

Effective DoE Implementation

Wolfson College, Cambridge
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Introducing Prism

- Independent company offering statistical training, consultancy and software services
- Founded in 2000
- Based in Cambridge, UK
- Consists of a small [team](#) of statisticians, trainers, programmers, scientists etc.
- **JMP Partner** for consultancy, training, software customisation and clinical trials



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Introducing Prism – here today

- Dr. Paul Nelson – Technical Director
 - Consultancy lead
- Chris Challis – Business Director
 - Contracts & project management
- Andrew Macpherson – Managing Director
 - Training lead



Seminar Overview

Accelerate Innovation with Design of Experiments:

- **Why?** Phil Kay
- **What?** Owen Jonathan
- **How?** Andrew Macpherson



How to implement DoE?

- Trial and error
- Self-taught study
- “Easy DoE” tool in JMP
- In-house expertise
- External support
 - Ad hoc, project-specific consultancy
 - Instructor-led training (on-site or online), e.g. our *Effective DoE Implementation* workshop



Benefits of Prism training

Our belief:

- Develop in-house expertise x10
- Industry-specific case studies
- Statistical concepts explained in plain English
- Interactive course structure & content
- Charming & witty trainers guaranteed*
- Delegates enabled to design and analyse their own studies

* Not legally binding



Benefits of Prism training

Previous *Effective DoE Implementation* workshop attendee:

- **“DoE is the most impactful thing I’ve learned about since undergrad (I’d say more valuable than a PhD!).**

Thanks for teaching me these skills – the Prism course was excellent.”

Our training feedback shows that:

- 99% of responses rate Course Content as Good or Excellent
- 98% of responses rate Presentation Quality as Good or Excellent
- <1% felt that our training would not be applicable to their own work
- More feedback info at prismtc.co.uk/training/training-course-feedback



Training Taster

Biotechnology case study: configure the settings of the fermentation process to meet the customer requirements.

- The factors which potentially affect the responses are:
 - Temperature 30 – 40 deg C
 - pH 6.8 – 7.2
 - DOT 10 – 40 %
 - Feed Rate 0.5 – 1.5 units/l
- The customer has specified the following criteria:
 - Product > 90 units/l
 - Impurity < 2 %
 - Unutilised Substrate < 3 %



Process Challenge

Use as few experiments as possible to determine how to configure the settings of the process in order to meet the customer requirements.

— Run Scenario

Factor	Value	Coded	Actual	Units	Response	Result	Criteria
Temperature	<input type="range" value="35"/>	<input type="text" value="0"/>	<input type="text" value="35"/>	deg C	Product		> 90 units/l
pH	<input type="range" value="7"/>	<input type="text" value="0"/>	<input type="text" value="7"/>		Impurities		< 2 %
DOT	<input type="range" value="25"/>	<input type="text" value="0"/>	<input type="text" value="25"/>	%	Unutilised Substrate		< 3 %
Feed Rate	<input type="range" value="1"/>	<input type="text" value="0"/>	<input type="text" value="1"/>	units/l			

RUN EXPERIMENT

Can you find an optimal combination of factor settings, where all responses pass specification simultaneously?



Process Challenge video

Factor	Value	Coded	Actual	Units	Response	Result	Criteria
Temperature	<input type="range" value="35"/>	<input type="text" value="0"/>	<input type="text" value="35"/>	deg C	Product		> 90 units/l
pH	<input type="range" value="7"/>	<input type="text" value="0"/>	<input type="text" value="7"/>		Impurities		< 2 %
DOT	<input type="range" value="25"/>	<input type="text" value="0"/>	<input type="text" value="25"/>	%	Unutilised Substrate		< 3 %
Feed Rate	<input type="range" value="1"/>	<input type="text" value="0"/>	<input type="text" value="1"/>	units/l			

RUN EXPERIMENT



How much process understanding do you have after 14 runs?

- Rank the parameters in order of importance.
- Any dependent relationships (interactions) between the parameters?
- What if one of the parameters is constrained?
- Estimate of background variability?
- How to control manufacturability & quality to minimise adverse impact on downstream processing?

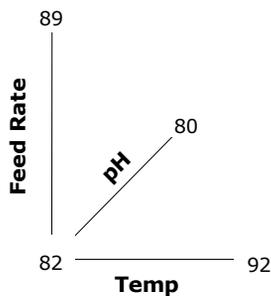
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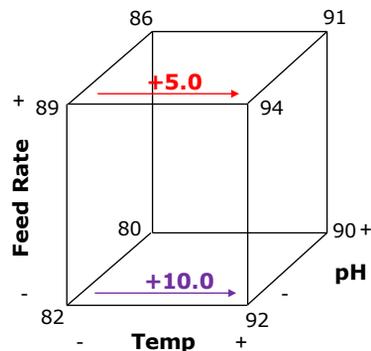
Compare Strategies

OFAT Design - varying One Factor at a Time provides estimates of effects at **set conditions** of the other factors and **no interaction effects**.

Factorial Design - provides estimates of effects at **different conditions** and therefore enables you to **estimate interactions**.



Response: Product

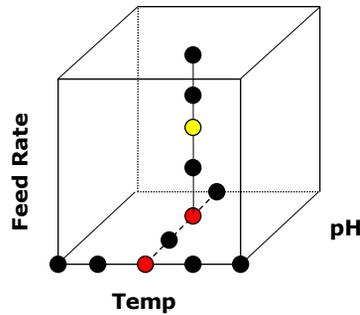


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Compare Strategies

OFAT - Does not cover the experimental space very well and may miss the optimal solution:

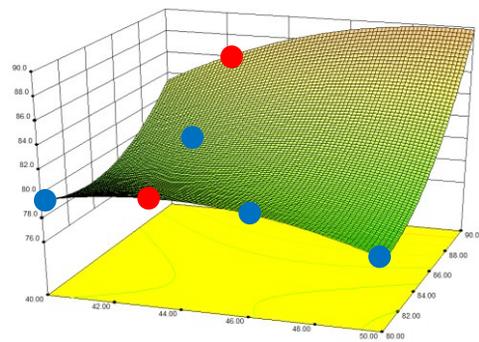
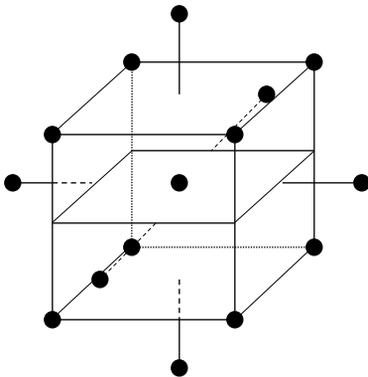


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Compare Strategies

DoE - Good coverage of space and locates solution with as few design points as is needed:



OFAT finds a **local** optimum; DoE finds the **global** optimum

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JMP design setup video

The screenshot shows the JMP DOE - Screening Design - JMP Pro interface. It is divided into three main sections: Responses, Factors, and Design List.

Responses:

Response Name	Goal	Lower Limit	Upper Limit	Importance	Lower Detection Limit	Upper Detection Limit	Units
Product	Maximize	90	units/L
Impurity	Minimize	.	2	.	.	.	%
Unutilised Substrate	Minimize	.	3	.	.	.	%

Factors:

Name	Role	Values	Units
Temperature	Continuous	30 40	deg C
pH	Continuous	6.8 7.2	
DOT	Continuous	10 40	%
Feed Rate	Continuous	0.5 1.5	units/L

Design List:

Choose a design by clicking on its row in the list.

Number of Runs	Block Size	Design Type	Resolution
8	4	Fractional Factorial	4 - Some 2-factor interactions
8	2	Fractional Factorial	4 - Some 2-factor interactions
16	8	Full Factorial	5+ - All 2-factor interactions
16	4	Full Factorial	4 - Some 2-factor interactions
16	2	Full Factorial	4 - Some 2-factor interactions

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JMP demo analysis

- Live software demo alert!! (Wish me luck...)

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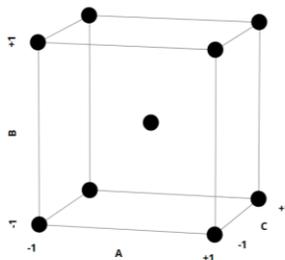
How much process understanding do you **now** have... after just 10 runs?

- Rank the parameters in order of importance.
- Any dependent relationships (interactions) between the parameters?
- What if one of the parameters is constrained?
- Estimate of background variability?
- How to control manufacturability & quality to minimise adverse impact on downstream processing?



... and there's more!

- After motivational activity and initial software exercise, we provide further details on:
 - Underlying DoE principles
 - Practical interpretation of statistical output
 - Different design types
 - Sequential DoE framework
 - Hands-on software practice
 - Plus much more!

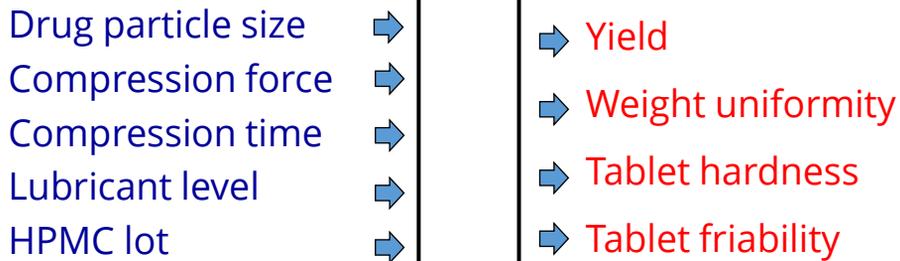


Please select coded axial value (based on 3 factors):

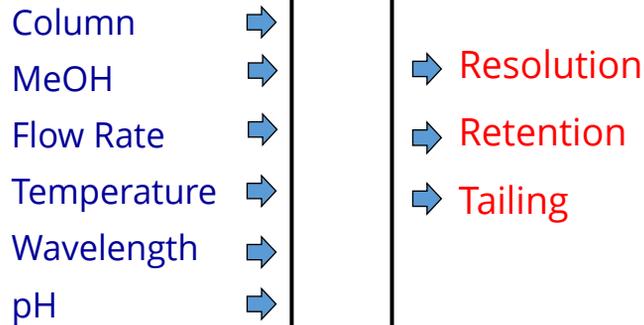
- None
- Rotatable (1.68)
- Spherical (1.73)
- Orthogonal Quadratic (1.52)
- Practical (1.32)
- Face Centred (1)
- Custom
- Box-Behnken



Industry-specific case studies

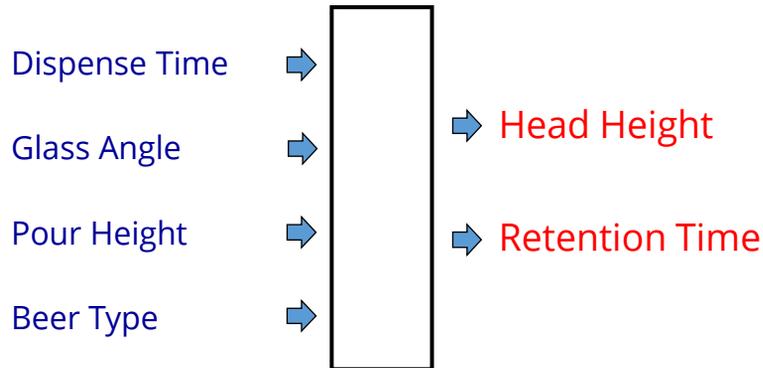


Industry-specific case studies





Non-industrial case study?



Why not have a look at how we ran this experiment?
Visit www.prismtc.co.uk/quality-beer-design



Conclusions

- DoE is awesome (DoE > PhD?)!!
- It can be beneficial in **any** industry or application area
- It offers a proven framework to help you maximise your scientific expertise
- It can be learned in various ways, but a 2-day workshop (4 online sessions) is ideal to get teams up and running
- If you're not using it already... why not?!?
Plan beats no plan!



Further information on Prism

- Effective DoE workshop info: prismtc.co.uk/effective-doe-workshop
- Our website: prismtc.co.uk
- Email us at info@prismtc.co.uk
- Talk to us today!

