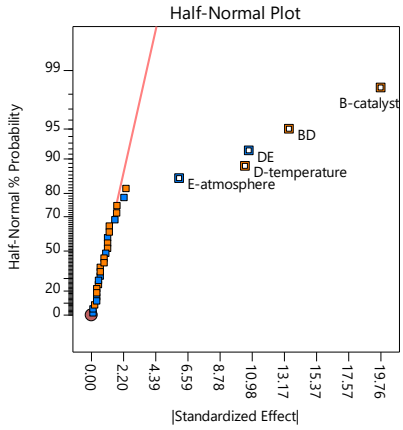
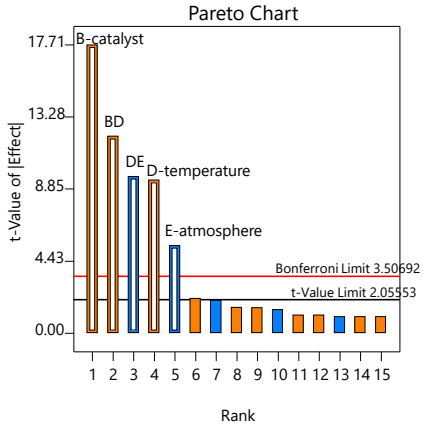
Teaching How to Communicate
Ex: Choosing the right graphics for the audience

Statistically-saavy → Non-Technical





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Teaching How to Communicate
Ex: Choosing the right information for audience

Statistically-saavy

ANOVA for selected factorial model

Response 1: Fluorescent Units

Source	Sum of Squares	df	Mean Square	F-value	p-value	
Model	4.792E+06	3	1.597E+06	9.26	0.0001	significant
B-Stimulant	3.074E+06	1	3.074E+06	17.82	0.0002	
C-Substrate	5.856E+05	1	5.856E+05	3.40	0.0736	
BC	1.133E+06	1	1.133E+06	6.57	0.0147	
Residual	6.208E+06	36	1.724E+05			
Lack of Fit	2.280E+05	4	56991.00	0.3050	0.8725	not significant
Pure Error	5.980E+06	32	1.869E+05			
Cor Total	1.100E+07	39				

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Teaching How to Communicate
Ex: Choosing the right information for audience

~~Statistically-saavy~~ → Non-Technical

Source	p-value	
Model	0.00011	significant
B-Stimulant	0.00016	
C-Substrate	0.07360	
BC	0.01469	
Residual		
Lack of Fit	0.87249	not significant

Rather than report numbers in static form – connect them to dynamic actions that drive business results.

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Teaching How to Communicate Results
To the Non-Statistician

Communications need to be:

1. Clear (limited statistical jargon)
2. Concise (get to the point quickly)
3. Results-oriented (what is the value to the business)

- ✓ Professors can promote this skill set by expecting these same characteristics in project reports.
- ✓ Consultants can demonstrate these skills when providing work reports.

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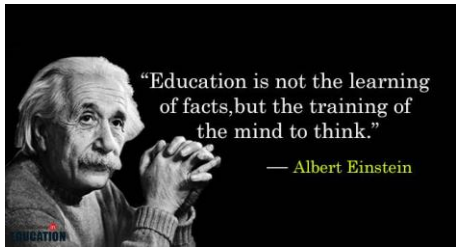
Art of Teaching DOE
Take Homes

- Be the teacher you want to learn from!
- Find and use illustrations to bring statistics to life!
- Encourage thinking about work-related scenarios.
- Teach others how to THINK about their intent, audience, message, and data display



Any Questions?

Connect! We share content via LinkedIn – follow Stat-Ease, Inc. and Shari Kraber

Best of luck for your teaching!

For further questions or a copy of this presentation, contact me at the e-mail below!

Shari Kraber
MS Applied Statistics,
Certified Professional in Learning and Performance
Stat-Ease, Inc.
shari@statease.com

