(Multifactor) DOE for Non-Manufacturing (Processes)

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*Peer reviewer of “Applying design of experiments (DoE) to optimize the performance level of a curling sport team”, submitted to the International Journal of Quality & Reliability Management

Maximizing this educational opportunity

Welcome everyone! To make the most from this webinar:

- Attendees on mute
- Chat addressed afterward
- Send further questions to mark@statease.com

PS: Presentation posted to www.statease.com/webinars/

👉 Please press the raise-hand button if you are with me.
Talking Points

- The multifactor tools of design of experiments (DOE), though proven for manufacturing quality improvement, remain underutilized in service, business administration, and other transactional processes.

  “Over 40% of the process improvement professionals in the service sector do not have any hands-on experience with the application of DoE.”

- For inspiration, this presentation reveals several successful DOEs done for non-manufacturing applications.

- Hopefully, this will provide inspiration for more use of this powerful testing tool by six sigma professionals beyond its current silo of manufacturing.

Agenda

- Many non-mfg processes ripe for multifactor testing
- Application to sales and marketing
- Making training more effective
- Improving delivery time
- Many other successes
- Take-homes
Many non-manufacturing processes ripe for multifactor testing

- Gleaned from January 2021 ISSSP webinar by Kevin Keller and his experience working on dozens of “Non-Traditional Applications of Lean Six Sigma Methodology”: logistics (supply chain!), human resources, procurement, finance, legal, sales and marketing.
- From internet surfing many other arenas mentioned by six sigma consultants: healthcare, restaurants, accommodations (e.g., hotels), public transportation (e.g., airport security), retail and other service industries.
- Any processes, often transactional in nature, that do not involve the making of goods (things or stuff). Too many to enumerate!

DOE Works on Any Process: It’s a blank slate!

DOE is:

“A series of tests, in which purposeful changes are made to input factors, to identify causes for significant changes in the output responses.”
Challenges Doing DOE on Non-Manufacturing Processes

- People often involved who cannot be easily manipulated or readily chosen and treated at random under circumstances amenable to the “gold standard” of a double-blind test protocol.
- A lack of understanding or appreciation for natural variability, e.g., my paper helicopter experiments for Six Sigma training at Fisher College of Business, Ohio State University being very consternating for accountants because flight times and distance from target differed from drop to drop and between true replicates.
- Resistance from domain experts to planned, multifactor empirical testing is mighty (across the board, manufacturing or not).

Nonetheless, those seeking process improvement must consider deploying DOE!

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Application to sales and marketing

- By far the most non-manufacturing DOEs can be found in S&M.
- It’s the ‘secret sauce’ for internet sellers such as Amazon.
  “Tests at Microsoft in 2012 revealed that a tiny adjustment in the way its Bing search engine displayed ad headlines resulted in a 12% increase in revenue, translating into an extra $100 million annually for the company in the U.S. alone.”
  - Thomke, Experimentation Works: The Surprising Power of Business Experiments
- Retail stores such as Best Buy use multifactor testing for point-of-purchase optimization and many other for maximizing sales.
- Sadly, most of the experimentation is restricted to “A/B” splits, e.g., using tools in MailChimp for testing options in email blasts.

DOE reveals interaction in web page design that leads to a breakthrough improvement

A replicated, full, two-level factorial design produced a 5-fold increase in clicks. The key turned out to be the combination of going to a modern font (factor A) with a more compelling button label (C). A third factor (B), background being white versus blue, did not create a significant effect, providing valuable insights on the drivers for conversion.

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An experiment designed (badly) for a six-sigma project to improve training  

Nachtsheim & Jones report in “DOE in Six Sigma: Getting to the Root Cause”* a simple-comparative DOE (a la an A/B split) done on a team of programmers at a large insurance company. All were offered a workshop on a new coding tool. About half accepted. As seen on the effect graph, volunteers rated significantly higher (LSDs gapped) per their managers’ assessment.  

Flaws: Single factor, self-selection, not blinded either for subject or evaluator. But on the right track!  

*August 2003, *Six Sigma Forum Magazine
A far better project by Mannington Mills of the impact of training on defect reduction (1/3)

IPO Map: Inputs => Process => Outputs

*Source: 2nd Annual Lean Six Sigma Summit, Nov. 16-18, 2005, Dallas.

Averaging >50% defect 🎉

DOE for Non-Mfg

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A far better project by Mannington Mills of the impact of training on defect reduction (2/3)

Their team set up a $2^3$ full factorial and ran it in random order. Here are the results.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>Response</th>
<th>Defect Rate</th>
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<tbody>
<tr>
<td>1</td>
<td>Few</td>
<td>No</td>
<td>Small</td>
<td>0.48</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Many</td>
<td>No</td>
<td>Small</td>
<td>0.66</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Few</td>
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<td>Small</td>
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<tr>
<td>4</td>
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<td>Small</td>
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<td>8</td>
<td>Many</td>
<td>Yes</td>
<td>Large</td>
<td>0.56</td>
<td></td>
</tr>
</tbody>
</table>

DOE for Non-Mfg

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A far better project by Mannington Mills of the impact of training on defect reduction (3/3)

The analysis revealed two strong main effects that led to a major improvement in quality.

<table>
<thead>
<tr>
<th>Standardized Effect</th>
<th>Half-Normal % Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: Items</td>
<td></td>
</tr>
<tr>
<td>B: Train</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>0.00</td>
</tr>
<tr>
<td>Few</td>
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<tr>
<td>Many</td>
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<td></td>
<td>0.21</td>
</tr>
<tr>
<td></td>
<td>0.28</td>
</tr>
</tbody>
</table>

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Improving a beverage bottler’s delivery time

An industrial engineer asked two workers to move 40 cases of glass versus plastic 32-ounce bottles 50 feet on a standard hand-truck and stack them on to a display, requiring that they do so four times over to develop power (and muscles!). The IE measured the delivery time (left) and elevation of the workers’ pulse rates (right) for all 16 runs ($2^2 \times 4$).

<table>
<thead>
<tr>
<th>Bottle Type</th>
<th>Worker 1</th>
<th>Worker 2</th>
<th>Worker 1</th>
<th>Worker 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass</td>
<td>5.12</td>
<td>4.89</td>
<td>6.65</td>
<td>6.24</td>
</tr>
<tr>
<td></td>
<td>4.98</td>
<td>5.00</td>
<td>5.49</td>
<td>5.55</td>
</tr>
<tr>
<td>Plastic</td>
<td>4.95</td>
<td>4.43</td>
<td>5.28</td>
<td>4.91</td>
</tr>
<tr>
<td></td>
<td>4.27</td>
<td>4.25</td>
<td>4.75</td>
<td>4.71</td>
</tr>
</tbody>
</table>

(Source: Montgomery, Design and Analysis of Experiments, 8th Ed., problem 6.9)

DOE for Non-Mfg

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DOE for Non-Mfg
Many other successes* (1/2)


- **Sensory**: A candy maker measured consumer acceptance of defects in the packaging of chocolate-covered cherries. They determined the acceptable thresholds for upside down or sideways candies as well as leakers.

- **Billing**: A large company reduced their receivables from 200 days to only 44 days, generating a large cash flow in the process. They studied 4 factors: billing with the shipment or on a separate invoice, automation, follow-up by letter or telephone, contract or in-house billing service. They ran only 8 of the combinations—a half-fraction. Two of the factors were highly significant.

- **Medical services**: St. Luke’s Hospital in Kansas City tested 7 factors to better educate patients on how to safely take Warfarin, an anti-blood-clotting drug, which can be fatal if used improperly. They achieved a 68% improvement in understanding by using a standardized instruction sheet and having a pharmacist discuss the drug.

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Many other successes (2/2)

- **Air traffic control**: To minimize communication delays, the FAA investigated 8 factors in 16 runs on a simulation model of its New York air traffic control system. Factors included number and location of navigation beacons and the mix of standard versus jumbo jets.

- **Sales**: A sales team greatly improved its success rate via a DOE on attire (suit or casual), number of salespeople (one or two), presentation (high pressure or low) and brochure (old or new).

- **Information systems**: A major telecommunications provider deployed a series of DOE’s to reduce outages, minimize order processing time, improve response times and increase sales-per-call-centers.

- **Sports**: As noted at the outset, a curling team (German) applied DOE to study the impact of sweeping, rotation and many other factors on accuracy and precision of their throws.

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Many non-mfg processes ripe for multifactor testing

Application to sales and marketing

Making training more effective

Improving delivery time

Many other successes

Take-homes

“One of the biggest concerns for senior managers in many service industries is that DOE is a very technical tool and it does not have many practical applications in the service industry, which deals with people instead of machines.

Consequently, we propose that senior managers in the service industry be introduced to DoE as a powerful tool to improve service performance, reduce the number of customer complaints, increase service efficiency, improve service reliability and increase sales revenue.

We also encourage the subsequent dissemination of the results with the necessary rigour and detail. Both of these recommendations could help achieve a small scientific community of experts in experimental applications [you all!] in the service industry to support and transfer knowledge to the sector for its constant growth and improvement of its quality and service.”

Take-Homes

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- For inspiration, this presentation reveals several successful DOEs done for non-manufacturing applications.
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References

DOE/RSM/Formulation Simplified Series*

Stat-Ease Training: Sharpen Up Your DOE Skills

- Modern DOE for Process Optimization
- Mixture Design for Optimal Formulations
- Private class tailored to your team

<table>
<thead>
<tr>
<th>Individuals</th>
<th>Teams (6+ people)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improve your DOE skills</td>
<td>Choose your own date &amp; time</td>
</tr>
<tr>
<td>Ideal for novice to advanced</td>
<td>Customize via select case studies</td>
</tr>
</tbody>
</table>

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Stay on for some chat if you like.