BY RONALD D. SNEE AND ROGER W. HOERL

Further Explanation

Clarifying points about statistical engineering

AS THIS COLUMN'S name suggests, the purpose of a roundtable is to facilitate discussion. Here, we want to facilitate discussion on statistical engineering.

Since publishing our ideas on statistical engineering earlier this year in QP, we have received questions on the what, why and how of the approach. This dialogue will only enhance understanding and development of statistical engineering.

We defined statistical engineering as "the study of how to best use statistical concepts, methods and tools and integrate them with IT and other relevant sciences to generate improved results."[1]

Such an approach, while not new, is not widely practiced, not taught at universities and not covered in textbooks. Through the use of statistical engineering, the impact of statistical thinking and methods will increase, and the art, science and technology of statistical problem solving will be better understood, used and rewarded.

The following are some critical questions and concerns from those evaluating and debating statistical engineering's merits.

Is statistical engineering new? Isn't this what statisticians already do? This is asked early in any conversation on statistical engineering. The short answer is no. Some veteran statisticians have been performing statistical engineering for some time, but too often in an ad-hoc manner. The profession hasn't focused on statistical engineering, and there is no system available to guide the use of the approach. As a result, statistical engineering has been underused, and its theoretical foundation is not well developed. There are few articles on the subject, no books on the approach as we defined it, and it is not taught in universities.

Does statistical engineering refer to engineers using statistics or to the application of statistics to engineering problems? Absolutely not. Think about computer engineering. Does this refer to engineers using computers, or to the application of computers to engineering problems? It refers to the engineering of computer technology, which can be applied in finance, healthcare, academia or any other field. You do not have to be an engineer to use a computer, even a computer that was properly engineered.

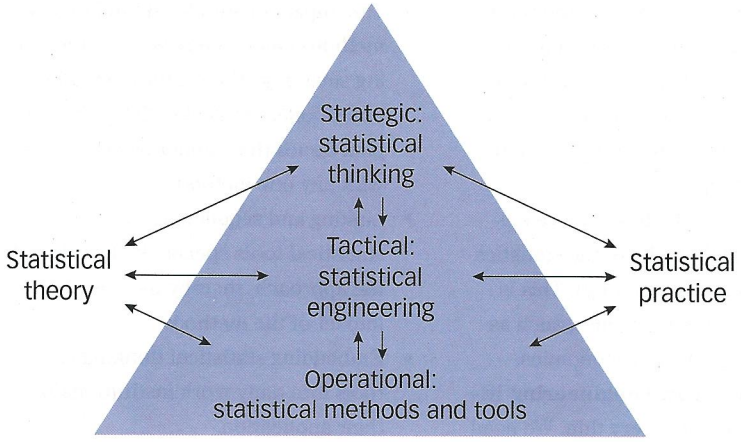
Won't the term statistical engineering turn off some people? Why is new terminology needed? Terminology is important. Statistical engineering is different and, therefore, needs different terminology. We selected the term because it thoroughly describes what we are proposing. We are using the terms in their literal, dictionary sense. Engineering is the noun describing what we are doing. Statistical is the adjective that modifies the noun, describing the area we are engineering.

The definition of statistical engineering reflects what engineering does; it integrates known methods and tools to solve problems for the betterment of humankind. The big idea is the approach, not the terminology. Use and debate over time will sort out what's the best terminology. The one constraint is that the terminology needs to be accurate, otherwise there will be confusion.

How do all these concepts (statistical engineering, statistical science, statistical thinking and statistical methods) fit together? We fit these terms together in Figure 1 by depicting the statistics discipline as a system, rather than as a collection of tools. Statistical thinking is the strategic aspect of the discipline, providing a philosophy on how to think about statistics and its application.[2]

After people understand the philosophy of statistics (why, when and where it should be used to drive impact), they need an overall approach to attack big, unsolved problems that cannot be solved with only one method. Statistical engineering can provide the tactical approach

The statistics discipline as a system / FIGURE 1



to implement the philosophy.

One example is through the integration of diverse methods to provide an overall approach to problem solving or process improvement, such as lean Six Sigma. Of course, to make an impact, you need the actual statistical methods and tools; this is where the rubber meets the road.

Further, theory needs to guide you—not only the mathematical theory of the methods themselves, but also a well-developed theory of statistical thinking and statistical engineering.

There needs to be a rigorous discussion and debate within the profession on the best philosophies of why, when and where statistics should be applied (statistical thinking) and the best approaches to integrate the methods and drive more universal application (statistical engineering).

Similarly, the profession must learn and document how statistical thinking, statistical engineering and the statistical methods and tools apply in practice to advance our ability to properly apply the theory.

How is statistical engineering different? Isn't it just a fancier term for good ol' fashion applied statistics? Traditionally, applied statistics has referred to the application of individual statistical tools to real problems. This definition must be broadened to include the application of statistical thinking and statistical engineering.

Statistical engineering, on the other hand, is the building of something novel from the statistical parts list of tools—something bigger than individual tools. There is creativity involved in how the solution is developed and how the tools are linked and sequenced to build and sustain the solution. This is illustrated in Figure 2 and Figure 3 (p. 70).

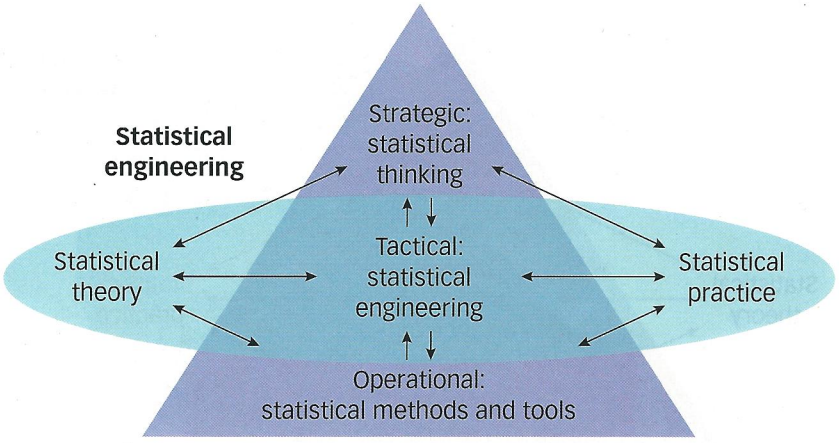
In Figure 2, statistical engineering, the formal study of how you can drive greater practical impact from the existing science (theory) of statistics, is essentially a horizontal slice of the model, connecting statistical theory with statistical practice.

In Figure 3, applied statistics includes the application of statistical thinking, statistical engineering, and statistical methods and tools to real problems. It is essentially a vertical slice of the model. Of course, all of these concepts need to be tightly integrated, as we hope is clear in Figure 1.

Should statistical engineering be used on all problems? No, it is not always needed. The hallmarks of typical problems requiring a statistical engineering solution are as follows:

- The solution will satisfy a high-level need of the organization.

The statistics discipline as a system: statistical engineering / FIGURE 2



Statistical engineering is a discipline that studies how to drive greater improvement using he existing science or theory of statistics. It is, therefore, a horizontal slice connecting statistical theory with statistical practice.

- There is no known solution to the problem.
- The problem has a high degree of complexity involving technical and nontechnical challenges.
- More than one statistical technique is required for the solution. Typically, nonstatistical techniques are also required.
- Long-term successes require embedding solutions into work processes, typically through using custom software and integrating with other sciences and other disciplines.
- The whole is greater than the sum of the parts. The impact is greater than what could be achieved with individual tools.
- Theoretical foundation is needed to guide solution development. We understand why it works.
- The solution can be leveraged to similar problems elsewhere. It's not just a one-off.

How should statistical engineering be addressed in statistical education? Today, statistical education focuses solely on statistical science. There are a few exceptions, such as Virginia Tech and North Carolina State universities, that offer lean Six Sigma courses.[3] In the future, there must be a balanced presentation between the tools themselves and what can be built with them—that is, solutions to real problems requiring more than one statistical technique.

We also would like to see more emphasis on the philosophy of the statistics discipline (statistical thinking). This is done in many other disciplines, such as physics, engineering and economics.

Is there statistical engineering literature? Yes, but it is very thin. We need much richer literature and more rigorous research on statistical engineering. A high priority should be innovative case studies that would show people the approach in action and identify limitations in the theory, strategy, methods and tools that require further work.

What is the underlying theory of statistical engineering? While some parts of this theory are not well developed, other key elements are:

- A system or strategy is needed to guide effective application of statistical tools.
- The impact of statistical thinking and methods can be increased by integrating several statistical tools, enabling practitioners to deal with highly complex issues that cannot be addressed with any one method.
- Linking and sequencing the use of statistical tools speeds the learning of the approach, thereby increasing the impact of the methods.
- Embedding statistical thinking and tools into daily work institutionalizes their application.
- Viewing statistical thinking and methods from an engineering context provides a clear focus on problem solving that benefits humankind.[4]

This is a starter set. This theory should be compared to the results and experiences of case studies to identify areas for improvement in the theory.

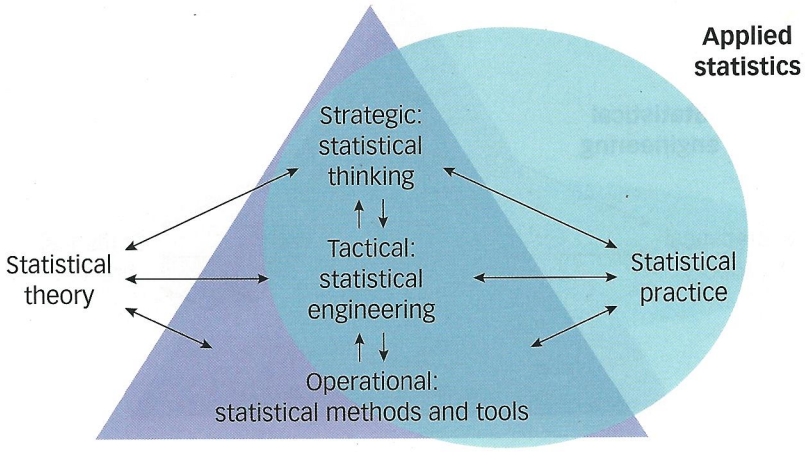
Are there other examples of statistical engineering? There are many, including the use of designed experiments and other tools to address a credit card collections problem, the strategy and planning system, the product quality management system,[5-6] process variation reduction[7] and the Strategy of Experimentation method developed at DuPont.[8-9]

More is needed and will appear as statistical engineering is discussed and debated at professional meetings, in journals and elsewhere.

If statistical engineering is different, are there new skills needed to be successful? It does require some, in addition to the skills required for using statistical thinking and methods effectively to solve problems and improve processes.

In particular, statistical engineering requires leadership skills and business acumen in the form of assessing the impact—financial and otherwise—of issues and

The statistics discipline as a system: applied statistics / FIGURE 3



Applied statistics is the application of statistics to real problems and is, therefore, a vertical slice involving statistical thinking, statistical engineering and statistical methods.

Statistical engineering is **the building of something novel** from the statistical parts list of tools—something **bigger than individual tools.**

proposed changes to an organization, its products, services and processes. Having a major impact on an organization requires the ability to successfully lead projects that produce significant bottom line results.[10]

One of the more important skills needed is being able to determine the financial impact of a proposed improvement.

An effective approach is to join forces with the financial organization. Consider finance professionals as partners and allies, rather than adversaries.

You will need to learn from each other: how to identify improvements and then how to turn improvements into financial value. An effective byproduct of such an arrangement is that finance will support and defend the financial value of your work, removing this burden from your responsibility.

Do I really need to be a leader? Isn't that the manager's job? The importance of leadership is clear when we recognize that statistical engineering is about improving processes and systems, and the deployment of changes needed to implement and sustain the improvements.

These changes also require altering how people think about things—the philosophy of the statistics discipline. Leaders help people and organizations move from one way of thinking and working to another. To be successful with statistical engineering, leadership skills are required.

Those specific skills include: strategic planning and deployment, process and

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systems thinking, structured improvement methods such as lean Six Sigma, stakeholder building, project planning, management and review, building and leading teams, and meeting design and facilitation.[11]

The good news is these tools are well developed, and training and literature are readily available. The remaining critical ingredient—the will to learn and work in new ways—must come from the statistical engineering practitioners.

I work at a nonprofit organization. Some statisticians are employed by government entities. We don't have a bottom line. Can statistical engineering still be useful? Yes. All organizations have bottom lines. For nonprofits, the bottom line is their budgets.

By using statistical engineering concepts, methods and tools to identify and solve high-impact problems and issues, you will help the organization better meet its budget and, even more importantly, enable the organization to make its budget go further, doing more with what you have.

As nonprofit leaders have told us: "No margin, no mission." In other words, if you don't handle your finances well, you won't be able to achieve the mission of the nonprofit.

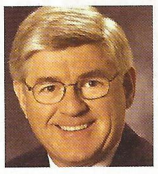
More discussion necessary

The development and use of statistical engineering is different from the development of new statistical methods and tools. Statistical engineering is more complex and requires more discussion and debate.

The conscious collection of issues and concerns and constructive debate in forums such as this column will help us speed up the development and use of the approach. QP

REFERENCES

1. Roger W. Hoerl and Ronald D. Snee, "Closing the Gap: Statistical Engineering Can Bridge Statistical Thinking With Methods and Tools," *Quality Progress*, May 2010, pp. 52-53.
2. Roger W. Hoerl and Ronald D. Snee, *Statistical Thinking—Improving Business Performance*, Duxbury Press, 2002.
3. Ronald D. Snee and Roger W. Hoerl, *Leading Six Sigma—A Step by Step Guide Based on Experience With General Electric and Other Six Sigma Companies*, FT Prentice Hall, 2003.
4. Roger W. Hoerl and Ronald D. Snee, "Tried and True—Organizations Put Statistical Engineering to the Test and See Real Results," *Quality Progress*, June 2010, pp. 58-60.
5. D. W. Marquardt, ed., *PQM: Product Quality Management*, E.I. DuPont de Nemours & Co. Inc., Quality Management and Technology Center, 1991.
6. Joseph M. Juran and A. Blanton Godfrey, *Juran's Quality Handbook*, fifth edition, McGraw-Hill Professional, 1998.
7. Stefan H. Steiner and R. Jock MacKay, *Statistical Engineering—An Algorithm for Reducing Variation in Manufacturing Processes*, ASQ Quality Press, 2005.
8. Roger W. Hoerl and Ronald D. Snee, "Post-Financial Meltdown: What Do the Services Industries Need From Us Now?" *Applied Stochastic Models in Business and Industry*, December 2009, pp. 509-521.
9. Roger W. Hoerl and Ronald D. Snee, "Moving the Statistics Profession Forward to the Next Level," *The American Statistician*, February 2010, pp. 10-14.
10. C.G. Pfeifer, D.W. Marquardt and Ronald D. Snee, "A Time for Change," *Chance: New Directions for Statistics and Computing*, Vol. 1, No. 1, 1988, pp. 39-42.
11. Ronald D. Snee and Roger W. Hoerl, "Statistical Leadership: As Traditional Workplace Roles Change, Learn to Transition From Consultant to Leader," *Quality Progress*, October 2004, pp. 83-85.



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