



Academic Statistics Education: What is the Business World Really Looking For?

(With a Special Emphasis on Introductory
Statistics)

Beyond the Formula

July, 2003

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Outline

- Why is the intro course so important?
- What are we currently trying to accomplish?
- How do other disciplines position the intro course?
- What does business really want?
- A suggestion to consider
- Summary

Why Is The Intro Course So Important?

- Our profession is faced with a number of significant challenges (e.g., ASA Presidential Addresses of the past 10 or so years).
- Many of the challenges relate to how others, e.g., business leaders, view us.
- The impressions of others towards statistics are often begun, if not completed, in their intro stat course.
- The intro stat course may be the single most powerful leverage point to improve our status and influence.

What Are We Currently Trying to Accomplish?

- These has been much discussion on improving the intro course, *but*:
 - few suggestions have been guided by an underlying theory, or even clear objectives.
 - “...so much of what we do is not thought through from a careful consideration of customers, aims, and objectives: it just grows in an ad hoc way over the years, building on what has been done before.” (Wild)
- If pressed for an answer, some teachers would say teaching as many statistical techniques as possible is their objective. This leads to the classic “mile wide and inch deep” course.

Does “Teaching As Many Techniques as Possible” Make Sense as an Objective?

- If your academic customers actually expect your students to come out of the intro course competent in:
 - Probability
 - Sampling distributions
 - Regression
 - Non-parametrics
 - Hypothesis testing
 - DOE
 - ANOVA
 - Time series, etc.,

then you need to have a “heart to heart” talk with them!
- Clearly, if we can’t agree on what we are trying to accomplish, we will never agree on the appropriate course! (If you don’t know where you are going, any road will do!)

How Do Other Disciplines Position Their Intro Courses?

- To get ideas for what our intro course should try to accomplish, it is helpful to benchmark other disciplines (and consider our customers' needs!).
- For example, as an undergraduate, two intro courses which I enjoyed, and also which had a significant influence on me, were geology and psychology.
- These disciplines do not generally consider their intro course an end in itself, but view it within the context of the overall educational experience.

What Did I Really Get Out Of My Intro Geology Course (27 Years Ago)?

- I remember virtually no definitions or formulas.
- I did learn that the world is constantly changing (dynamic versus static paradigm), even mountains and oceans.
- I am more aware of ongoing mechanisms at work in nature, e.g., erosion, movement of tectonic plates, meandering of rivers over time, etc.
- I have a better appreciation of interrelationships in nature, e.g., rain to rivers to sedimentary deposits to rock formation, and so on.

What Did I Really Get Out Of My Intro Psychology Course (28 Years Ago)?

- I remember virtually no definitions or formulas.
- I did get a new understanding of people:
 - Human beings are very complex; they are not as predictable as machines.
 - In some ways, everybody is the same. These common human needs and traits are well understood and documented (e.g., Maslow's Hierarchy).
 - In some ways, everybody is different, and needs to be respected as a unique individual.

What Is The Moral Of This Story?

- In a liberal arts education, an “intro” course should primarily broaden students’ thinking relative to the topic at hand, and educate them in the fundamental concepts of that field.
- There is no attempt in any other field of which I am aware to “teach students as many techniques as possible”. For example, graduates of intro physics are not expected to be practicing physicists!
- Rigorous treatment of the methodologies should be left to subsequent, more advanced courses. (Of course, some degree of rigor is required even in intro courses!)

What Does Business Really Want?

- In general, the business world takes the “geology/psychology” viewpoint, versus the classical statistics viewpoint (see sample exceptions below).
- The business world does not expect Stat 101 grads to be statisticians, any more than it expects Chem 101 grads to be chemists.
- Sample exceptions: engineers should know how to design experiments, and MBA’s should know how to forecast, but ideally these skills should be developed:
 - In subject matter courses (e.g., design courses in engineering, or forecasting course in business school), or
 - Subsequent courses in statistics, beyond the intro course.



What Does Business Really Want?

- Some things we value, and expect from intro stat graduates:
 - A continuous improvement mindset
 - Ability to study and improve real processes*
 - Understanding of variation (i.e., can apply the concept to everyday situations).
 - Ability to plot data (and interpret the plot).
 - Belief in data based decision making.
 - Enthusiasm to learn more statistics.
- Unfortunately, we are almost always disappointed!

*Can integrate tools into an overall approach to scientific inquiry

What Does Business Really Want?

- These attributes cluster into three major categories:
- Skill
 - Ability to study and improve real processes
 - Ability to plot data (and interpret the plot)
- Knowledge
 - Understanding of variation
 - A continuous improvement mindset
- Attitude
 - Belief in data based decision making
 - Enthusiasm to learn more statistics
- Business ranking: attitude, knowledge, skill
- Typical academic ranking: skill, knowledge, attitude(?)

What Does Business Really Want - Summary

- Major disconnects between business needs and the classical intro course
 - The *lack* of emphasis on broadening students' thinking
 - The *lack* of emphasis on fundamental concepts
 - The *lack* of emphasis on overall approaches to scientific inquiry
 - The *overemphasis* on formula memorization and narrow skills development
- Students entering the workforce will likely have:
 - Totally forgotten the definitions and formulas
 - Totally forgotten narrow skills, such as how to perform a paired t-test
 - Retained a negative attitude about statistics

A Suggestion to Consider

- I would therefore suggest that a set of objectives which emphasizes understanding of, and ability to apply, key concepts would:
 - Better satisfy the needs of business employers, and
 - Better set the stage for future, more advanced courses in academia.
- Better set the stage, because these students would have the proper context to understand:
 - Why they are learning a technique
 - What it actually does
 - When it would, or would not, be appropriate to use
- These are typically glossed over or totally missed in the classic course.

A Suggestion to Consider

- So what are some of the fundamental concepts that we should be emphasizing to students?
 - Any activity can be studied, and the results improved (“All work is a process”).
 - Appropriate data help us “study and improve”.
 - Variation exists in all data and activities (“Variation happens”).
 - In many cases, reducing variation is the key to improvement, even when the objective is to move the average (i.e., in golf).
- Many people call this stuff “Statistical Thinking”.

An Example Of Such a Mindset Change

- I was introduced to Statistical Thinking in October, 1988 when I attended Heero Hacquebord's course on "Statistical Thinking for Leaders". I went into the course thinking that I already knew everything I needed to know about SPC. I came out of the course with a whole new perspective on statistics, looking upon SPC and other statistical applications more as a way of thinking about processes so we can learn how to improve them. I also found that I could never again be satisfied with looking at numbers without graphical analysis. Tom Pohlen (Chemist at 3M)



Definition

Statistical Thinking is a philosophy of learning and action based on the following fundamental principles:

- All work occurs in a system of interconnected processes,
- Variation exists in all processes, and
- Understanding and reducing variation are keys to success



A Suggestion to Consider

- If you think you are already doing this, ask your students on their course evaluation to list the most important things they learned in the course, which they can apply to everyday life or business situations.

A Suggestion to Consider

Potential objectives for students coming out of introductory statistics, to satisfy business needs:

- Understand, and can apply to real problems, the fundamental concepts of statistical thinking
- Can appropriately apply basic tools (i.e., graphics and “quantitative literacy” tools) to real problems
- Can integrate basic tools into an overall approach to scientific inquiry
- Understand how more advanced tools could help them in their chosen profession

SUMMARY

- We cannot make students experts in all statistical techniques in one course.
 - If we could, why have any advanced courses?
- Agreement on specific, tangible objectives is necessary to obtain agreement on the right course.
- Other disciplines take a very different approach to the intro course, and stress understanding of the fundamental concepts of that field.
- This is the approach desired by employers in business.
- Applying this approach to statistics would result in objectives which stress understanding of statistical thinking over covering more techniques.

Six Sigma: Why Should Academia Care, and How Should it Respond?

Beyond the Formula

July, 2003

Roger Hoerl – GE Global Research

Outline

- What is Six Sigma?
- Why should academia care?
- Challenges to integration of Six Sigma into college curricula
- Some specific suggestions for integration
- One case study at Virginia Tech
- Summary

Six Sigma Overview

- Six Sigma is an overall quality (and business) improvement initiative, originally popularized by Motorola.
- It utilizes a five step improvement process:
 - Define: Identify and plan promising projects
 - Measure: Identify customer needs, and quantify defect levels.
 - Analyze: Determine root causes of defects.
 - Improve: Permanently eliminate root causes.
 - Control: Maintain gains over time.
- Team projects are run on a three month “drumbeat.”

Disciplined, quantitative methodology.

Six Sigma Overview

- Objective of projects is typically 90% reduction in defects, with ultimate goal of 3.4 PPM (6σ).
- Team projects are typically led by Black Belts (BB's), who are taught and mentored by Master Black Belts (MBB's).
- BB's and MBB's start out full time, with their previous positions back-filled.
- Tools used are traditional improvement tools: QFD, Seven Basic Tools, DOE, SPC, etc.

Statistics-based improvement for the masses.

Six Sigma Overview

“Strategy”

→ **M**easure

Product

→ **A**nalyze

or

→ **I**mprove

Service

→ **C**ontrol

“Cookbook”

- 1 *Select CTQ Characteristics*
- 2 *Define Performance Standards*
- 3 *Validate Measurement System*

Characterize

- 4 *Establish Product Capability*
- 5 *Define Performance Objectives*
- 6 *Identify Variation Sources*

- 7 *Screen Potential Causes*
- 8 *Discover Variable Relationships*
- 9 *Establish Operating Tolerances*

Optimize

- 10 *Validate Measurement System*
- 11 *Determine Process Capability*
- 12 *Implement Process Controls*

“Tools & Concepts”

- QFD
- *Process Mapping*
Measurement Systems

- Benchmarking/Baselining*
- *Process Capability*
7 Basic Tools

- *Design of Experiments*
Brainstorm & Workout

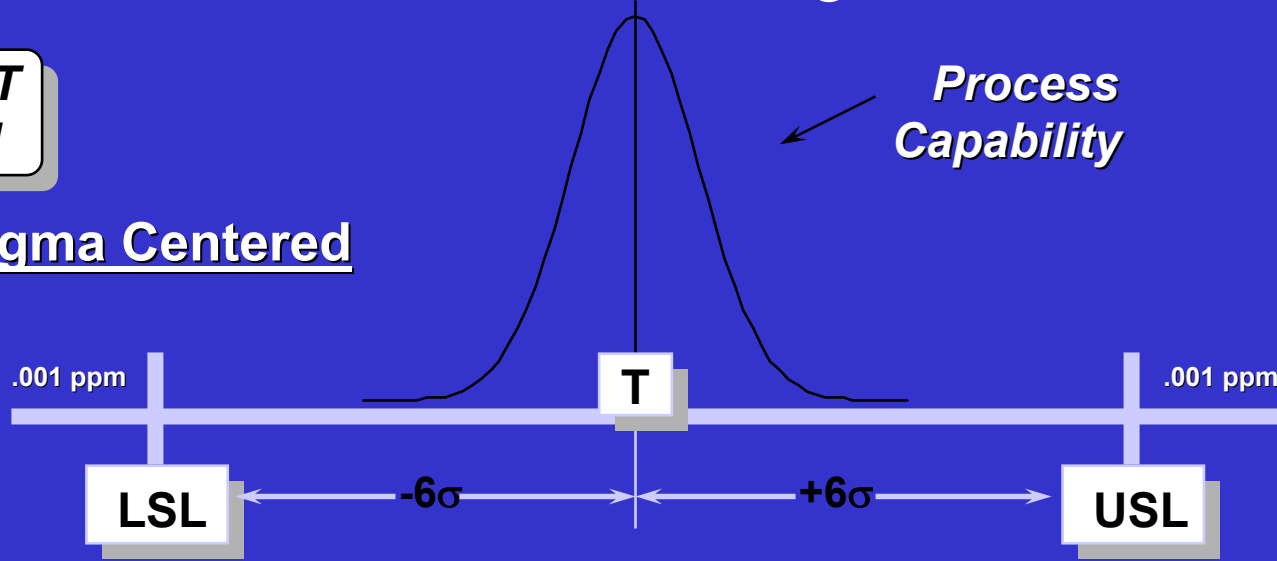
- Control Charts*
- *Procedures*
Training

Overview of Six Sigma

“Short Term Centered” versus “Long Term Shifted”

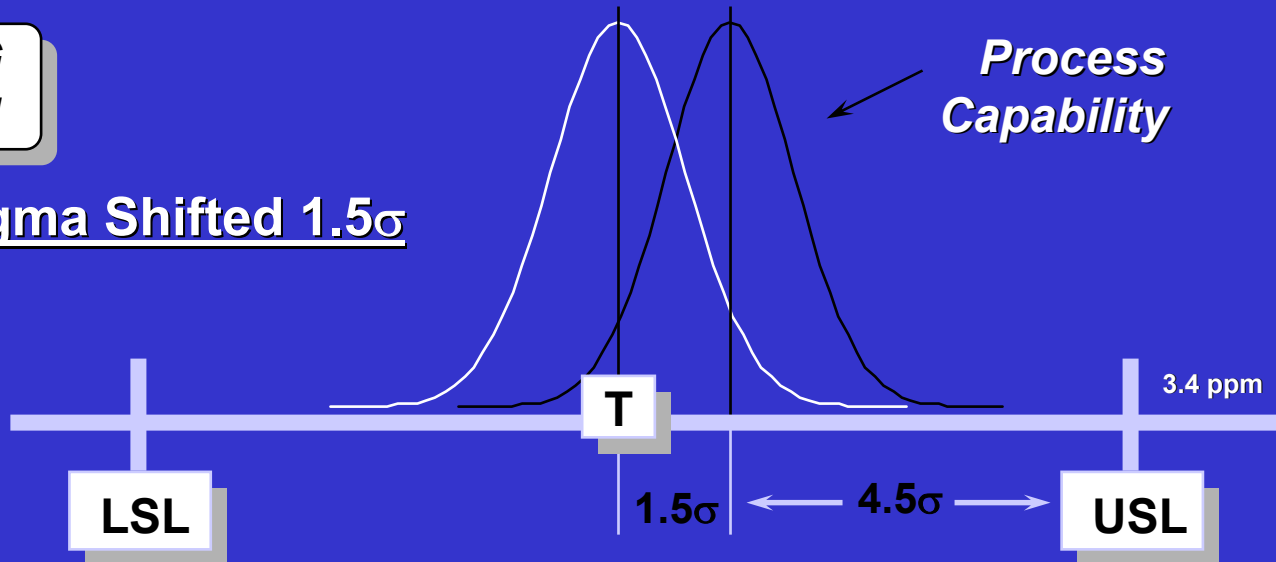
**SHORT
TERM**

Six Sigma Centered



**LONG
TERM**

Six Sigma Shifted 1.5σ



Higher Defect Level in Long Term Process Capability than Short Term Process Capability

How Is Six Sigma Different From Traditional Industrial Statistics?

- Few MBB's/BB's have statistical backgrounds.
- Six Sigma is being applied to all processes, including non-manufacturing processes, such as finance, accounting, human resources, sales, etc.
- Six Sigma provides an overall “road map” to help practitioners integrate the various tools into an overall approach to improvement (not a collection of tools!).
- Formal infrastructure is provided (budgets, roles, etc.)
- Variation is the focus, not a “nuisance parameter”.

Tools are not new; deployment strategy is.

GE's Experience

- GE invested about \$200 MM in 1996, mostly for training and back-filling for the MBB's and BB's. The return was about \$170 MM.
- In 1997, the investment was \$380 MM, and the payoff about \$750MM.
- By 1998, annual returns were consistently over \$2 billion.
- The savings come from reduced rework, waste, customer returns, etc., and do not document increased sales and customer satisfaction.
- Many other companies, e.g., AlliedSignal, 3M, and so on, have obtained similar results (on a % basis).

Huge, tangible impact on the US economy.

Why Has Six Sigma Been So Successful?

Some Important Attributes:

- Zealous leadership from the top.
- Focuses on improving the process (addresses root cause versus symptoms).
- Quantitative approach utilizing metrics.
- Forces understanding of variation.
- Provides practitioners an overall road map, versus a miscellaneous collection of tools.
- Uses a proven set of tools in the road map.
- Is being applied to all processes, not just manufacturing.
- Provides a supporting infrastructure (roles, project selection, reviews, included in budgets, reporting, etc.)

Any initiative sharing these attributes is likely to succeed.

Why Should Academia Care?

- Six Sigma is perhaps the largest statistical training initiative in history (measured in millions of people)
- It is having a huge impact on society (measured in billions of dollars)
- It is expanding from industry to business to healthcare to government and education
- It has presented our profession with a rare opportunity for a broad leadership role in something important to society
 - So far we have not stepped up to the plate, so others have
 - See further discussion in September 2002 Amstat News

It's time to put up or shut up!

Challenges to Inclusion of Six Sigma Into College Curricula

- Difficulty in cutting through the media hype to understand just what Six Sigma really is
- Lack of clarity on exactly where Six Sigma should be included in academic curricula
- Identifying something else to delete to make room
- Finding appropriate materials and case studies
- Persistent misconceptions:
 - Six Sigma is a fad
 - Six Sigma is not scientific
 - Six Sigma only applies to industry

How to do it is not obvious.

Some Specific Suggestions for Inclusion

- Add an elective graduate level Black Belt course to the curricula
- Incorporate the DMAIC process in introductory general, business, and engineering statistics courses
- Set up Black Belt internships for graduate students
- Jointly sponsor a DFSS course with an engineering college

There are many options.

Suggestions: An Elective Black Belt Course

- This course could be roughly equivalent to standard Black Belt training
- Opportunity for BB Certification would provide a significant benefit to students
 - Need real project
- Texts, articles, and case studies are now available
 - Remember that Six Sigma is not just statistics!
- Using adjunct faculty with MBB experience would be optimal
 - Angie Patterson at Virginia Tech is one example
- An elective course would not displace existing courses

Fairly painless option.

Suggestions: DMAIC Process in Intro Courses

- Some known major weaknesses of intro stat courses:
 - The integration of the tools into an overall process of scientific inquiry is not explicitly taught
 - Students therefore don't see any “big picture”; they see a miscellaneous collection of tools
 - As a result, students view applications as “one-shot studies”
- The DMAIC process is one means of providing an overall integration of the tools
 - It has been proven in a variety of application areas
 - It is easy to teach in a short amount of time
 - Numerous case studies have been published
- Reducing emphasis on hypothesis tests or probability would free up sufficient time to cover DMAIC

This is a no-brainer.

Suggestions: Black Belt Internships

- Private sector internships are the highlight of graduate statistics programs for many students
- Many small businesses cannot afford major Six Sigma initiatives, but would love to hire “ready to go” Black Belt interns
- GE, among others, needs more Black Belts for “at the customer, for the customer” projects
- Such internships would provide invaluable experience to the students, enhance their market worth, and possibly lead to dissertation topics

An opportunity to enhance graduate programs. ¹⁵

Suggestions: Joint DFSS Course With Engineering

- DFSS is a more specialized and complex methodology than DMAIC
- However, engineering curricula already include design courses, including specialized courses such as:
 - Concurrent design/engineering
 - Value-based engineering (similar to QFD)
 - Design for reliability
- A DFSS course would be a logical extension of such courses, and truly cross-disciplinary

This requires a little more effort.

A Case Study at Virginia Tech

- “Structured Process Improvement” taught by Angie Patterson at Virginia Tech, Fall 2002
- MS-level course taught out of the Stat Department
- Objective was to prepare students to execute, and possibly lead, Black Belt projects
- About 20 students signed up, mostly stat majors (due to late publicity)
- Most were 2nd year MS students
- Angie primarily used PowerPoint notes as her “text”

Significant student interest in novel course.

A Case Study at Virginia Tech

- Content of course:
 - Leadership skills (teamwork, project management, etc)
 - Six Sigma tactics (problem solving process)
 - Soft tools (QFD, process mapping, etc.)
 - Hard tools (DOE, regression, etc.) – using Minitab
 - Tangible project experience
- Angie assumed students had competency in statistical basics.
- Students worked on a real GE project, and completed a Six Sigma team project based on paper helicopters.

Broad mix of topics and experiences.

A Case Study at Virginia Tech

- Postscript:
 - Student evaluations were very positive
 - Stat Department is working with Dean to make this course a permanent part of curriculum
 - Christine Anderson-Cook is teaching this in Fall 2003
 - Team projects provided a valuable and unique learning experience
 - With hindsight, Angie may have assumed too much about MS students' statistical capabilities

Huge success – VT will continue course.

Return to Challenges

- Difficulty in cutting through the media hype to understand just what Six Sigma really is
 - Authoritative sources exist that do not oversell Six Sigma, e.g., Hahn et al. 1999, 2000
- Lack of clarity on exactly where Six Sigma should be included in academic curricula
 - See previous suggestions
- Identifying something else to delete to make room
 - Minimal deletions required
- Finding appropriate materials and case studies
 - See enclosed references
- Persistent misconceptions
 - Academia must be open-minded and want to do this (Friedman 2001)

We can make the changes if we want to.

Friedman's* (2001) Comments on Our Culture

- “Most statisticians seem to agree that Statistics is becoming relatively less influential among the information sciences.”
- “Perhaps more than at anytime in the past Statistics is at a crossroads; we can decide to accommodate or resist change.”
- “...we may have to moderate our tendency to disregard developments...that appear to work well, simply because the reasons for their success are not yet well understood by us.”

*Friedman, J.H.(2001), “The Role of Statistics in the Data Revolution?”, International Statistical Review, 69, 1, 5-10.

It's time to put up or shut up!

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Summary

- Six Sigma has created perhaps the largest statistical training initiative in history
- All statisticians who care about the future of our profession should care about Six Sigma
- The next logical step is inclusion into academic curricula
- There are several challenges that need to be overcome to do this
- Some potential approaches to inclusion have been suggested, and one case study shared
- If the will exists, the challenges can be overcome