Experimentation by Design Workshops

Our Experimentation by Design workshops have been refined over the last 25 years to include the latest methods and tools for experimental design. Over 5,000 professionals have attended these workshops worldwide. This methodology has helped create and optimize billions of dollars of leading products representing virtually all markets including:

- pharmaceuticals
- food
- beverages
- electronic equipment
- plastics
- construction materials
- catalysts
- mechanical design
- semiconductor materials
- integrated circuit processing
- metallurgy
- batteries
- composite materials
- adhesives
- automotive
- aerospace
- medical devices (stents)
- candy
- personal care products
- ceramics

The Basic DOE workshop gives attendees the knowledge AND skill to independently apply DOE methodology to their research. The integration of the methodology and the software provides the non-statistician long term ease of use of DOE. Studies have shown that over 90% of those having taken this workshop were still using DOE 3-years later.

The Advanced DOE and Using Mixtures/Formulations workshops deliver sophisticated application of DOE to more complex development systems.

Finally, the most important part of any Experimentation by Design effort is an environment which supports rather than undermines the use of these powerful techniques. Our workshop, Experimentation by Design – Managing DOE Projects, shows how to effectively marry the power of DOE to project development programs. Without some very straightforward training the typical manager has no way to determine which polices and decisions will help or hinder the ability of these techniques to maximize results from the R&D staff.

The available workshops and their syllabi are shown below.

Basic Experimentation by Design Workshop – 3 Days

Goal: Give experimenters the ability to predict how their control variables affect their processes in the fewest experimental trials.

This 3-Day Basic workshop teaches a highly effective robust strategy to give non-statisticians the tools to independently develop, analyze and apply the results from complex Experimental Designs. The first two days focus on a "core strategy" for obtaining interactive "pictures" of your process. The last day concentrates on dealing with real-world problems with experimentation.

The workshop runs from 8:00 am to 5:00 pm except for the third day which ends at 4:00 pm.

Day 1:

1. "Bag Sealing" Problem - Try It Your Way First
2. Overview Of DOE Experimental Cycle - The Strategy For Success
3. "Bag Sealing" Problem Using DOE - Follow The Experimental Cycle
4. First Time Around The Experimental Cycle Topics
    a. Objectives
    b. Variables & Models
    c. Resolving Power
    d. Design
    e. Data Collection
    f. Analysis
    g. Contour Plots & Tables
    h. Check Points
    i. Report

5. Putting The Experimental Cycle To Work - Working In Teams You Conduct A Real Experiment To Optimize A 3-Variable Process, Make Predictions, And Run Check Points.

Day 2:

6. Second Time Around The Experimental Cycle

    Review And Elaborate On Topics: Objectives Through Design

7. Second Time Around The Experimental Cycle Continues

    Review And Elaborate On Topics: Data Collection Through Reports

8. Exam Problem: 10 Control Variables & 2 Responses.

    Teams Solve A Complex Experimental Problem Where The Data Are Created Dynamically Using A Real World Simulator Running A Non-Linear Model With Noisy Outputs. Even Though An Initial Screening Design Produces No Acceptable Operating Conditions, The DOE Process Finds Viable Operating Conditions For The 10 Control Variables. The Students Meet Goals Of Both Marketing And Manufacturing. All Teams Reach A Consensus Solution.

Day 3:

9. Discussion Of Exam Problem
10. Data Transformations - Eliminate Lack-Of-Fit; Predictions Make Sense
11. Simultaneous Optimization Of Multiple Responses
12. Non-Algorithmic Design Special Cases
13. Algorithmic Design To Solve Real-World Problems:

    Special Models

    Broken Design Repair

    Constrained Regions

    Introduction To Mixture (Formulation) Variables

    Categorical Variables

    Blocking Variables

14. Introduction To Robust Product Design

Advanced DOE Methods Workshop – 2 Days

Goal: Give experimenters with basic DOE skills the ability to use the more sophisticated DOE techniques designed to maximize the output from the investment in R&D.

The Advanced Workshop teaches use of the more sophisticated concepts which are available using the ECHIP DOE software. This workshop is available only to those who have already attended the ECHIP Basic Training Workshop. Throughout the course, we include a running discussion of the strategy of "innovation on-demand".

The workshop is modular. The order, timing, and emphasis of the topics will vary according to the interests of the participants. It can be structured as either a 2-day or 3-day course, depending upon client interest and whether more extensive examples are desired.

The workshop runs from at 8:00 am to 5:00 pm on the first (and 2nd) day and from 8:00 am to 4:00 pm on the final day.

1. Standard Designs
    a. Comparison of Screening Design Options
    b. Comparison of Response Surface Design Options
    c. Creating Run Sheets
2. Algorithmic Design
    a. What is G-Efficiency?
    b. Special Models
    c. Candidate Sets
    d. Uniform Blocking
3. Augmentation
    a. Broken Design Repair - Using Constraints And Blocking
    b. Augmenting To Increase Complexity Of Model
    c. Deleting Variables
4. Advanced Mixture Concepts
    a. Very Narrow Mixture Ranges
    b. Order Of Addition Of Components
    c. Mixture Candidate Sets Especially With 3 Variables Or Less
    d. Complex Algebraic Constraints
    e. Mixtures Summing To Less Than 100%

5. Categorical Variables
    a. Strategies For Using Categorical Variables
    b. Understanding The Model
    c. Understanding Table Results And Contrasts
    d. Continuous - Categorical Interactions
    e. Constraints - Using Special Candidate Point Sets
    f. Continuous, Mixture, Categorical And Blocking Variables In Same Design
6. Advanced Data Analysis
    a. The Coefficients Table
    b. Evaluating Lack-of-Fit
    c. Diagnostic Tools Using Residuals
7. Transformations
    a. Bounded One Side: Box-Cox
    b. Bounded Two Sides|: Aranda-Ordaz
    c. Poisson
    d. Arcsin
    e. Binomial Data
    f. Logit And Probit Data
8. Optimization
    a. Targeting
    b. Acceptable Range
    c. Computer Model
9. Robust Product Design Approaches
    a. More Robust Tolerances
    b. Minimizing Variance While Targeting Mean
10. Getting Out The Coefficients
    a. Echip's Default Coefficients
    b. "Raw" Coefficients
    c. For Transformed Responses
    d. For Mixture Variables
    e. For Categorical Variables

Using Mixtures/Formulations Workshop – 2 Days

Goal: To give attendees a working knowledge of how Design of Experiments (DOE) models differ for mixtures/formulations and how to leverage this knowledge to improve the ability to optimize a formulation.

The formulations workshop contains many of the same topics as covered in the advanced course, but from the viewpoint of always having a mixture/formulation as central to the development.

1. Understanding Formulations/Mixtures
    a. Pictorial Understanding Of The Loss Of A Degree Of Freedom
    b. The Scheffé Model For A Pure Mixture
    c. Using The Scheffé Model – No Constant Term, Turn Off Stretching
    d. Interpreting The Scheffé Model Terms
2. Working With Combined Mixture And Continuous Variables
    a. The Cox Model
    b. Showing The Equivalence Between The Scheffé And Cox Models
3. Creating Standard Designs
    a. Simple “Equal Variable Ranges” Standard Designs
    b. The Danger Of Including Zero As The Minimum Variable Setting
    c. Understanding The Possible Design Points As A Function Of Model Complexity
4. Special Algorithmic Designs
    a. Defining G-Efficiency for Algorithmic Designs
    b. Mixtures Summing To Less Than 100%
    c. Making Designs With Additives
    d. Using Mixture Constraints
    e. Applying Complex Constraints By Providing A Custom Candidate Set – Making Designs For Multiple Mixtures
    f. Working With Trace Variables (e.g. Catalysts)
5. Mixtures With Continuous and Categorical Variables
    a. Mixture and Continuous Variables – The Fish Patty example
    b. Continuous - Categorical Interaction Issues
    c. Sequential Experimentation Strategies
    d. Interpreting The Results – The Confusion Between The Magnitude Of Effects

6. Advanced Data Analysis for Formulation Designs
    a. Interpreting the Effects and Coefficients Tables
    b. Screening Designs – Defining Component Effects
    c. Response Surface Designs – Extending Component Effects Concepts
    d. Evaluating Lack-of-Fit
    e. Diagnostic Tools Using Residuals
7. Special Transformation Considerations
    a. Bounded One Side: Box-Cox
    b. Bounded Two Sides|: Aranda-Ordaz
    c. Poisson
    d. Arcsin
    e. Binomial Data
    f. Logit And Probit Data For Preference Analysis
8. Optimization
    a. Multiple Response Methods With Constraints
    b. The Difference Between Surface Crawl And Grid Search – Convex Hull Issues

Experimentation by Design
Managing DOE Projects – 2 Days

Goal: To give managers at all levels the foundations to effectively manage programs which will benefit from DOE methodology.

Unlike the classic One-Variable-At-A-Time (OVAT) approach to research, Design of Experiments (DOE) performs experiments as groups of trials – and the ability to understand and utilize the results only occurs at the completion of those trials. Before managers can agree to work in this manner they need to understand the power of the technique and how underpowered the classic OVAT approach truly is.

Once one understands the power of DOE, the next step is to ensure that it is executed in the most robust manner possible. This can only be achieved through effective education and/or the use of outside DOE experts (unfortunately there are many who use the words, but who promote DOE techniques which are substandard).

To be successful with a DOE approach, the planning and design phase of the work needs to be more rigorous, since you have considerably higher investment in resources before any results are seen. This planning often is a major learning process in itself.

Another consequence of using DOE is that once a response surface design is completed, there are no longer any unasked questions about that particular approach to the project. If predictions from the DOE do not meet the desired design specifications, there is no yet-to-be discovered magic combination of variable settings which will work. This means that excessive time is not wasted pursuing an inadequate approach, and you can move to another approach to the problem in the fastest possible manner. Remember, we call it research because we don't know the answer ahead of time.

Part of moving to an "Experimentation by Design" culture is to create a standard evaluation criterion for determining whether a particular project requires DOE. Our decades of experience have shown us that if the work requires experimentation, then the odds are very high that DOE should be used. In this workshop we discuss how one can create a standard evaluation process which the researchers can perform without a major investment in time.

1. Contrasting R&D With And Without DOE
    a. "Bag Sealing" Problem - Try It Your Way First
    b. Overview Of The DOE Experimental Cycle - The Strategy For Success
    c. "Bag Sealing" Problem Using DOE - Follow The Experimental Cycle
    d. A Hands On Experiment To Help Reaffirm The Understanding Of The Power Of DOE
    e. Understanding what to expect in a DOE report

2. The 9 Steps Of Experimentation By Design
    a. Overview – Alignment with Six Sigma's DMIAC and Deming's Plan-Do-Check-Act
    b. Determine The Goals
    c. Define The Measures Of Success
    d. Verify Feasibility (Statistical Power)
    e. Design The Experiment
    f. Run The Experiment
    g. Collect And Analyze The Data
    h. Determine Optimum Settings
    i. Verify The Optimum
    j. Act On The Results
3. Management Action Points In The Experimentation By Design Cycle
    a. Determine The Goals – Critical Alignment With R&D Portfolio
    b. Define The Measures Of Success – How Does One Know One Has Succeeded?
    c. Verify Feasibility (Statistical Power) – Reality Check Before Committing To Effort
    d. Design The Experiment – Getting The Hard Estimate Of Resource Commitment
    e. Run The Experiment – Now The Work Is On The Critical Path. Aggressively Remove Barriers To Completion
    f. Collect And Analyze The Data – Make Sure That The Precious Samples Are Given The Attention They Need
    g. Determine Optimum Settings – Use The Results To Predict The Optimum And Plan How To Integrate These Results In The Next Step Of Development
    h. Verify The Optimum – Make A Go/No-Go To Continue. Otherwise Decide If Investment In Investigating Another Approach Is Warranted.
    i. Act On The Results – It Isn't Worth Anything Unless The Results Are Used To Create A New Or Better Money Pump
4. Techniques To Create An Effective Experimentation By Design Culture
    a. Suggested Processes
    b. Reexamine Reward Systems – Make Sure They Are Aligned To The Required Activities For Both The Researchers AND The Managers
    c. New Levels Of Documentation
    d. Getting Marketing And Sales Involved
5. Wrap-Up
    a. Discussions of "How To Transition The Current Culture"