# DoE: Why even bother?

Extending the DoE toolbox to get deeper insights from multivariate experiments

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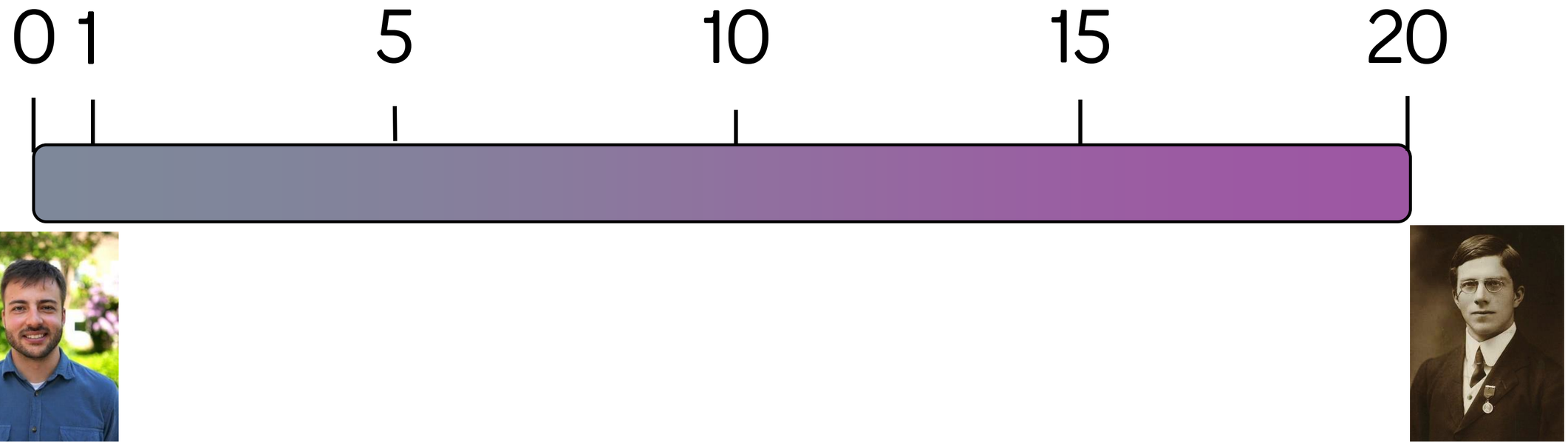
JMP STATISTICAL DISCOVERY

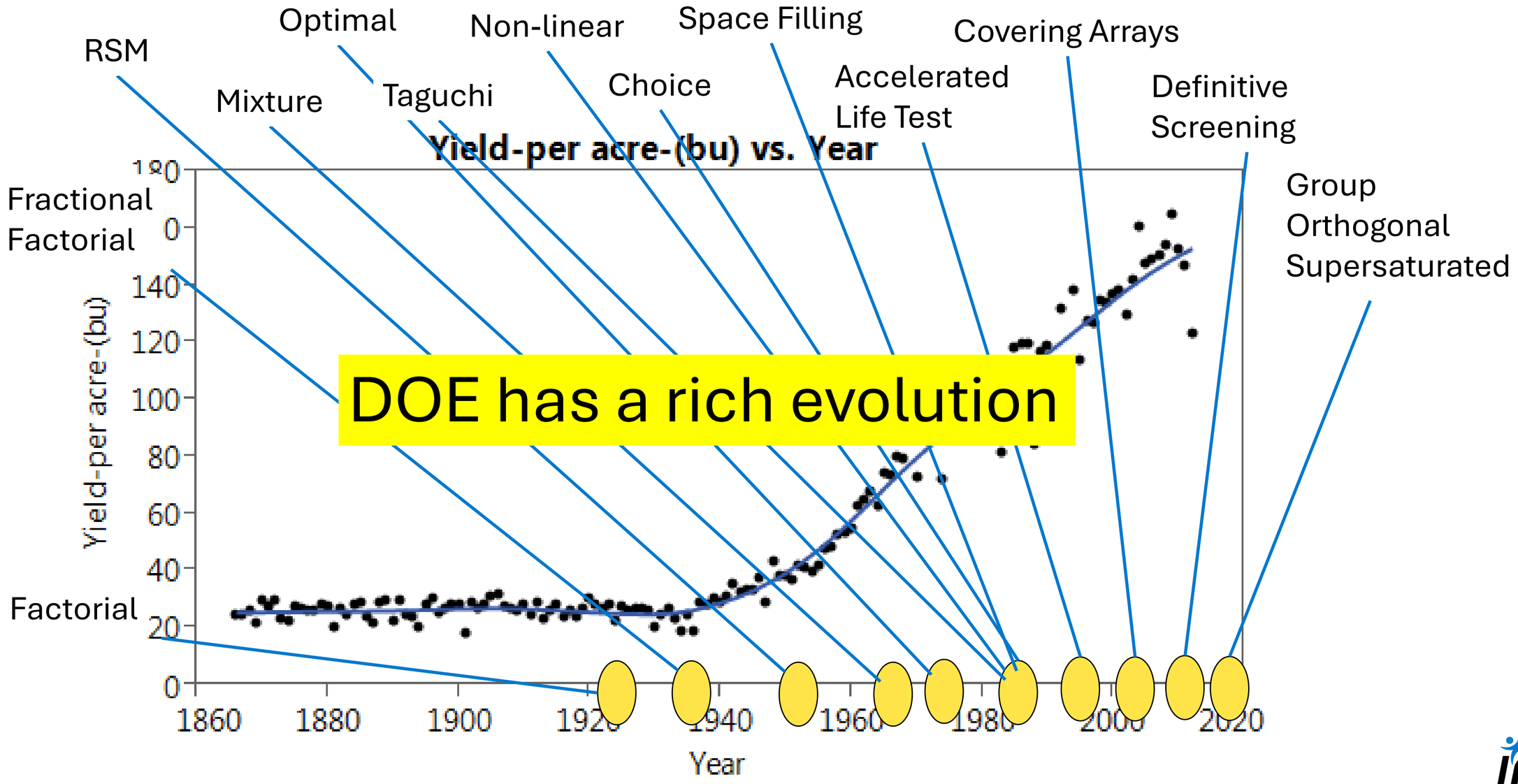
# What is your level/years of experience?

What am I doing here ?



# Evolution of Design of Experiments

It has a rich history



# How and where are companies using DoE and data driven solutions?

Common Problem-Solving Methodologies

| PDSA (PDCA) | DMAIC (Six Sigma) | A3 (Toyota) | 8D (Eight Disciplines) |
|---|---|---|---|
| Plan | Define | Clarify the problem | Form team and collect data |
| | Measure | Break down the problem | Describe the problem |
| | | Set the target/goal | Contain the problem (interim) |
| | Analyze | Analyze root causes | Analyze root causes |
| | | Develop countermeasures | Identify corrective actions |
| Do | Improve | Implement countermeasures | Implement corrective actions |
| Study (Check) | Control | Evaluate results | Implement preventive actions |
| Act | | Standardize success | Verify and congratulate team |

| | PDSA | DMAIC | A3 (Toyota) | 8D (Eight Disciplines) |
|---|---|---|---|---|
| Problem | | | Clarify the problem | Form team and collect data |
| | Plan | Measure | Break down the problem | Describe the problem |
| Cause | | | Set the target/goal | Contain the problem (interim) |
| | | Analyze | Analyze root causes | Analyze root causes |
| Solution | | | Develop countermeasures | Identify corrective actions |
| | Do | Improve | Implement countermeasures | Implement corrective actions |
| | Study (Check) | Control | Evaluate results | Implement preventive actions |
| Sustain | Act | | Standardize success | Verify and congratulate team |

general groupings of activities

DOE

Data

Statistical Problem Solving


Streamlined Processes

Analytics

What can we do to **change** that ?

How to implement a statistical and **data-driven** mindset?

How can **DoE** help itself?

# Quotes

Sir Ronald A. Fisher: "To consult the statistician after an experiment is finished is often merely to ask him to conduct a post mortem examination. He can perhaps say what the experiment died of."

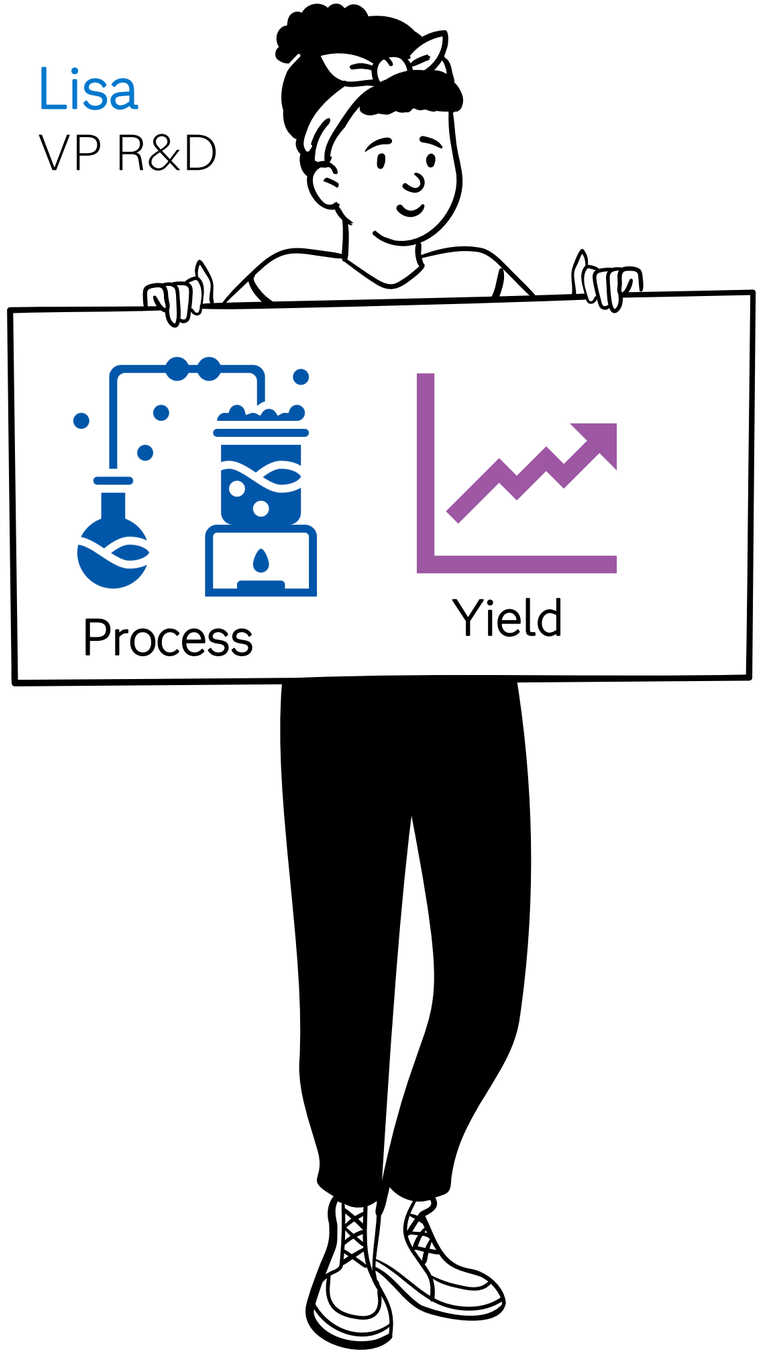
George E. P. Box: "All models are wrong, but some are useful. Experimental design helps us find the most useful models through a structured approach to learning from data."

Genichi Taguchi: "The most important aspect of quality improvement is in the design of the product and the manufacturing process. By using experimental design, it is possible to produce higher quality products at a lower cost."

Kaoru Ishikawa: "Quality control starts with the needs of the customer and ends with the customer. To meet those needs efficiently, scientific methods like DoE are indispensable."

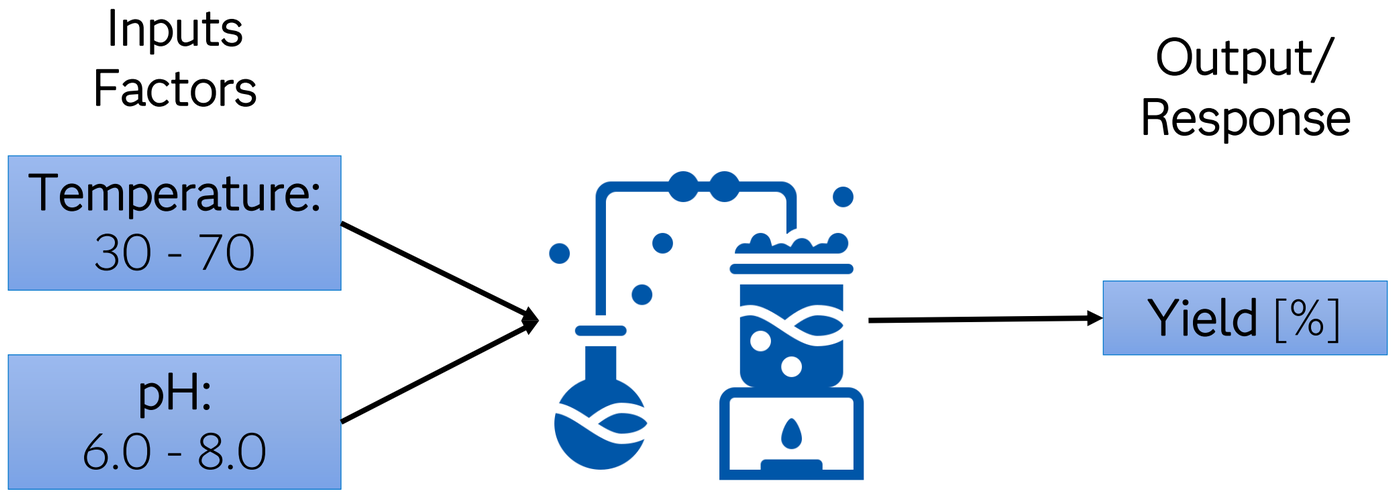
# A simple example

## Part 0: OFAT vs DoE

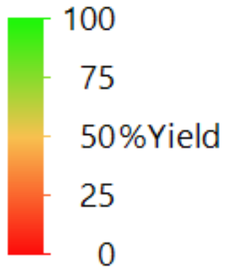


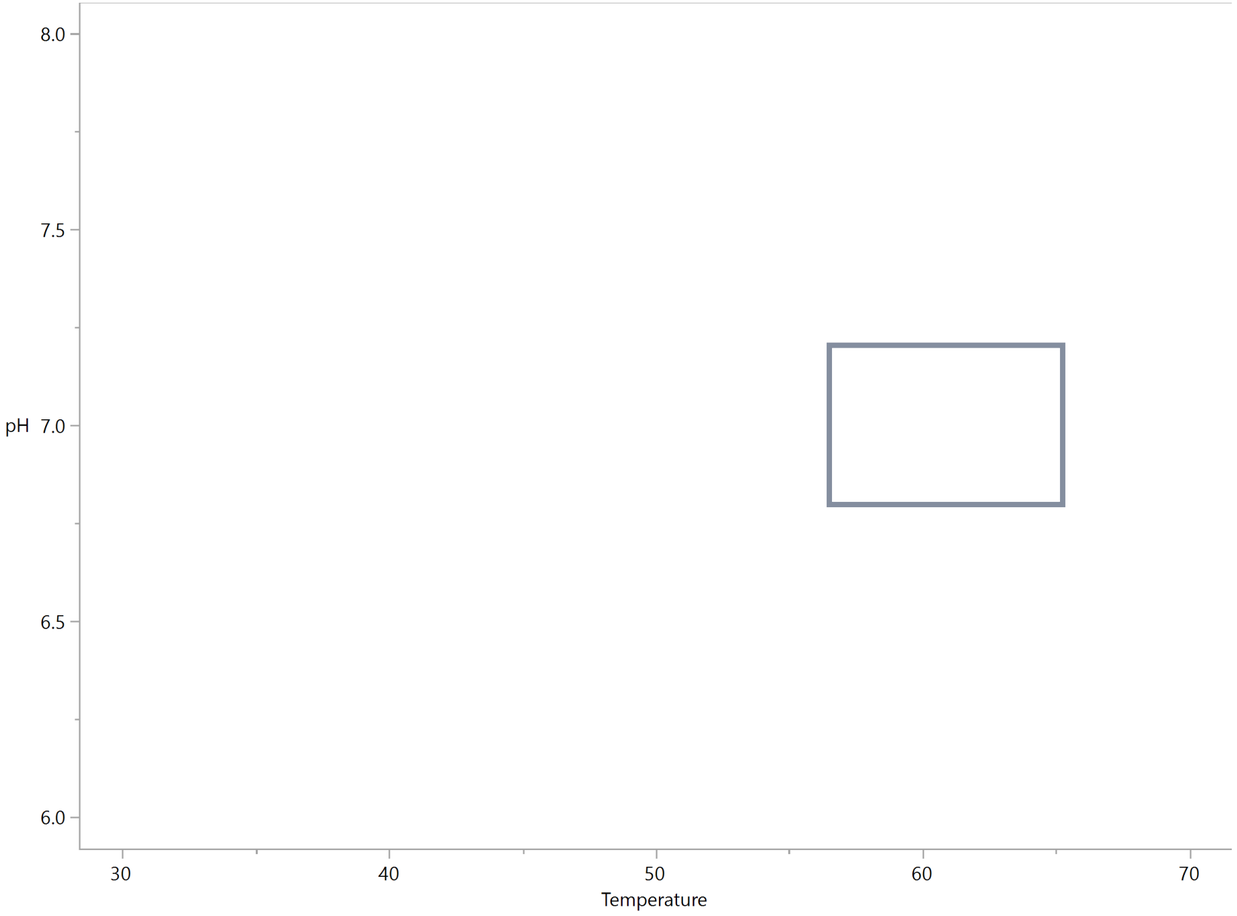

VP of R&D tasks two scientists:

"You both have **9 attempts** to maximise the **yield** of this process by changing only **temperature** and **pH**."

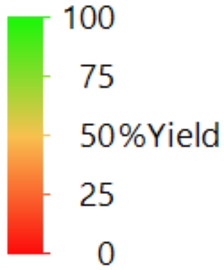


# Spyros

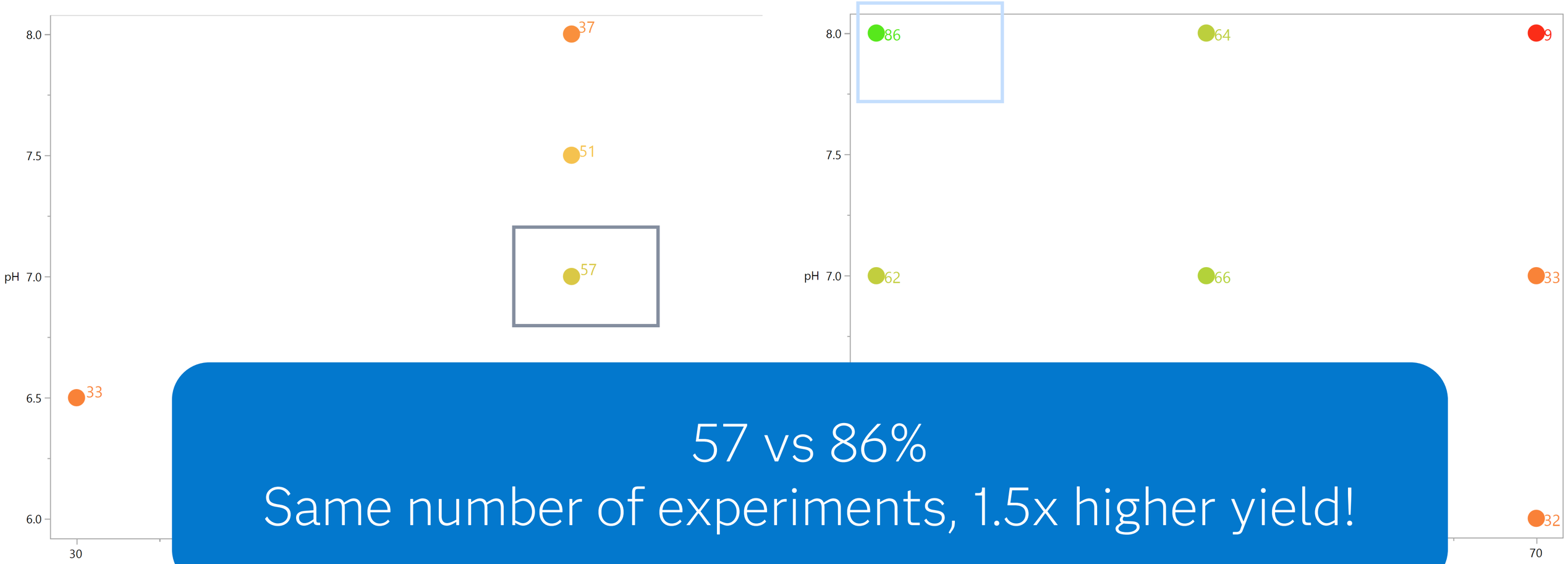


**Spyros**




**Marija**



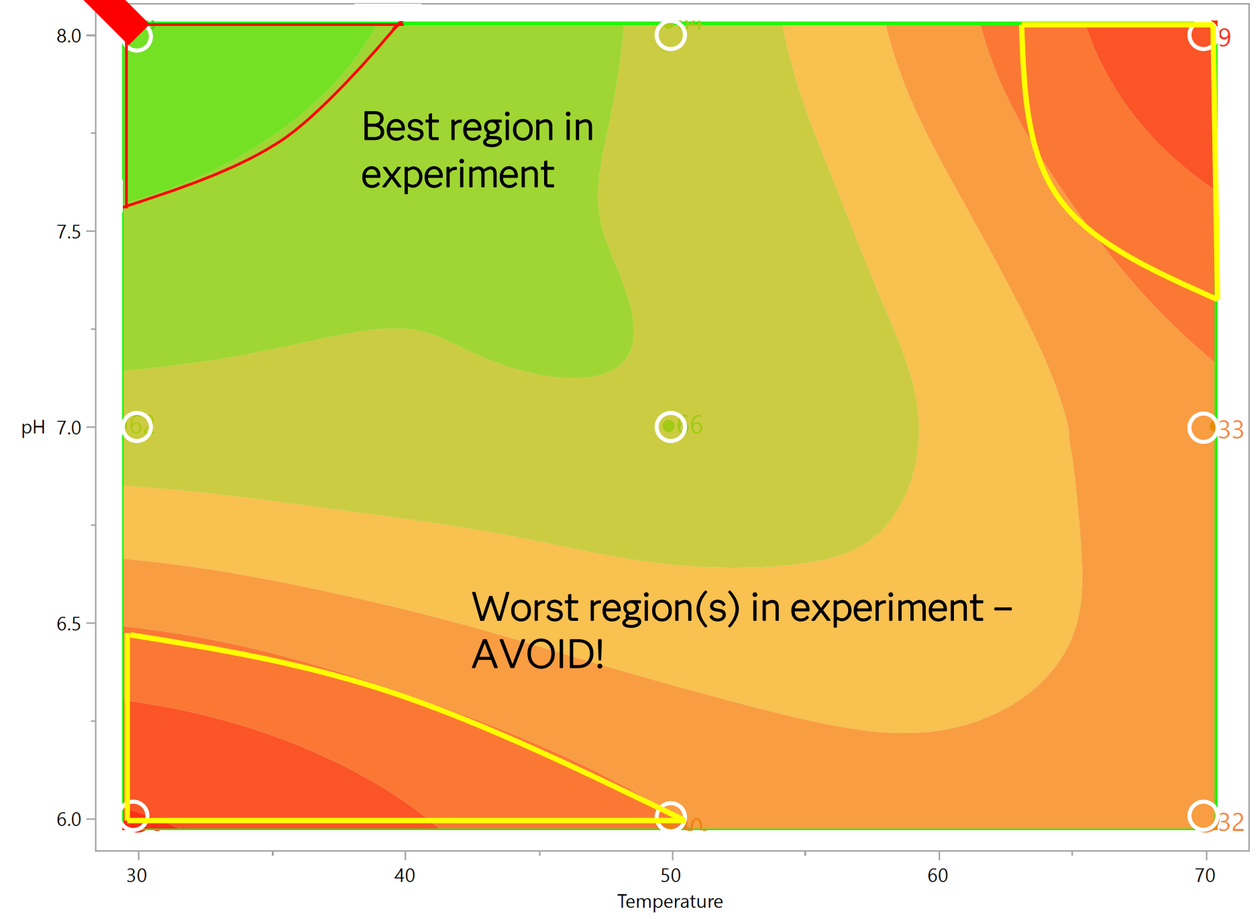

57 vs 86%

Same number of experiments, 1.5x higher yield!

# Spyros

Even better yields?

# Marija

# Customer Stories

## Part 1: The Novomer case

# Case Study: New Process Optimization

A company wanted to bring a catalyst to market that could <u>synthesise aliphatic polycarbonate polyols from waste carbon dioxide</u>

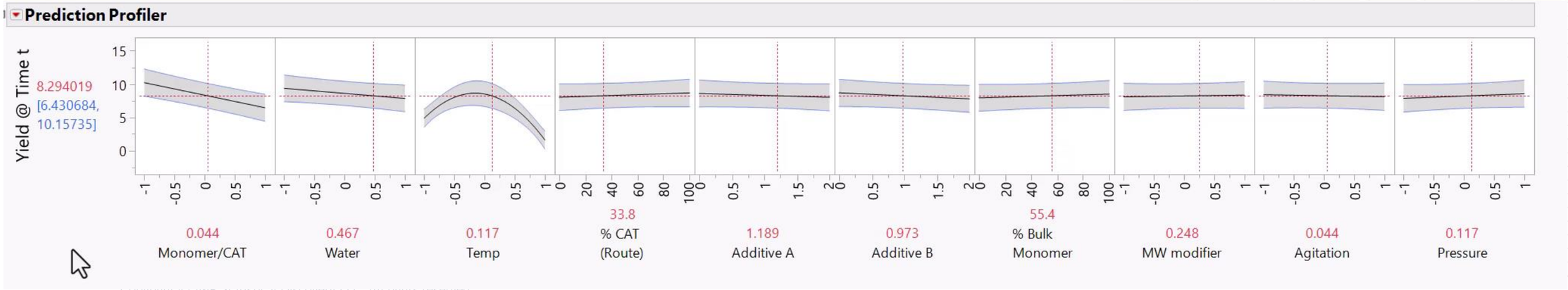
35 potential factors - Which way to go?


Identified top 10 factors with Data Mining

**Column Contributions**

| Term | Number of Splits | SS | Portion |
|---|---|---|---|
| Temp | 33 | 20.8820353 | 0.3152 |
| Monomer/CAT | 32 | 20.6150248 | 0.3112 |
| % CAT (Route) | 22 | 4.57679838 | 0.0691 |
| Water | 19 | 4.09873027 | 0.0619 |
| Additive A | 13 | 3.30497 | 0.0499 |
| Additive B | 19 | 3.13100209 | 0.0473 |
| Pressure | 15 | 2.92489544 | 0.0442 |
| MW modifier | 19 | 2.83586923 | 0.0428 |
| % Bulk Monomer | 18 | 2.08480677 | 0.0315 |

**Delivered insight needed to scale-up to 7500 litre capacity and sold business for $100M**




| | | | |
|---|---|---|---|
| 0 | -1 | 1 | 6.44 |
| 1 | -1 | 0 | 5.96 |
| -1 | -1 | -1 | 4.34 |
| -1 | -1 | -1 | 10.46 |
| -1 | -1 | -1 | 6.95 |
| 1 | 0 | -1 | 8.58 |
| 1 | 1 | 1 | 2.69 |
| -1 | 1 | 1 | 4.3 |
| 1 | -1 | -1 | 0.77 |
| 0 | 1 | -1 | 2.87 |
| 1 | 1 | 1 | 1.01 |
| 1 | -1 | 1 | 9.47 |
| 0 | 0 | 0 | 7.49 |
| -1 | 1 | 0 | 0.98 |
| -1 | 1 | -1 | 0.86 |
| 1 | 1 | -1 | 1.25 |
| -1 | -1 | 1 | 1.03 |
| -1 | 1 | 1 | 1.07 |
| 0 | 0 | 0 | 7.33 |
| -1 | -1 | -1 | 2.61 |

# Customer Stories

## Part 2: The Unilever case

# The first step

Can DoE achieve sustainability?

## Hypothesis

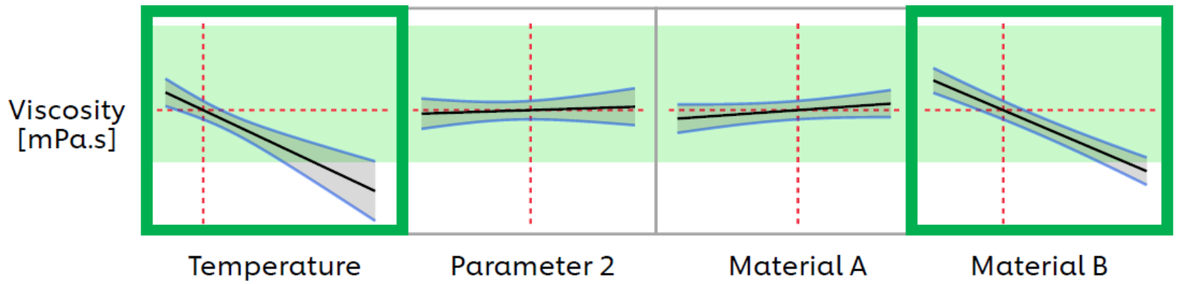
Which process parameters might influence the product

## Design of Experiments

Trialed designed experiments in pilot scale, to minimize cost and raw materials

## Identify and Optimize

Start modeling some of the quality parameters, identify actual critical control points




**Double-digit €Ms in material savings**
**Sustainability through energy reduction**

# Extending to everyone

## Building an active global community

**Global Community of Practice**

**20%**

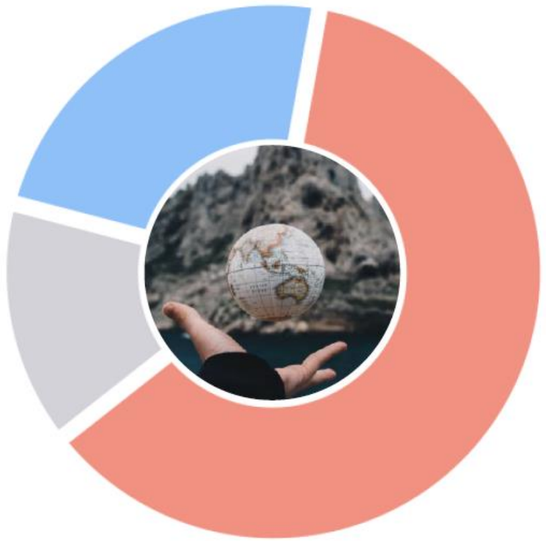
**Shared Learnings**

through regular sessions with all participants and mentors

**10%**

**Structured Training**

led by JMP champions working within Home Care Process Development



**70%**

**Delivering Impact**

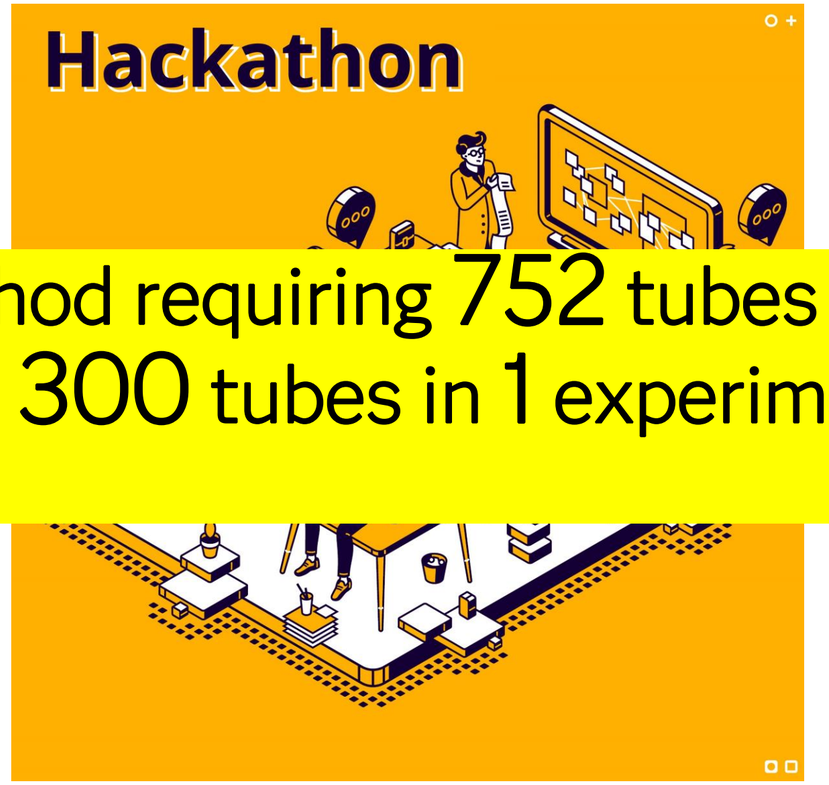
through key technologies in high-value projects

# Customer Stories

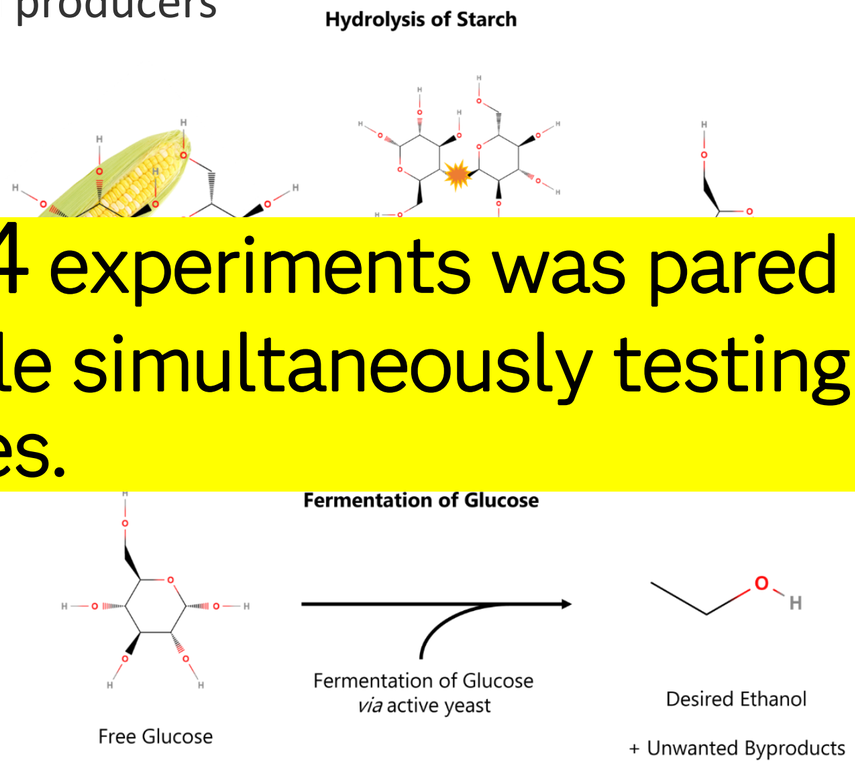
Part 3: The Novozymes case

# Diving past the surface of software at Novozymes

How Novozymes harnessed collaboration to spread analytic thinking across an organization




The selection of top-performing yeast strains to deliver to ethanol producers




A method requiring 752 tubes across 4 experiments was pared down to just 300 tubes in 1 experiment, while simultaneously testing more variables.

"The Hackathon was a chance to turn ideas into opportunities“: Michael Akerman, Data Scientist, Novozymes

# Key Learnings

## Extending the value

- Extend **DoE Toolbox**
  - There are steps before and after
  - DoE is an iterative/recursive process
- Extend **Knowledge**
  - Build upon your knowledge in DoE
  - Try to find new methods
- Extend **Use and Sharing**
  - Share results and stories of impact
  - Create a Community

# Links to stories

Share your own story

- Novomer Case: https://tinyurl.com/d33jtddv
- Unilever Case: https://tinyurl.com/mrynhzf3
- Novozymes Case: https://tinyurl.com/3v8k3nsx
- JMP's Customer Success Stories: https://tinyurl.com/3ddz46hn
- DoE Introduction Kit: https://tinyurl.com/yreaupmh

It's time to share your **story**...

# Thank you very much

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