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Uncovering Design Strategies

A collection of 77 examples helps students tap their own creativity.

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Good ideas are the foundation for successful engineering. The ability to generate novel ideas is essential to innovation and to producing designs that solve practical problems. But how do engineers learn to generate ideas? While there are a few systematic methods available, the existing techniques are not grounded in empirical evidence. Our study examines how engineers, both students and practitioners, come up with design solutions. By understanding how engineers generate ideas, we can develop an empirically based technique to help others learn to do so.

Participants in our study followed a “think aloud” protocol while they generated ideas for a new design problem. We collected design drawings with written descriptions and labels, and transcribed verbal data. This collection of data was reviewed multiple times as we searched for evidence of how designers generated ideas and transitioned from one concept to another. From the written and verbal data, we identified the strategies evident in their designs by looking for characteristic differences between concepts in each participant’s set, distinguishing characteristics of individual concepts, and explanations of

driving factors of an idea.

Consider the example of generating an idea for a chair. One design might be characterized as supporting multiple functions, such as a chair that offers shelves under the seat. Another design might display foldability, by including multiple hinges to make the chair more compact when not in use. As another example, consider one chair design that looks similar to a standard classroom desk chair, and a second chair design that maintains the similarity to a standard classroom desk chair but has utilized the back of the chair for a coat hook. The designer used the strategy of utilizing an opposite surface to add a feature. By analyzing many designs across individuals, we were able to identify a set of strategies embodied in different designs.

In our paper, we present the collection of strategies we extracted from participants' data, and show examples of how the use of the strategies prompted new design ideas. We call these strategies "Design Heuristics" because while the strategies are not deterministic, they guide engineers toward possible design solutions. Design Heuristics evident in the examples above include Make Multifunctional, Fold, and Utilize Opposite Surface. Additional examples of Design Heuristics include Compartmentalize, Create System, Incorporate Environment, Mirror, and Rotate. Our analysis of the data collected found empirical support for the use of Design Heuristics in idea generation across levels of expertise.

By uncovering the Design Heuristics that engineers use to explore solution spaces, we can provide engineering students and practitioners with a collection of explicit, empirically based strategies to aid their idea generation. Based on our additional studies on Design Heuristics across engineering problems, we have created an idea generation tool called "77 Cards: Design Heuristics for Inspiring Ideas" *(www.designheuristics.com)*. The tool includes the 77 Design Heuristics strategies identified to date, along with examples of their use in existing products as illustrations.

We have now used this tool in numerous engineering classrooms, and collected data on student outcomes. Neutral coders rated the ideas generated with the tool as more creative and diverse than those generated without the tool. This collection of Design Heuristics can become a part of the repertoire that engineering students and practitioners can turn to when generating ideas, assisting them in identifying and modifying concepts and leading to greater success in idea generation.

The Design Heuristics approach is founded on empirical examination of engineers' designs. As a result, it offers a way to teach engineering students specific strategies that will increase their chances of success in generating ideas to solve design problems when they become practicing engineers.

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