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# Assessing Design Heuristics for Idea Generation in an Introductory Engineering Course*

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Design Heuristics are prompts that encourage design space exploration during concept generation. Design Heuristics were developed by analyzing trends in innovative products and patterns in ideation by engineering and industrial designers of varying experience levels. In this study, 48 freshmen engineering students were given a short design task and a set of twelve Design Heuristics Cards. Each card described a heuristic, and gave two examples of its application in a product. Students were asked to create new design concepts using the heuristics. The results showed that the concepts created without Design Heuristics were less developed, and were often replications of known ideas or minor changes to existing products. However, concepts created using Design Heuristics resulted in more developed, creative designs. Students often applied the same heuristic in multiple ways, supporting our premise that the heuristics lead to exploring multiple solutions. The results also showed that some students readily applied the heuristics, while others struggled to understand how to apply them.

**Keywords:** Design Heuristics; concept generation; design pedagogy

## 1. Introduction and background

Our society requires a design workforce capable of innovation to meet key problems in the world, such as the Grand Challenges of the 21st Century [1]. Meeting this need requires establishing successful pedagogies for creativity in concept generation. Designers need the ability to generate novel and diverse concepts in the initial stages of design in order to create potentially innovative solutions. Innovative outcomes are often traced to success in the concept generation phase, where multiple creative ideas can be developed, and diverse concepts can be evaluated and pursued [2, 3]. The potential for innovative design outcomes increases as more, and more varied, ideas are produced.

However, engineering students often struggle to generate multiple ideas [4, 5]. Studies show they become attached to initial ideas, even when they recognize problems in these designs [6–8]. Even students who are inclined to think creatively often lack specific strategies to help them explore solution spaces of potential designs. This limits their ability to transform an initial creative idea into something more innovative, or to suggest multiple solutions.

Engineering design education provides opportunities for students to engage in each stage of design through project-based courses [9]. However, these courses may not include strategies specific to idea generation. Instructors might encourage students to 'brainstorm' by generating many ideas, limiting evaluation, and allowing 'wild' ideas to emerge [10]; however, these suggestions do not provide students with specific, systematic methods for generating creative designs.

While not commonly integrated into engineering design courses, there are a variety of other idea generation tools available. A sample includes those aimed to: (1) facilitate the flow of ideas (e.g., brainstorming [10] and brainwriting [11]); (2) stimulate the formation of an initial idea, (e.g., analogical thinking [12], morphological analysis [13, 14], and Synectics [15]), and (3) transform ideas into more or better ideas (e.g., lateral thinking [16], SCAMPER [17], TRIZ [18, 19]). Other tools include IDEO™ Method Cards [20], intended to improve understanding of the user and 'Whack Pack' cards [21], designed to help break out of habitual views by providing general techniques and decision-making advice.

These ideation methods vary in their focus, specificity, and usability. For example, TRIZ [18, 19] is focused on refinements of mechanisms and resolving specific design tradeoffs that occur later in the design process (the implementation phase). Brainstorming includes general guidelines, such as, 'suggest many ideas,' 'do not evaluate ideas,' and 'build off of others' ideas,' but it does not provide students with specifics for *developing* ideas [10]. SCAMPER [17] offers more information about how to transform ideas, but its set of general guidelines (e.g., 'combine') may be difficult for designers

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of all experience levels to understand *what* to 'combine' and *how* to apply the guidelines to their tasks. Some of these methods also require extensive training and practice (e.g., Synectics, TRIZ, and SIT [22] (a modified TRIZ approach). Most importantly, many of these tools are not empirically driven, nor have they been rigorously tested for their impact on ideation.

The Design Heuristics approach is based on strategies of ideation identified in award-winning products and designers' approaches to concept generation [23–26]. The resulting set of seventy-seven strategies can be used by designers of all skill levels to facilitate exploration of the design solution space. Design Heuristics help with innovation by providing cognitive 'shortcuts' to create intentional variation in designs. With more, and more varied, designs generated during the ideation stage, there is greater potential for discovering innovative solutions.

We consider a well-explored design solution space to be one in which a designer has generated multiple creative and diverse ideas. The outcomes of solution spaces that are not well explored are considered 'obvious' ideas, ones that most people would think of quickly. We illustrate this idea with the three circles in Fig. 1. Each circle represents an infinitely large potential solution space. The white shape in the center represents the more obvious, less unique ideas. Similar ideas are represented as nearby in the design space, while diverse ideas are shown further apart. Circle I represents a general solution space, three obvious concepts, A, B, and C, and three potentially creative solutions, D, E, and F. Circle II represents a path resulting in a poorly explored design solution space. Circle III represents the aim for a path impacted by the use of Design Heuristics, facilitating the designer in more fully exploring the design solution space.

Design Heuristics are intended to help designers explore solution spaces by specifically guiding them to generate non-obvious ideas that are also diverse from one other. They are also intended to support designers in becoming 'unstuck' when they have worked on a task for a long time and struggle to come up with more and different ideas. To support designers in applying Design Heuristics, we translated the heuristics extracted from a wide range of experimental studies into Design Heuristic cards. Each card includes a specific description of a heuristic, an abstract image depicting the application of the heuristic, and two product examples that show the application of the heuristic to existing consumer products (Fig. 2). This paper reports the result of one study we conducted to understand how the use of heuristics by novice engineering designers

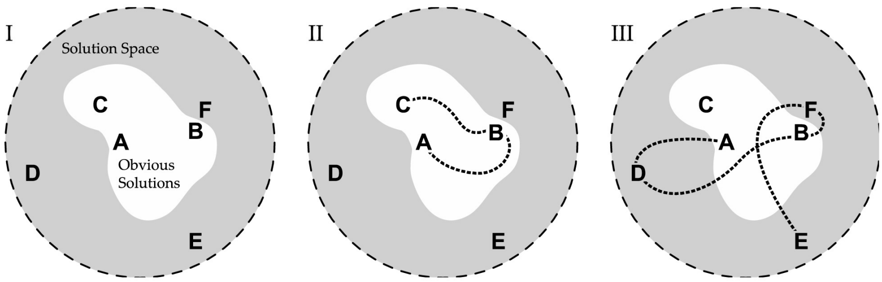


**Fig. 1.** Design Solution Space, Typical Novice Path, and Suggested Impact of Design Heuristics.

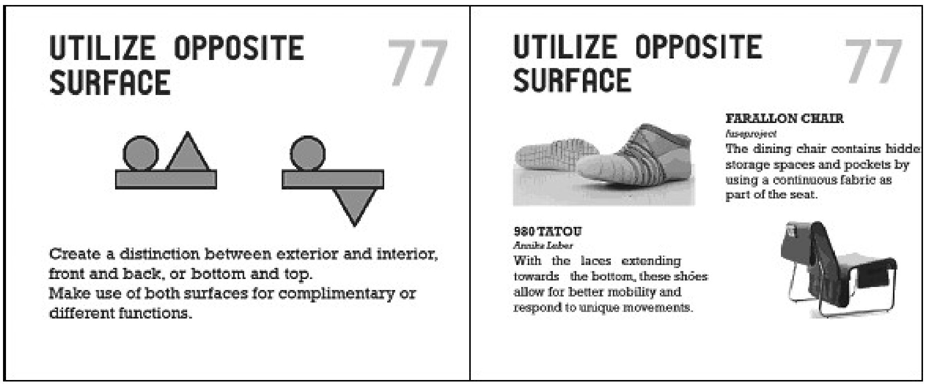


**Fig. 2.** Heuristic Card Example (Front and Back of the Same Card). Card Images: www.idsa.org/content/content1/980-tatou-sport-shoe-le-parkour, http://www.fuseproject.com/category-3-product-19

affected the outcomes of idea generation as well as how the Design Heuristic cards were interpreted. Specifically, our work was guided by the following research questions:

- How does the use of Design Heuristics impact the exploration of the solution space for a given design task for first-year engineering students?
- How do first-year engineering students interpret the ease of use and applicability of the Design Heuristic Cards?

## 2. Research methods

Forty-eight students (ages 17–19; 39 males, 9 females) in an Introduction to Engineering course at a large Midwestern university participated in the study. This semester-long course provided first-year students with an introduction to topics such as computer coding, data management, communication skills, and teamwork. Students also participated in a guided design opportunity, in which they worked on a team project while learning the stages in design processes. This class was selected because it included first-year engineering students in their first term. They can be considered design novices as they reported little or no design experience.

The study was conducted approximately one third of the way into the semester. Students participated in an 80-minute session on 'concept generation.' Prior to this session, students had not received any introduction to the topic. The session included 20 minutes of introduction to Design Heuristics in which three cards were provided as examples (*Bend, Synthesize functions*, and *Use packaging as a functional component*). These three cards were chosen to help the students understand the differing types of heuristic cards they may encounter.

The first card (*Bend*) was used to highlight the format of the card and discuss how it could be used to generate an idea. For the second and third cards, we showed students the description on the front side, and asked them to generate a concept for a seating device by applying the heuristic to a traditional chair. After students shared their suggested ideas for a seating device using the heuristic, we showed students the opposite side of the card so they could see another solution. The purpose of sharing multiple ideas for the heuristic application was two-fold: first, to help guide students in the right direction if they did not understand how to apply the heuristic, and second, to show the students that there are multiple ways to apply the same heuristic.

After this introduction, each student received his or her own subset of 12 Heuristic Cards. Based on our previous work, we considered this a manageable number of cards to read and try to apply in the time allotted. Each set was compiled randomly from the existing set of 74 (the three examples from the introduction were excluded). Across the 48 students, each card was included in the sets between 5 and 9 times. Titles of the 77 Design Heuristics cards are shown in Fig. 3.

Next, students were given a simple design task, and asked to generate as many concepts as possible in 25 minutes using Design Heuristic cards. The students were free to select and combine any of the heuristics they thought most applicable. The design problem statement was:

> *Sunlight can be a practical source of alternative energy for everyday jobs, such as cooking. Simple reflection and absorption of sunlight can generate adequate heat for this*

1 Add features from nature
2 Add gradations
3 Add motion
4 Add to existing product
5 Adjust function through movement
6 Adjust functions for specific users
7 Align components around center
8 Allow user to assemble
9 Allow user to customize
10 Allow user to reconfigure
11 Animate
12 Apply existing mechanism in new way
13 Attach independent functional components
14 Attach product to user
15 Bend
16 Build user community
17 Change contact surface
18 Change direction of access
19 Change flexibility
20 Change geometry
21 Compartmentalize
22 Convert 2-D to 3-D
23 Convert for second function
24 Cover or remove joints
25 Cover or wrap
26 Create system
27 Distinguish functions visually
28 Divide continuous surface
29 Elevate or lower
30 Expand or collapse
31 Expose interior
32 Extend surface
33 Extrude
34 Flatten
35 Fold
36 Hollow out
37 Impose hierarchy on functions
38 Incorporate environment
39 Incorporate user input
40 Layer
41 Make components multifunctional
42 Make components attachable or detachable
43 Make product reusable or recyclable
44 Merge functions with same energy source
45 Merge surfaces
46 Mirror or Array
47 Nest
48 Offer optional components
49 Provide sensory feedback
50 Reconfigure
51 Recycle to manufacturer
52 Reduce material
53 Reorient
54 Repeat
55 Repurpose packaging
56 Reverse direction or change angle
57 Roll
58 Rotate
59 Scale up or down
60 Separate parts
61 Slide components
62 Stack
63 Substitute
64 Synthesize functions
65 Telescope
66 Texturize
67 Twist
68 Unify
69 Use alternative energy source
70 Use common base to hold components
71 Use continuous material
72 Use human-generated power
73 Use multiple components for one function
74 Use packaging as functional component
75 Use recycled or recyclable materials
76 Utilize inner space
77 Utilize opposite surface

**Fig. 3.** Heuristic Card Titles.

*purpose. Your challenge is to develop products that utilize sunlight for heating and cooking food. The products should be portable and made of inexpensive materials. It should be able to be used by individual families, and should be practical for adults to set up in a sunny spot. Note: Specific materials for a targeted temperature can be postponed to a later stage. Do not worry about the specific quantity of heat that can be generated. Please focus on conceptual designs. Please consider both the ways of capturing the light, and the structural variety of the concepts.*

A brief outline of ways solar energy could be used for heating (e.g., concentrating sunlight, absorbing sunlight, and trapping sunlight) was also provided for background information.

After completing idea generation, students were instructed to respond to the following prompts for each concept they generated: 1) 'Describe the concept in detail. How does it work? What are the unique features, mechanisms, and details?' and 2) 'What made you think of this concept? Where did this idea come from?' For the second prompt, we instructed students to list the heuristic card numbers they used in that design. Finally, they completed a post-task questionnaire asking, 'Which heuristics were most useful to you in this task? Why?' and 'Which heuristics were difficult to apply in this task? Why?'

Two coders trained in identifying Design Heuristics analyzed heuristic use. One coder had a background in engineering and in art & design, and the other in engineering and engineering education. These coders scored:

- Evidence of heuristic use: Sketches and descriptions were reviewed for whether each heuristic in a student's set was evident in his/her design concepts. For example, if a student had the card *Fold*, and they included folding solar panels in their design, the heuristic was considered 'evident.' In addition, coders recorded when each student had self-identified heuristic use (if any). At times, heuristic use was judged 'evident,' though the student did not identify it. Thus, each concept had four possibilities: 1- Heuristic(s) evident and claimed; 2- Heuristic(s) evident but not claimed; 3- Heuristic(s) not evident but claimed, and 4- Heuristic(s) not evident and not claimed. If multiple heuristics were observed or claimed, the concept was coded in the most comprehensive (lowest numbered) category represented by one of the heuristics.
- Solution type: Each concept was classified by solution type based on the features of the design. This coding scheme consisted of six exclusive categories differentiating 'obvious' concepts (1- solar panel attachments to an existing device, 2- simple box, 3- simple box with reflector, 4- simple reflector, and 5- simple lens) from the more original and unexpected concepts, representing combinations of any of the other five categories, more developed ideas with additional features, new mechanisms, or ideas that did not fit into the above categories.

For these measures, the two coders worked together and discussed each item to consensus. Raters agreed 95% of the time and discussed to a consensus the other 5%.

Two different coders with no knowledge of Design Heuristics scored outcome measures of design quality. Both were seniors; one was in a mechanical engineering program and one was in an aerospace engineering program. The concepts were presented in a randomized order on separate sheets with no indication of heuristic use. These judges scored each concept for:

- Concept creativity: Using the Consensual Assessment Technique (CAT) [27], each concept was individually rated on a scale of 1 (not creative) to 7 (very creative). Between coders, the Pearson correlation was .57.
- Concept set diversity: Using CAT as a model, each participant's set of concepts was rated for diversity on a scale of 1 (not diverse) to 7 (very diverse). Between coders, the Pearson correlation was .43.

Data analysis also included a comparison of how different students applied the same heuristic. Concepts created with the same heuristic were considered side-by-side and coded for similarities and differences. Additionally, we analyzed student responses to questions about card usefulness.

## 3. Results and discussion

*How does the use of Design Heuristics impact the exploration of the solution space for a given design task for first-year engineering students?*

The 48 student participants generated a total of 161 concepts. In 45% (73) of the concepts, none of the given heuristics were evident. In 11 of these concepts, students claimed to have used a heuristic.

In 55% (88) of the concepts, heuristics were evident. Students claimed heuristic use in 46 of these concepts. In the other 42, students did not claim heuristic use even though the coders identified evidence of heuristic use. This may occur by omission in reporting, or because the student did not recognize he or she had made use of a heuristic. These two categories of evident heuristic use were grouped for analysis, and we compared these to concepts showing no evidence of heuristic use. Figure 4 includes examples in which heuristics were not evident (top row) and evident (bottom

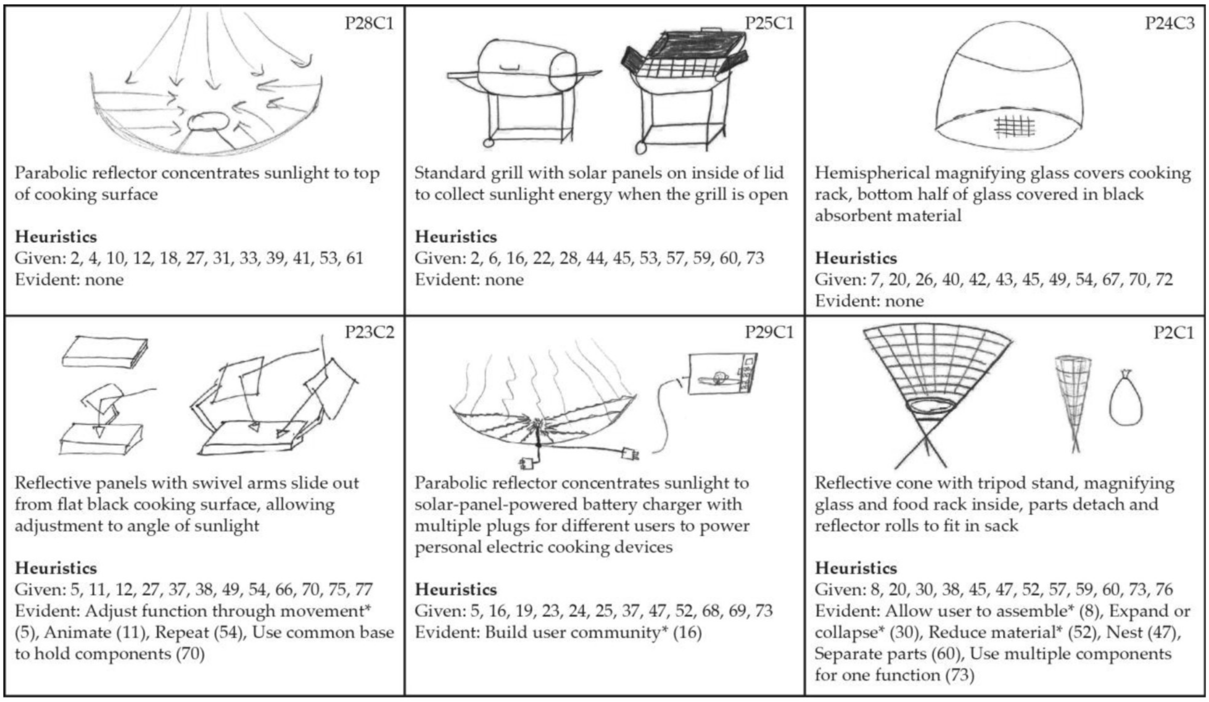


**Fig. 4.** Example Concepts with Evident and Not Evident Heuristics.

row). Heuristics marked with an asterisk were also claimed by the students.

To explore differences among concepts with and without Design Heuristics, we compared heuristic use on measures that represent exploration of the solution space: the number of concepts generated, quality of solution type, concept creativity, and concept set diversity.

Students generated between 1 and 8 concept, averaging 3.4 concepts. We found no correlation between the number of heuristics used during the ideation session and the number of concepts generated. With a short idea generation period, many ideas could be generated from simple brainstorming. In a different study [28] involving a longer design task, Design Heuristics were found to increase the number of ideas generated by expert designers.

The number of concepts for each solution type are shown in Fig. 5. The 'other' category represents ideas that were not adequately described by the first five categories.

Of all designs with no heuristics evident, 48% of the concepts were solar panel attachments (see Fig. 6 for examples), another 47% were other 'typical' designs, and only 5% were designs coded as 'other.' Of all concepts with heuristics evident, 60% were categorized as 'other.' Concepts showing heuristic use often went beyond the simple, 'typical' solutions.

A third measure of solution space exploration is creativity. We compared heuristic use to the averaged creativity ratings from the two blind coders (see Fig. 7). The percentage of concepts with evident and non-evident heuristic use was identified for each

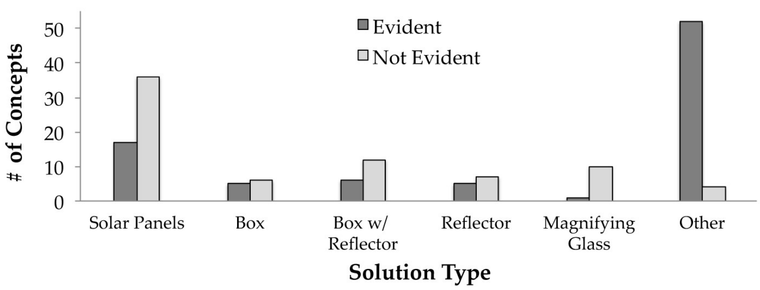


**Fig. 5.** Number of Concepts Grouped by Solution Type for Concepts Where Heuristics Were, and Were Not, Evident.

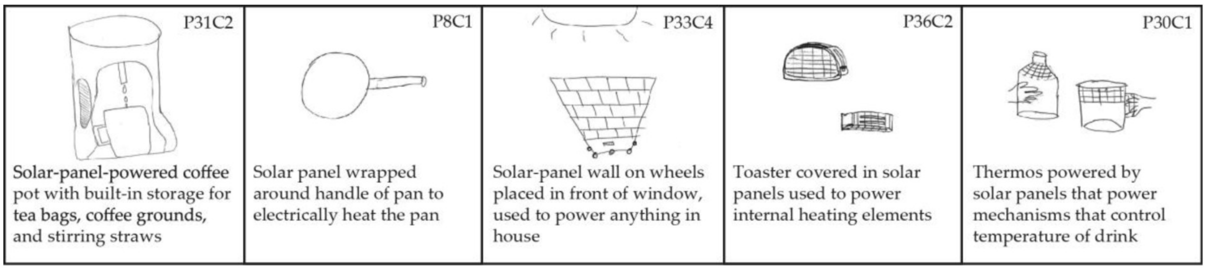


**Fig. 6.** Solar Panel Attachment Examples.

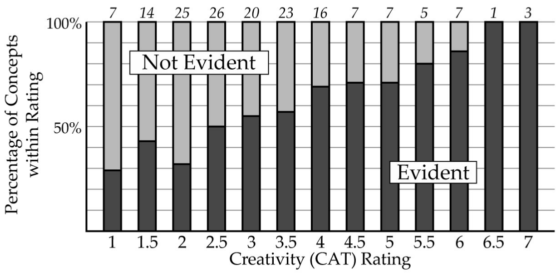


**Fig. 7.** Creativity Rating as a Function of Evident Heuristic Use.

level of creativity rating. The size of the rating group is included at the top of each bar.

The graph shows a strong trend: The percentage of concepts with evidence of heuristic use increases with higher creativity ratings. Of the concepts scored above the scale midpoint, 76% had evidence of heuristic use. Concepts with evidence of heuristic use averaged a creativity score of 3.6, while those without evidence averaged 2.7. This difference is significant, $t$ (159) = 4.5, $p < 0.01$.

Figure 8 shows three examples of concepts rated low (top row) and three rated high (bottom row) on creativity. The evident heuristics are included below the descriptions, and heuristics claimed by the student are marked with a star.

These example designs show a distinct difference between high and low creativity concepts. Creative concepts using heuristics appear to consider aspects beyond function, such as the inclusion of user options and more developed forms.

Finally, concept set diversity serves as a measure of exploration of the design solution space. In Fig. 9, the diversity ratings by the two coders for each student are averaged and shown plotted against the total number of heuristics used by that student in their concept set (counting each heuristic only once).

The diversity score for students who used four or

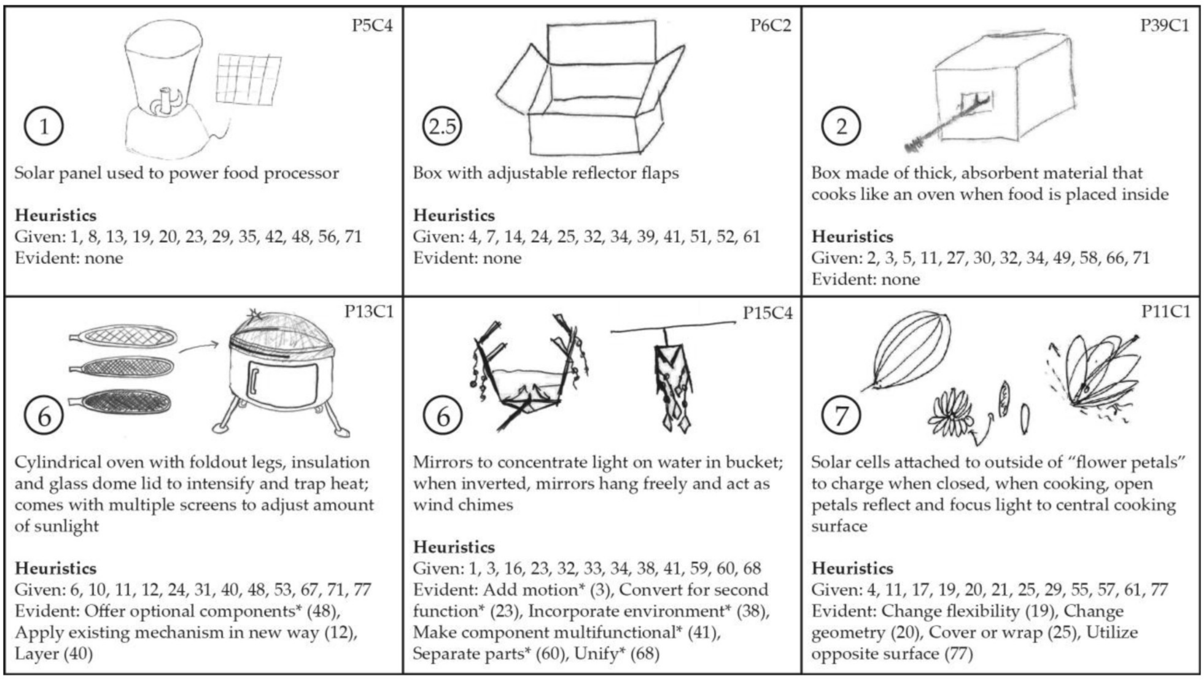


**Fig. 8.** Concept Examples with Low (top row) and High (bottom row) Creativity Ratings.

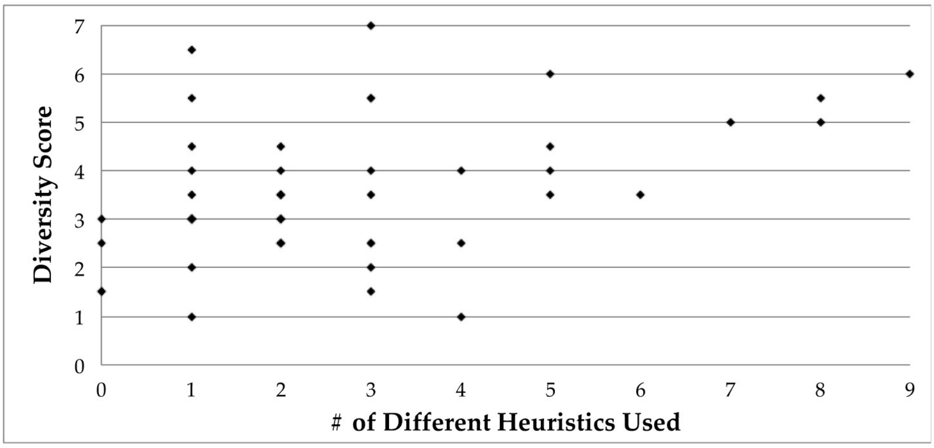


**Fig. 9.** Diversity Score as a Function of Number of Different Heuristics Used.

**Table 1.** Frequency of Heuristic Card Application

| Use Percentage | Heuristic Card Number |
|---|---|
| 0% | 1, 2, 6, 9, 14, 24, 28, 33, 37, 43, 44, 46, 49, 53, 55, 56, 59, 71, 72, 75 |
| 1–20% | 8, 10, 12, 17, 18, 20, 26, 27, 31, 32, 38, 39, 45, 50, 51, 66 |
| 21–40% | 3, 7, 11, 16, 21, 22, 36, 40, 41, 42, 47, 48, 52, 57, 58, 60, 61, 62, 63, 65, 67, 69, 73 |
| 41–60% | 4, 19, 25, 29, 30, 34, 54, 70, 77 |
| 61–80% | 5, 23, 35, 68 |
| 81–100% | 13, 76 |

fewer different heuristics in their concepts ranged from very low to very high. However, the diversity scores for students who used at least five different heuristics in their idea generation session were above 3.5. Thus, students who used a variety of heuristics were more likely rated high in diversity on their set of concepts. This indicates that high heuristic use in an idea generation session can increase the potential for concept set diversity.

In summary, with four different measures of solution space exploration (number of concepts generated, solution type, concept creativity, and concept set diversity), we found that concepts using heuristics were more atypical and more creative. Also, use of a variety of heuristics occurred in more diverse concept sets. The heuristics appeared to facilitate exploring the space of possible solutions in this design task.

*How do first-year engineering students interpret the ease of use and applicability of the Design Heuristic Cards?*

Another goal of our work was to understand student reactions to the Design Heuristics cards. Thus, the second part of the results presents student interpretations of the heuristics, challenges they faced, and their perceptions of the usefulness of the cards.

Recall that seventy-four cards were sorted randomly into sets of 12 among 48 students; each card was given a maximum of 10 times and a minimum of 5 times. For each heuristic, we counted the number of students who used that card. Table 1 lists the heuristics according to their use, specifically, the ratio of the number of students who used the card at least once to the number of students who were given the card. Some students did not use a card at all, some applied it once, and some applied it multiple times. As we only counted whether the student used the card once given the opportunity, the use of a heuristic multiple times by a student is not reflected in this part of the analysis. Cards with lower use percentages were most likely harder for students to apply to the design task.

Two cards, *Attach independent function components* (13) and *Utilize opposite surface* (76) were used by every student who had them (seven students). Thirteen other cards were used by more than 40% of the students who had them. In the post-design open-ended questionnaire, at least one student specifically chose one of these cards as most useful, with *Fold* being the most frequently cited (by four different students).

Twenty cards were not applied at all, and eleven of these were cited by the students at least once as the most difficult to apply (1, 9, 14, 28, 33, 43, 55, 59, 71, 72, 75). The cards cited as difficult to use in the post-questionnaire were *Add features from nature* (cited 3 times) and *Use Human-generated Power* (cited 5 times). Students may have interpreted using human-generated power as contradicting the

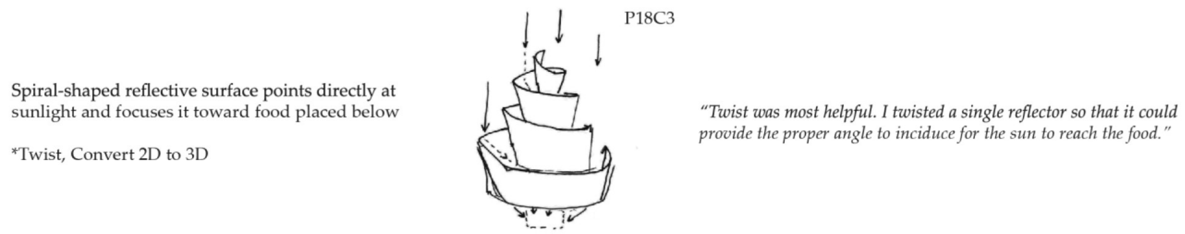


**Fig. 10.** Example of a Student's Concept Using the *Twist* Heuristic

design task specifications (because the task required using solar power). However, the heuristic could have been applied in other ways, such as adding a hand crank to open and close reflectors. The difficulties in using some heuristic cards suggest ways to improve the clarity of the title, description, and examples on the cards for future use.

Many students reported that the reason application of a card was difficult was because it 'did not seem to apply to the design task.' Fifteen of the 48 students claimed they did not use any of the cards. Their reasons focused on their perceived relevance, e.g., 'I did not use any of them. Mine didn't pertain well to the task at hand,' and 'Most of them [were difficult to apply], because they did not seem relevant, at least not in my mind.' We acknowledge that the nature of the design problem may limit both the use and perception of applicability of some of the Design Heuristics. However, we have seen broad use of most of the heuristics on the solar cooking design task from other studies [23, 26]. Thus, while we continue to study applicability in diverse design contexts, these student struggles also suggest the need to facilitate students' ability to understand their application.

Some of the cards reported 'difficult to apply' by one student were reported 'most useful' by another. And, the cards applied most often were also reported by some as 'difficult to use.' For example, *Hollow out*, *Utilize inner space*, *Utilize opposite surface*, and *Add to existing product* were applied five or more times, and cited by at least one student as the most useful card; at the same time, at least one other student cited each of these cards as most difficult to apply. As another example, Participant 18 used the *Twist* card to generate an idea for a spiral reflector (shown in Fig. 10), and cited *Twist* as the most useful heuristic. In contrast, another student reported that the card *Twist* was difficult to apply, and shared his confusion by saying: 'What would I even twist? I mean, come on.'

One typically expects high variability when participants are asked to evaluate based on their own criteria, much like an instructor's course evaluations where one evaluation reports the lectures were crystal clear and another evaluation reports the lectures were confusing. Such contradictory reports do not undermine the value of such evaluations; rather they can point to the different criteria evaluators use. Clearly, one student could perceive a card as useful, and another not see its potential applicability.

This evidence of multiple perceptions of the same card demonstrates that heuristics are not determinate, but allow free expression of ideas. The Design Heuristic Cards are intended to guide ideation, but not to direct the creation of specific concepts. We expected the card prompts to be interpreted in

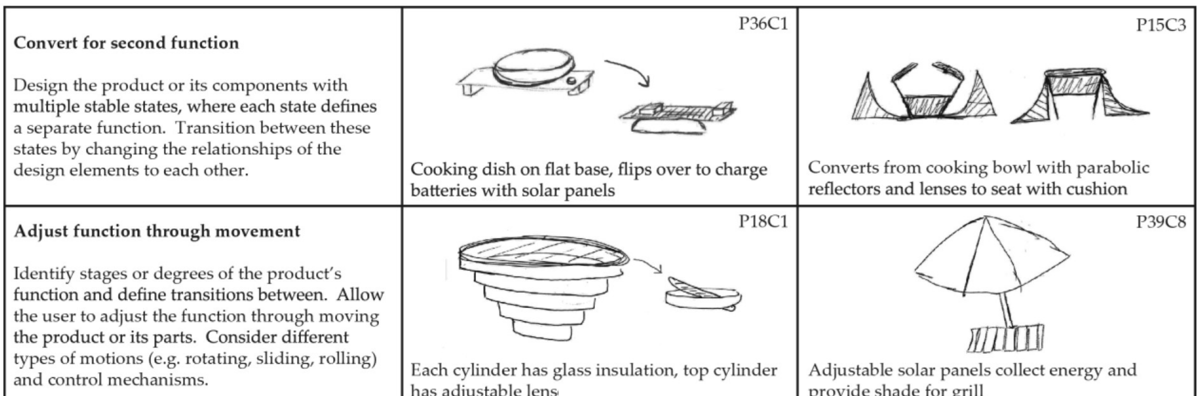


**Fig. 11.** Examples of Different Heuristic Card Interpretations.

multiple ways, and the data analysis supported this hypothesis. No two students who applied the same card to their solution ideas generated the same concept. In fact, 28 times, multiple students applied the same card to yield different concepts. Fig. 11 shows two different heuristics and their application in two different concepts students. The figure also includes the written description of the prompts on the cards.

In the first row of the figure, one student used the heuristic *Convert for Second Function* to create 'charging' and 'in-use' orientations for the product. A second student designed a solar cooker that served as a chair when it was not in use. In the bottom row, the heuristic *Adjust function through movement* is highlighted in two different concepts with adjustable components. The first concept has multiple lenses that could be moved to focus the sun's energy, and the second has moving solar panels that could be aligned with the sun.

In summary, from card to card, and student to student, Design Heuristics varied in their ease of use and interpretation. This empirical finding is further supported by questionnaire responses suggesting some heuristics did not make sense to some students given the intended function of the product, while others were perceived as not applicable to the task. From students' differing perceptions, we conclude: first, the heuristic cards can be improved in the language and images used to more clearly communicate their application; and second, heuristic use may be difficult when students are unable to reframe the design task or challenge the guidelines. Finally, as intended, we observed differences in the ways students successfully interpreted the heuristic cards, such that no two solutions based on the same heuristic were alike.

## 4. Conclusions

This empirical study explored the impact of Design Heuristics on novice students' exploration of a design solution space. Concepts with heuristics evident were more developed solution types, and rated higher in creativity. While concepts with heuristics included a focus on function, they often included features that went beyond basic principles by considering the context of the product, e.g., what the product would look like, who would use the product, and other features that might be important to users. These concepts included features relevant to a more complete product that would be desirable, easy to use, and aesthetically pleasing. The Design Heuristic Cards seemed to provide students with guidance for exploring more creative and diverse ideas.

Concepts without heuristics were often either replications of, or minor changes to, existing concepts, products that substituted solar panels for typical power sources, or basic forms focused only on harnessing energy from light. These concepts were rarely developed further to consider context or users. These findings are consistent with previous research on novice concept generation [29–33]. The contrast with concepts using Design Heuristics confirms that the approach is a sound method in ideation education for novice designers.

This study also contributes to our understanding of how Design Heuristics are interpreted by novices. Some students struggled with understanding how some cards can be applied, indicating a need to improve the titles, descriptions, and examples included on certain cards. Students applied the same heuristics in a variety of ways. They appeared to use the heuristics as jumping-off points, and explored what the card could mean in the context of their specific explorations of the design solution space. Multiple applications of the same heuristic did not yield prescribed solutions. This finding supports the level of specificity the heuristics provide, suggesting they serve to aid in exploration without limiting possibilities.

A limitation of the study is that only one design problem was included. While this provides evidence that informs the question of perceived ease of use, we need to investigate card applicability with different problem contexts. In addition, a small sample of students in one engineering course was collected. To test the feasibility of scaling up the use of Design Heuristics as an instructional method, it is important to demonstrate its robustness across students, courses, and design problems. Furthermore, this study does not measure the impact of heuristics on the practicality of student concepts. We saw no obvious distinction in practicality of the concepts in this study; however, it appeared heuristics helped students to more fully develop ideas. Our future work includes evaluating the impact of heuristics on practicality, including an assessment of final product decisions, based on use of heuristics during ideation.

The application of Design Heuristics by novice engineering designers proved to be an effective way to support their exploration of the design solution space, resulting in more creative and diverse ideas. Design Heuristics can help to broaden the scope of solutions considered, thereby improving the set of concepts available for further development in the design process. Incorporating this instructional tool into engineering education can support novice engineers as they develop skills in ideation, and foster the creation of innovative ideas. Given the challenges of problems faced in society, this pedagogy for innovation is a promising development.

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