# *Sometimes, opinion not only counts, it's all you have*

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## INTRODUCTION

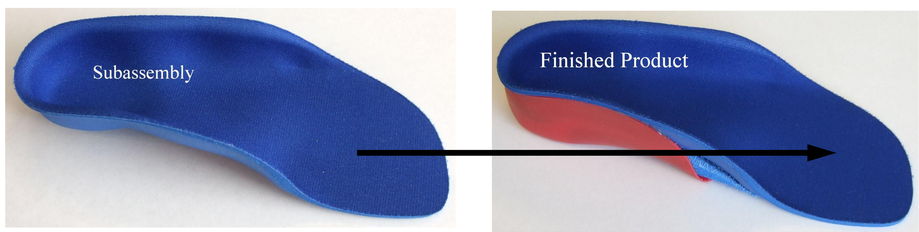
This poster paper describes a designed experiment with a unique challenge:

***How does one validate expert opinions and convert them into a continuous response variable?***

While the experiment itself was interesting, it blazed no new trails, so this paper is focused on the subjective response itself and the challenges that it presented. Particular emphasis is placed on overcoming the inevitable obstacles one faces when designing a custom measurement system.

## PROJECT CHALLENGES & GOALS

The project team had to improve the edge finish of a critical sub-assembly in an orthotic shoe insert. The cut edge of the sub-assembly is in full view on the finished product and complaints, both internal and external, were getting louder.

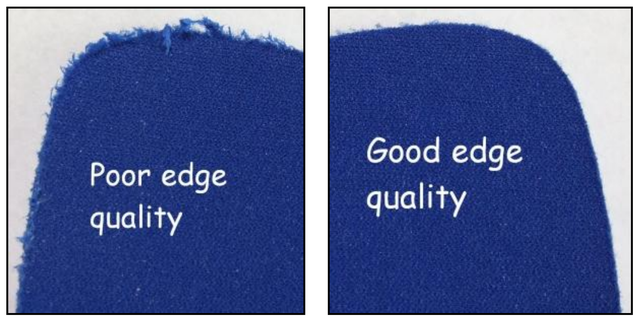



## THE TEAM & ITS STRATEGY

The project team consisted of staff from R&D, Production, Quality Engineering and Business Development. When the project team confronted a seemingly insurmountable response variable obstacle, the team used JMP's EMP III measurement systems analysis to help customize its measurement system. The team then collaboratively used JMP's Custom DOE to design an I-optimal experiment and the ObDOE *5-Step Design of Experiments System* to keep the project on track.

## THE PROCESS – WATER JET CUTTING

The water jet process settings (*pressure, feed rate, tooling, etc*) had been determined over a long period of time by persistent trial and error, but results were erratic at best. Therefore, the project goal was to abandon the historic process settings and co-optimize the machine settings for both edge quality and a target production rate.




## A PESKY RESPONSE VARIABLE

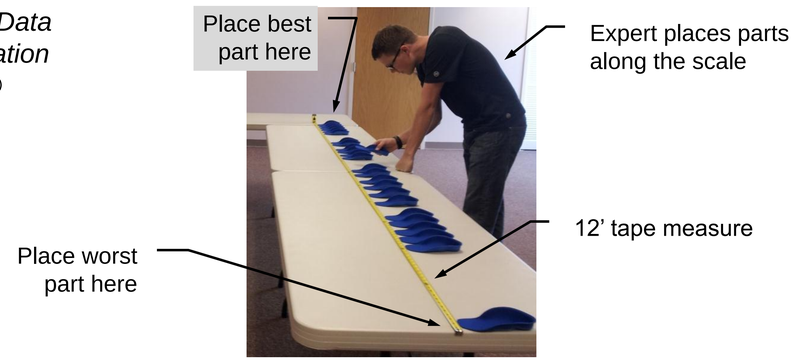
Initial efforts to characterize edge quality met with failure. The first attempt, *cut the fuzz off and weigh it*, failed because of variation in the cutting method both within and between operators. The second attempt, *measure the length of the fuzz with a textile eye loupe*, failed because the eye loupe is unsuitable for thick parts

Recalling Leonardo daVinci's famous quote that, *simplicity is the ultimate sophistication*, the project team reconsidered its approach and stumbled its way to one rather simple possibility - visual evaluation by experts. But, the team was keenly aware of a formidable obstacle – *the need for a continuous response variable for its designed experiment.*

## MEASUREMENT IS A PROCESS

Conversion of expert opinion into continuous data suitable for designed experiments is not a subject that one finds readily in a Quality Engineering handbook, so the team was left on its own to devise the measurement system it needed. After trying a number of methods, the project team devised a simple, highly effective way make this critical conversion.

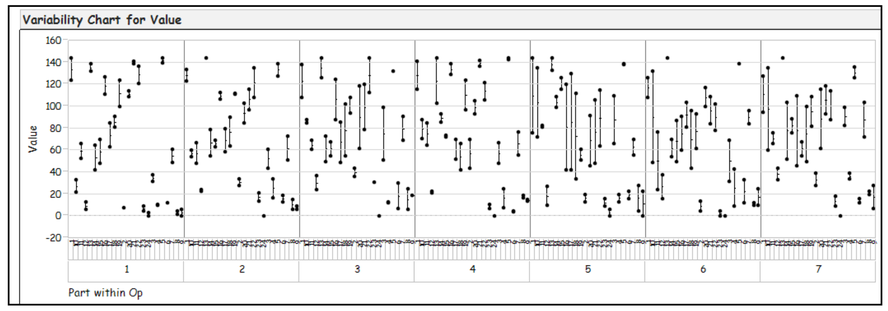
*A Custom Data Transformation Machine ☺*




Early in the measurement system development, the team made a series of mistakes, so initial repeatability and reproducibility were poor. However, iterative application of JMP's EMP III capability provided valuable insight and the project team learned quickly that certain things previously ignored or taken for granted were, in fact, critical to success. For example, the project team found that background color and evaluator stress could dramatically affect both repeatability and reproducibility. For the latter phenomenon, the project team half-heartedly coined the term *Stress Bias* as a constant reminder that human considerations are vital in the design of good measurement systems.

Eventually, the team had a detailed work instruction for its measurement system including a control of room temperature, optimization of ambient lighting, remediation of reflected light and specific color backgrounds for different colors of foam. The work instruction addressed *Stress Bias* by assuring the experts were left undisturbed to ponder their evaluations.

Getting closer to the actual experiment, the project team then screened 7 experts using JMP's EMP III method with 25 parts and 2 measurements each. JMP's Variability Chart shows clearly that experts 1, 2 and 4 were the best choices for evaluating experimental data. The Probable Error for each expert corroborated the conclusions drawn from the Variability Chart.




During the experiment, the parts were placed randomly in a container and given to the first expert who then evaluated each part and placed it along the tape measure according to their expert opinion. Similar braces were grouped side-by-side and gaps were left to indicate subgroup differences. All experts made numerous changes to the relative positions of the parts, shifting them along the scale many times, before settling on a "final answer". A measurement coordinator recorded the part numbers and their location on the 12' scale. The parts were randomly placed back into the container for the next expert's independent evaluation.

## SUMMARY

The averages of the 3 expert evaluations were used as a continuous response variable for the experiments. With a reliable response measurement system in hand, the project team executed an iterative series of I-optimal experiments, steadily built upon its knowledge and eventually found a process sweet spot that met both edge quality and productivity requirements. Continued random monitoring of edge quality using the same measurement method and JMP's superb Control Chart Builder can assure the process does not drift back to its original state.

## KEYS TO SUCCESS

- ✓ Persistence in designing and validating *the right measurement method*
- ✓ Careful consideration of human, environmental and ergonomic factors
- ✓ A collaborative approach to decision-making
- ✓ Harnessing the brainpower of a wide variety of people, especially front line workers
- ✓ Using JMP's concise graphical outputs to present and explain results to management

## ACKNOWLEDGEMENTS

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