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Brownie Bee

A simple and free tool for process and product optimization

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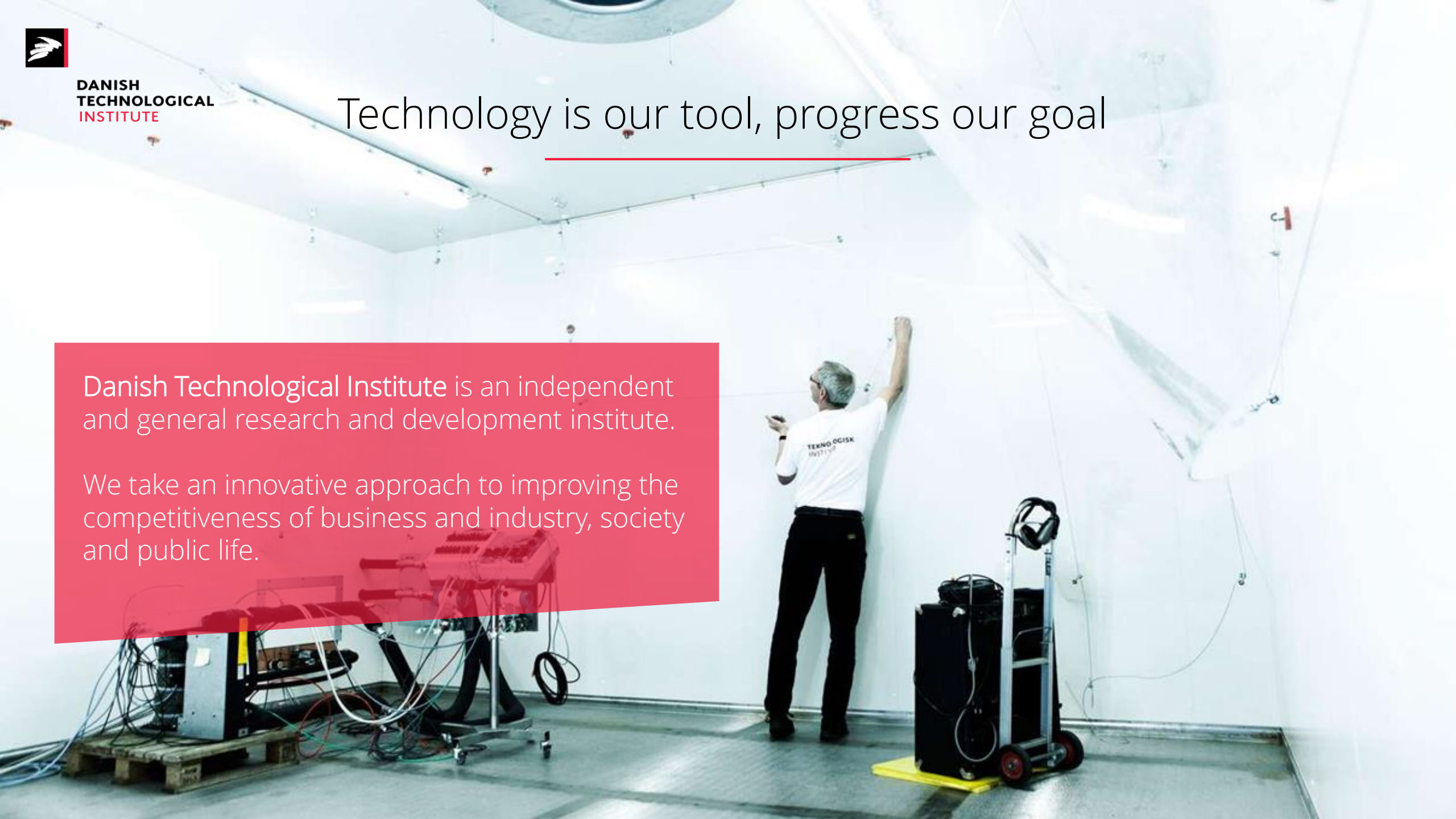
Technology is our tool, progress our goal

Danish Technological Institute is an independent and general research and development institute.

We take an innovative approach to improving the competitiveness of business and industry, society and public life.



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BOOST Væksten – a project supported by Industriens Fond

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Project goal:

BOOST Væksten aims to increase growth in the Danish SME-segment by developing and implementing a new open-source tool that combines modern machine learning with well-established 'Design of Experiments' principles

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Implementing Brownie Bee generates great value

RADISURF

140 % increase in main product pot-life

pK Chemicals

25 % increase of production capacity with no loss of product quality

Struers
Ensuring Certainty

20 % reduction of development time compared to budget

ceramicspeed

New complex product formulation developed in 15 experiments

GRAM EQUIPMENT

Early discovery of inadequate design during development process

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Almost all industries struggle with this problem:

"Finding optimal settings for a process, based on a set of pre-determined quality requirements."

One effective way of solving this is to use:

Bayesian Optimization

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Finding an optimal process is surprisingly *difficult* and requires us to carry out experiments

Factors:
- Ambient temperature
- Cycling speed
- Depth of discharge
- Cathode material
- Anode material
- Electrolyte formulation
- Recharge voltage
- Recharge rate
- …

Process

Quality requirements:
- Price
- Cyclic life
- Total lifetime
- Capacity
- …

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How we like to think about experiments:

Experiments are **measurement systems** for producing data

Data are the building blocks for **models** of nature

Models are used as maps to **find the shortest path to our goal**

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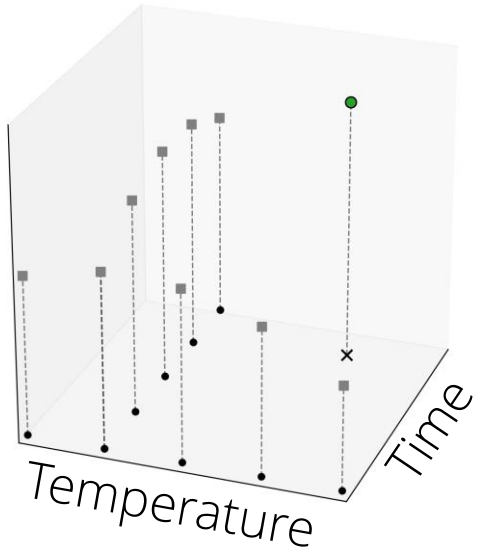
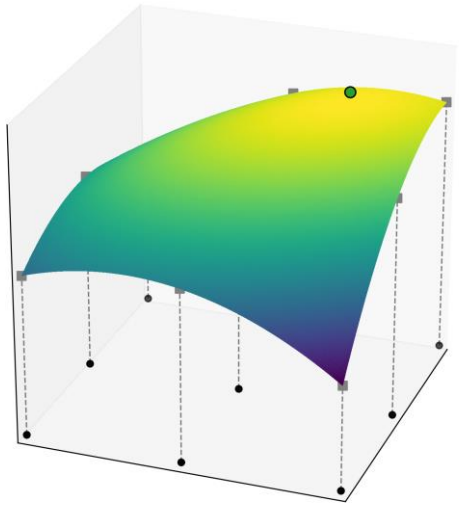
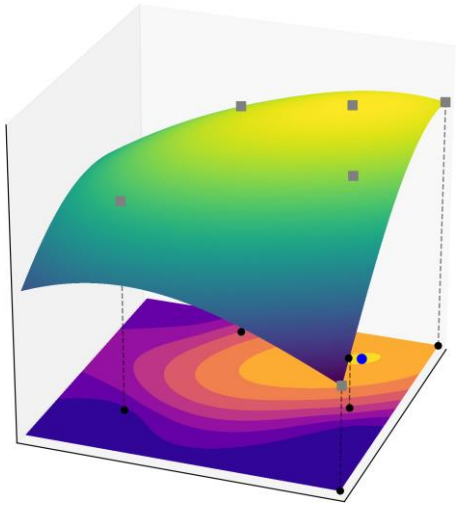
There are many strategies for building models

One Factor at a Time	Design of Experiments	Bayesian Optimization







Information pr. experiment

Ease of understanding

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An easily digested example:

Baking the best American Brownie

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American brownie

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Bake three cakes, using different recipes → score → update model → predict/bake/optimize loop

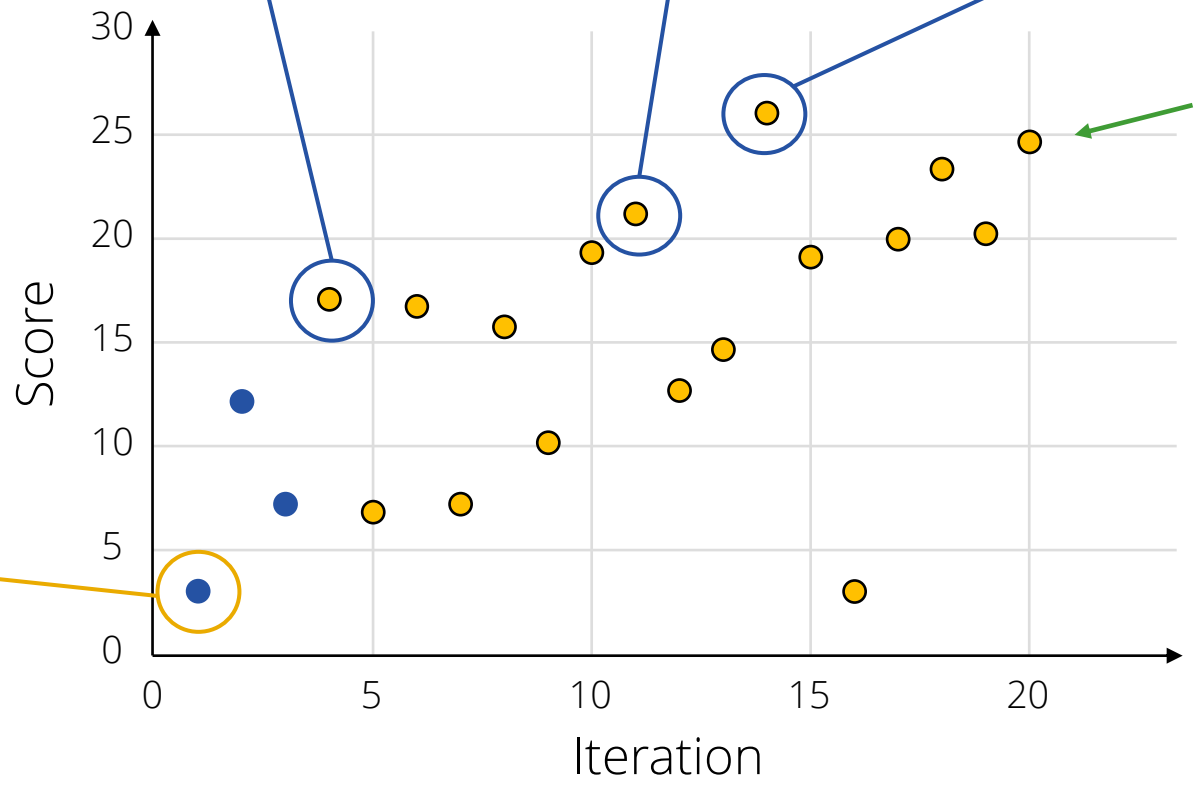
Scoring:
- 1-10 for taste
- 1-10 for looks
- 1-10 for texture

Parameter space:

Butter (g)	0.0-80.0
Sugar (g)	0.0-150.0
Flour (g)	0.0-60.0
Cocoa (tbl.sp.)	0.0-3.0
Eggs (whole)	0-2
Vanilla sugar (tsp)	0.0-2.0
Baking soda (tsp)	0.0-5.0
Time in oven (min)	0.0-30.0
Temperature (°C)	150.0-200.0

Recipe – best brownie

Butter: 72 g
Sugar: 134 g
Flour: 29 g
Cocoa: 2.5 tbl.sp.
Eggs: 2 whole
Vanilla sugar: 1 tsp.
Baking powder: 0 tsp.
Time: 27 min
Temperature: 160 °C



Average score >8 of 10

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Adressing this problem with regular DOE is not very appetizing:

With knowledge of DOE one could consider:

1. Trying to eliminate non-essential ingredients via a screening design (16-32 experiments). Realistically this would probably only remove 1-2 factors.
2. Optimizing the system with an RSM design, using 8 factors (6 ingredients, 2 process), requiring *at least* 50 experiments.

We have to bake ***50-80 cakes*** before we have any idea whether a solution is there to be found, so in practice most DOE-intentions get left behind at this stage.

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Brownie Bee quickly identifies the optimal process – also in industry

Industry: Motorsport

Product: Breakpads for motorbikes

Optimization problem:

Ten formulation factors and three process factors optimized in 45 runs

Industry: Chemicals

Product: Dextran for medicine and cosmetics

Optimization problem:

Four factors optimized using 15 runs

Industry: Equipment and supplies for materialography

Product: Preparation disc

Optimization problem:

Six product related factors optimized in 17 runs

Industry: Ice cream production equipment

Product: Extruder prototype

Optimization problem:

Nine process factors optimized in 21 runs

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A simple and intuitive interface that anyone can use

- Easy setup of experiments
- Short path to the optimization loop
- Change between ‘explorative’ and ‘exploitative’ on the fly
- Simple plots illustrating the present model of our system
- More still to come…

And now, a live-demo!

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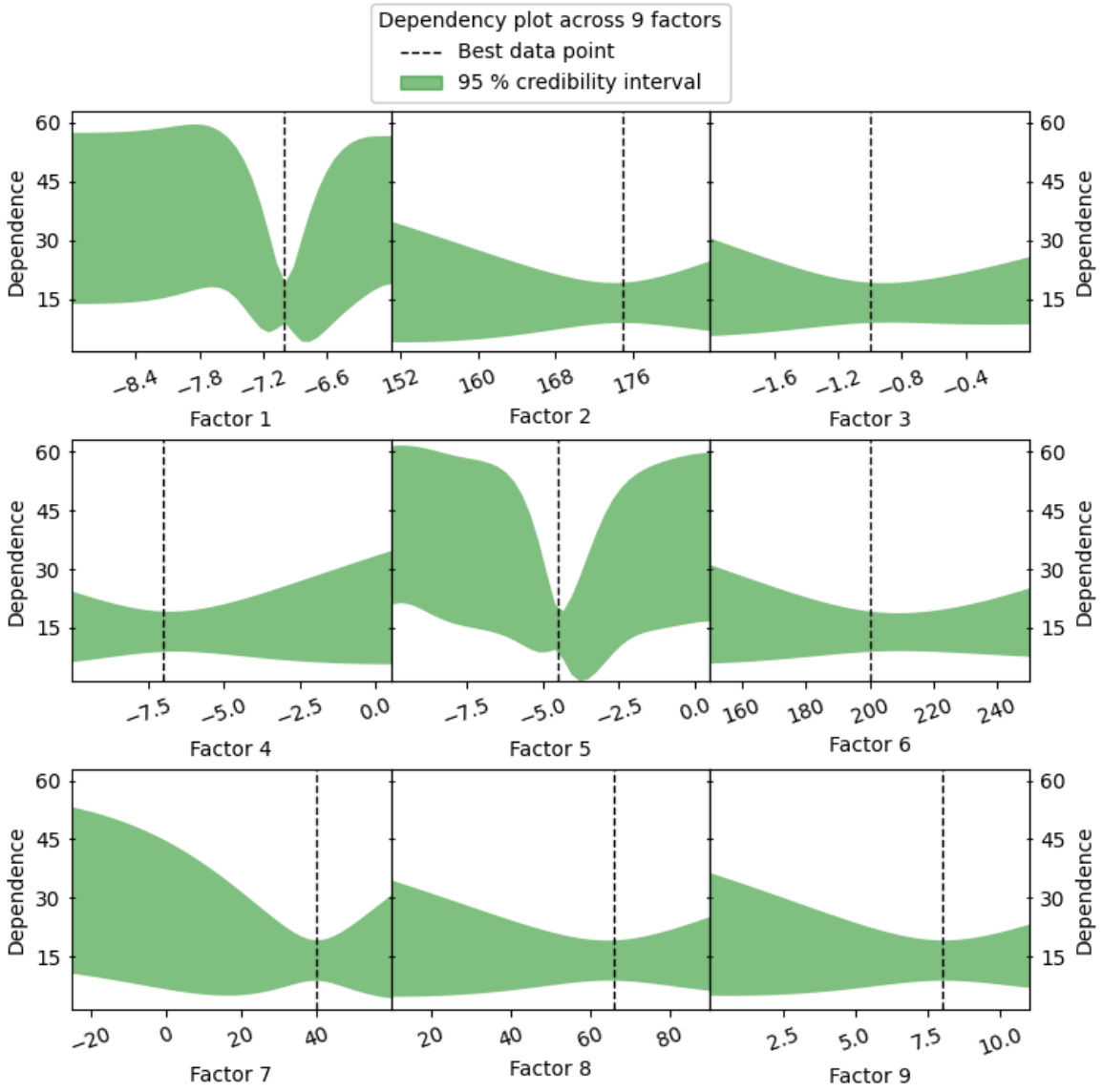
Still under construction…

In the pipeline we have:

- Further improvement of the UI
- Multi-score optimization
- Templates for different experiment types
- Tips and guidance in the interface
- Using ranking instead of scores



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We are presently implementing Brownie Bee at:

Faerch

KE FIBERTEC

Palsgaard®

MIDTJYDSK FORNIKLING

Your company next?

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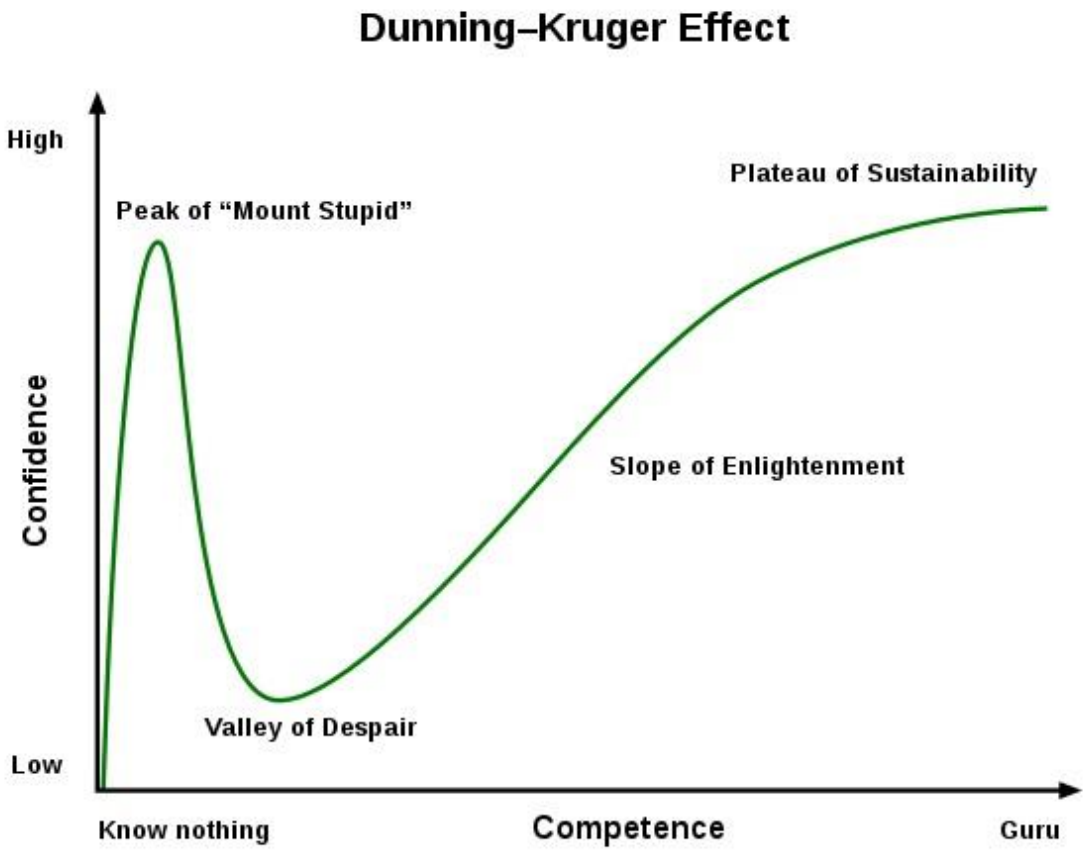
Trends we observe across all sectors



- One-factor-at-a-time is by far the most common method of optimizing and conducting R&D
- Creating problem statements that allow use of statistical tools is *much* more challenging than using the software itself
- Most companies vastly overestimate how much they agree on what ”product quality” means
- “Quality” is always based one multiple metrics
- It is difficult for most companies to set quantifiable goals for optimization processes

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Makes it easy to identify optimal settings for a process, based on a set of pre-determined quality requirements.

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Thank you for your attention – questions are very welcome!

- Newsletter, case-stories, longer webinars and more: http://browniebee.dk

- Direct contact: mon@teknlogisk.dk og pros@teknologisk.dk

- Try Brownie Bee now: https://prod.brownie.projects.alexandra.dk/

- The codebase is open-source! Have a look and contribute to the development:
  https://github.com/BoostV/process-optimizer-frontend
  https://github.com/novonordisk-research/ProcessOptimizer