A Design Science Approach for Automotive Design: Implications for Engineering Design Education

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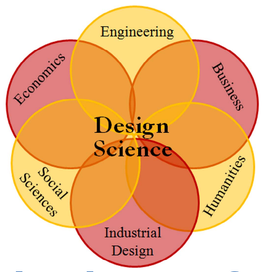
Research Motivation

Engineers are generally trained on the use of analytical methods for quantifying functional product attributes they desire to design. However, it is well known that consumers often make decisions about the products they purchase based on subjective or perception based attributes of a product. We demonstrate the use of a design science approach based on methods primarily from psychology and engineering for quantifying subjective attributes that can inform engineering design decisions.

What is Design Science?

Design Science studies the creation of artifacts and their embedding in our physical, psychological, economic, and social environment. Traditional science studies the world as we found it; design science studies the world as we make it.



Limitations of Using One Discipline

It is well known that the problems engineers of tomorrow will have to solve are increasingly interdisciplinary in nature. Approaching design problems from the perspective of one discipline limits the richness of their solutions. Table 1 shows 3 disciplines of interest to this research along with the benefits and limitations of each one on their own.

	Benefits	Limitations
The Psychology Discipline:	• Has methods and tools for predicting and understanding human behavior • Uses quantitative models • Uses the scientific method	• Has few techniques that can directly incorporate analysis for the direct design and development of physical products and artifacts.
The Engineering Discipline:	• Quantitative tools that can analyze physical systems represented by mathematic models • Provides analysis tools for the design process • Uses the scientific method	• [Traditionally] Has insufficient tools that can appropriately capture and reflect the mind of the consumer in engineering models
The Field of Industrial Design:	• Provides insight on the aspects of design important to the "irrational" needs of the consumer • Directly incorporates artistic elements into design	• Uses qualitative methods • Does very little to no analysis based on the scientific method

Table 1: The benefits and limitations of knowledge from engineering, psychology, and industrial design as applied to design problems

General Approach

The general approach is shown in Figure 1 below and consists of key steps from: Stimuli creation, data collection and analysis to engineering optimization methods (Reid et al., 2009).

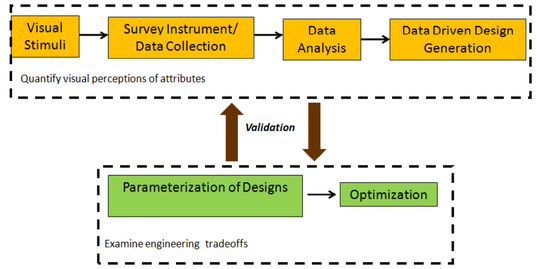
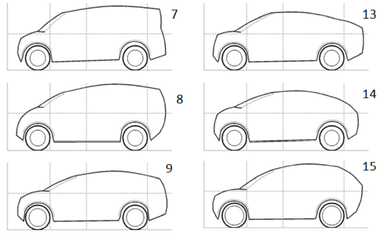


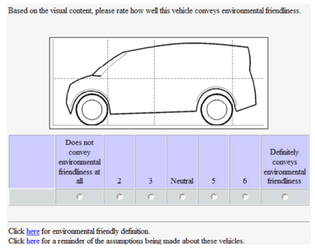
Figure 1: General approach for quantifying subjective attributes

Automotive Case Study

The general approach was used to quantify preference for positive "green" styling cues in an experimental survey format.

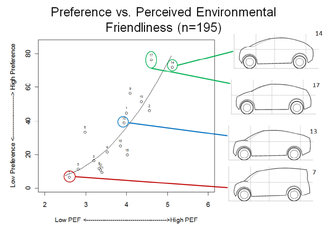


(1) Stimuli Creation using vehicle silhouettes (16 total used)

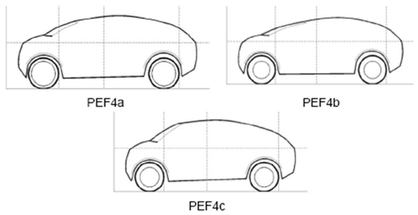


(2) Survey Instrument/Data Collection

Factor analysis identifies specific variables that influences green styling cues.



(3) Analysis results for most positive "green" styling cues and most important design variables



(4) Generation of New Designs

Maximize fuel economy

Subject to:
critical engineering parameters
Green styling cues

(5) General optimization framework for engineering decision making

Summary

The case study briefly demonstrates a tool developed from methods of psychology and engineering to provide designers with insight to aid engineering decision making. In this case, we assess people's perceptions about the "green" styling features of vehicle silhouettes that can be used at the conceptual stage of product design.

Implications on Design Education

The design issues of the present and future increasingly require engineering students to understand quantitative methods outside of their discipline. The case study above is based on doctoral research however, there is opportunity for undergraduates to learn such methods. The Analytical Product Design course (ME 455/DESCI 501), offered in the Fall is an exemplar to design science (Frischknecht et al., 2009) and provides engineering, business, industrial design, and information science students with an interdisciplinary design experience.

About the Authors

Tahira Reid is a PhD Candidate in the Design Science Program. She is co-advised by Richard Gonzalez in the Psychology Department and Panos Papalambros in the Mechanical Engineering Department. For more information about the Design Science program, please visit our website at http://designscience.umich.edu.

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References

Frischknecht, B. , et al, 2009, A Design Science Approach to Analytical Product Design, Proceedings of the International Conference on Design, August 24 -27, 2009, Stanford, CA

Reid, T., et al., 2009, Developing a Methodology for Quantifying the Perceived Environmental Friendliness of Vehicle Silhouettes in Engineering Design, Proceedings of the ASME Design and Engineering Technical Conference, August 29 – September 2, 2009, San Diego, CA