DESIGN HEURISTICS
INTRODUCTION

OVERVIEW

By uncovering the Design Heuristics that designers and engineers use to explore solution spaces, we can provide students with a collection of strategies to aid idea generation. Based on our 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.

RECOMMENDED LESSON SEQUENCE

1. Introduction to Design Heuristics
2. Idea Initiation
3. Idea Transformation
4. Sub-component Design

HOW THEY WERE DEVELOPED

The Design Heuristics are a result of combined outcomes from:

1. Analyses of award-winning concepts that transformed existing products;
2. A case study of a long-term project by a professional designer
3. Behavioral studies of student and expert conceptual designs;

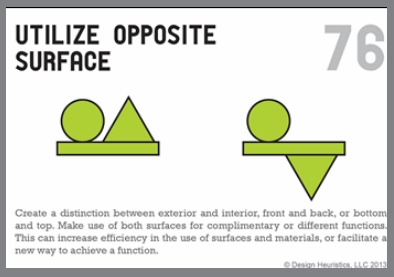
In a study of award-winning product concepts, characteristics that distinguished creative outcomes from existing products were identified. A detailed investigation of over 400 consumer product concepts identified forty Design Heuristics varying in functionality, form, and user-interaction.

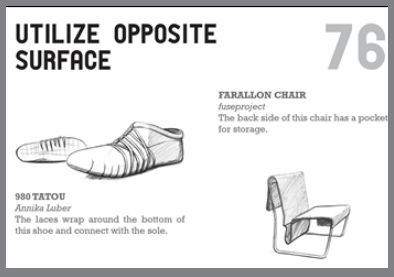
Another study examined over 200 designs by a professional designer for a universal access bathroom in residential homes. Thirty-four new Design Heuristics were identified through analysis of sketches showing transitions from one concept to another over time.

A third study added data based on observing engineers as they worked on novel design problems. Using protocols of their comments while sketching, the engineers' concept generation techniques were identified.

This resulted in seventy-seven heuristics which are each represented on a separate card. Each card includes a description of the heuristic, an abstract image depicting the application of the heuristic, and two product examples that show how the heuristic is evident in existing consumer products. To ensure their usefulness, each heuristic was observed multiple times, used by different engineers and designers, and observed in different design problems. (See example card opposite and complete list of 77 Cards: Design Heuristics for Inspiring Ideas).

THE CARDS





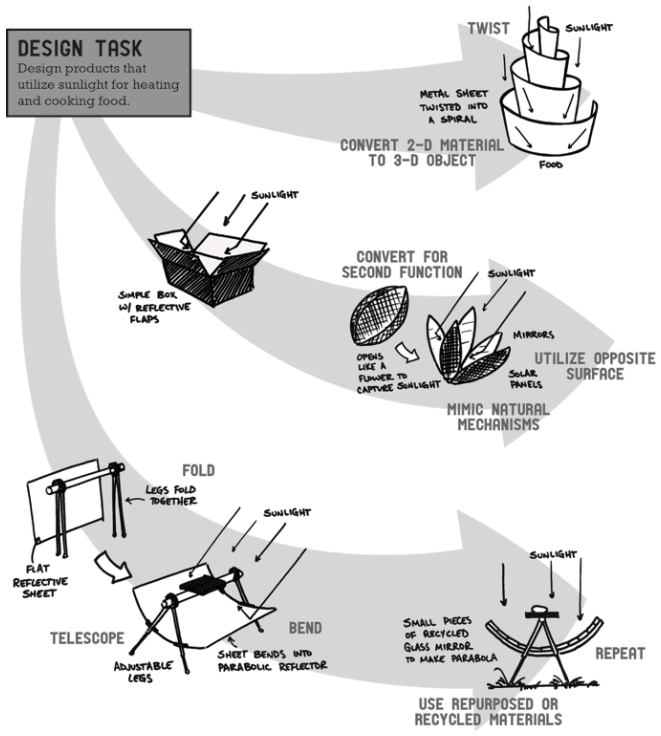
THE DESIGN HEURISTICS

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
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

DESIGN HEURISTICS
INTRODUCTION CONT'D

DESIGN HEURISTIC CARDS CAN BE USED IN MANY WAYS

- Use a new card every time you want to generate a new idea.
- Combine multiple cards to generate a single idea.
- Use a single card to generate multiple ideas.
- Generate new ideas by applying a card to a previous idea.
- Use the abstract image or the examples to inspire ideas.
- Using the cards Repeat and Use Repurposed or Recycled Material.



BEST PRACTICES

1. First concept generation session
2. Start with a subset of cards
3. Work individually (at first)
4. Encourage drawings
5. Creativity, Diversity, and Quantity!
6. Generative to Transformative

CONTACT DETAILS

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WATCH THE VIDEO

HOW THEY WORK

Design Heuristics are prompts that encourage exploration of possible product design solutions during concept generation. They are intended to help designers move through a "space" of possible solutions and also to support designers in becoming "unstuck" when they are struggling to generate more, and different, ideas.

The image above shows an example of what it might look like to generate ideas with the 77 Cards strategy. The engineering designer was tasked with developing conceptual designs for a device that utilizes sunlight to cook food. The designer developed three unique threads of ideas by using the 77 Cards prompts.

In the first thread she combined the strategies of two separate cards – Twist and Convert 2-D material to 3-D object – to generate a single idea. By combining these cards, she was able to create a spiral-shaped reflector out of a single sheet of metal, capable of concentrating a large amount of light onto a small cooking surface.

In the second thread of ideas, she did not generate her first idea with the cards (a simple box with flaps to reflect light into the center), but then used the cards to transform her ideas. Mimic Natural Mechanisms prompted thinking about how flowers bloom, Convert for Second Function prompted thinking about how the device could function in two different states (closed or open), and Utilize Opposite Surface prompted thinking about mirrors that could be used on the inside and solar panels that could be used on the outside.

In the third thread, she started with the cards Fold, Bend, and Telescope to generate an idea for a deployable parabolic reflector. Then, she modified that idea by changing the reflective parabola to be constructed from multiple small pieces of recycled mirrors by using the cards Repeat and Use Repurposed or Recycled Material.

DESIGN HEURISTICS
IDEA INITIATION

LESSON OVERVIEW

Designers can frequently struggle to generate solutions without basing their ideas on existing solutions. In this lesson, students create new designs using different Design Heuristic cards for a given or existing design task. This concept generation lesson emphasizes the ability to continue generating new and different ideas, and allows students to see how possible it is to generate a large quantity and variety of ideas for any design task.

LEARNING OUTCOMES

- Students should increase in their ability to produce multiple concepts for a given design prompt
- Students should be able to effectively generate concepts within defined time pressures
- Students should be able to recognize signs of fixation and overcome it through explicit actions

RECOMMENDED SEQUENCE (sample timing)

1. **Identification of the design problem (3-5 minutes)**
   - Existing design problem/context from course
   - Other general prompt (e.g., solar oven, bike rack, chair)
2. **Introduction to Design Heuristics (5-7 minutes)**
   - Challenge of being creative and combatting fixation
   - Design Heuristics provides shortcuts to help you think of ideas
   - Structure of cards
3. **Practice activity and reflection (7-10 minutes)**
   - Generate a design concept and use two different heuristics to produce two new concepts
   - Ask students to use their cards to generate two additional ideas for a given concept
   - Ask students to share the concepts they generated and how the heuristic influenced or triggered this concept
4. **Idea generation (10-15 minutes)**
   - Generate at least two concepts using traditional brainstorming
   - Use cards to generate additional concepts or concept variations
5. **Reflection (7-10 minutes)**
   - Solicit success stories first—how a heuristic led to a new concept
   - Then solicit challenges students faced—heuristics that were difficult or impossible to apply. Work through at least one of these cases with the class

MATERIALS NEEDED

- Design Heuristics cards (3-5 per student)
- Idea generation sheets (optional)
- Design prompt

COMPLEMENTARY METHODS

- Brainstorming
- Morphological analysis
- User research (e.g., user journey maps, contextual inquiry)

INSTRUCTIONAL SYNERGIES

- Explain differences between ideation methods
- Introduce a new problem space or "kickstart" a new project
- Discuss the divergent qualities of creativity

VARIATIONS

Teaming

This variation can be helpful if teams are already established, and team processes to facilitate equal communication are present (to avoid team domination by a single student). A team approach is also valuable if students are being engaged in a design problem that is related to an existing team project, where students are already motivated to work collaboratively. Ask each team member to individually generate a few concepts that address the design problem provided. Then ask each team to use the cards they have in front of them and their initial concepts to generate as many new concepts or concept variations as possible.

Flipped

This variation can be helpful if a more problem- or project-based focus is already used in classroom instruction, or if experiential learning is a common approach used by the instructor. A practice activity is done first, without the support of Design Heuristics. Students are then prompted to reflect on their experience, including more general frustrations they have with generating new ideas. Then, use this felt frustration to motivate and introduce the use of the Design Heuristics method, and demonstrate the method as described above.

Project Immersion

This variation can be used where students already have a working knowledge and understanding of Design Heuristics. When introducing new projects, it is often helpful to quickly immerse students in the problem space and begin generating concepts. The project is described by the instructor first, as above. Then, students will be directly engaged in idea generation, followed by a reflection on the ideation challenges specific to the defined problem space, possibly leading to broader discussion of potential approaches, strategies to narrow the problem, the need for user research, or the identification and application of explicit constraints.

DESIGN HEURISTICS
IDEA TRANSFORMATION

LESSON OVERVIEW

In this lesson, students are asked to apply Design Heuristics to transform, develop, elaborate, or iterate on their existing ideas. Design Heuristics can be applied at many points within design processes (e.g., after initial ideation, idea narrowing, prototyping, feedback sessions) to allow students to iterate and develop ideas. This lesson emphasizes that a single idea can be the source of many interesting novel ideas through transformations suggested by the Design Heuristics, and that ideas can continue to evolve throughout a design process.

LEARNING OUTCOMES

- Students should increase in their perceived and actual ability to produce multiple variations of existing concepts
- Students should be able to divorce themselves from previous ideas
- Students should be able to communicate individual ideas and their relationship(s) to other ideas they have developed

RECOMMENDED SEQUENCE (sample timing)

1. **Review of the design problem and existing solutions (3-5 minutes)**
   - Existing design problem from course, where students have already generated and/or developed initial concepts
2. **Introduction to lateral and vertical transformations (5-7 minutes)**
   - Lateral transformations build on a previous idea through incremental changes
   - Vertical transformations represent more detailed versions of an earlier idea
3. **Practice activity and reflection (7-10 minutes)**
   - Solicit a concept from the class or provide an example of your own
   - Demonstrate how you could perform lateral and vertical transformations on this concept using heuristics, with classroom participation where possible
4. **Idea generation (15-20 minutes)**
   - For each existing concept sketch, generate at least 2-3 additional concepts using lateral and vertical transformations inspired by one or more heuristics
   - If needed, ask students to switch sets of heuristics halfway through to provide more transformation possibilities
5. **Reflection (5-7 minutes)**
   - Allow students to debrief and share their experience in small groups, then have each group report their experiences to the class
   - Solicit successes and problem cases, and work through at least one problem case with the class

MATERIALS NEEDED

- Design Heuristics cards (3-5 per student)
- Idea generation sheets (optional)
- Existing concept(s)

COMPLEMENTARY METHODS

- Brainwriting
- Reverse brainstorming
- Empathic walkthrough

INSTRUCTIONAL SYNERGIES

- Explain incremental transformation of concepts
- Discuss the power of iteration in the design process
- Demonstrate how concepts can change based on feedback or additional constraints

VARIATIONS

Teaming

This variation can allow for individual and team interaction, taking advantage of existing teams or encouraging divergence among individuals. Ask each student to pick a starting concept that they have previously generated, and pass it to another teammate. Each teammate then modifies the idea they received using one or more heuristics. This process can continue around the table with as many rounds as there are team members. In each round, every team member generates at least one iterative concepts using heuristics either from the original concept or from the concept variations, creating a broad collection of new concepts.

Empathic Walkthrough

This variation encourages the consideration of user research and human-centered design principles. Students create a user story in pairs, acting out how a concept might be used, attempting to generate empathy with the desired end user. From the user stories, the partner generates potential concerns or interesting use cases, which then serve as a set of generative constraints for targeted iteration, using brainstorming and heuristics.

Functional Decomposition

This variation allows for a traditional analytic method, functional decomposition, to introduce productive constraints to fuel the iteration process. Ask students to functionally decompose existing concepts individually or in pairs, identifying which abstracted functions appear across multiple concepts. These functions can then be used as starting points for additional constrained iteration, using heuristics to imagine how an individually function might be alternately satisfied.

DESIGN HEURISTICS
SUBCOMPONENT DESIGN

LESSON OVERVIEW

In this lesson, students generate ideas for subcomponents of a design artifact and recombine them to create ideasdesign products using incremental changes to improve components. They list required functions based on a design problem, decompose existing products using functional decomposition, or start with the design problem and decompose the functions using morphological analysis. These components or functions can then be redesigned using Design Heuristics, which, when recombined, suggest new versions of the product based on combinations of the redesigned components.

LEARNING OUTCOMES

- Students should be able to evaluate and dissect an existing artifact that they did not create
- Students should be able to articulate the part/whole relations of an existing artifact
- Students should increase in their ability to produce multiple variations of existing concepts within a predefined use context

RECOMMENDED SEQUENCE (sample timing)

1. **Identification of the design solution (3-5 minutes)**
   - Existing product or solution, with a moderate amount of complexity to allow for multiple subcomponents to be identified
2. **Functional decomposition or morphological analysis (10-15 minutes)**
   - Use an analysis technique to identify functions or parts of the existing solution, documenting them as a list or function tree
   - Solicit sample functions from the class to ensure that a sufficient variety of functions has been identified
3. **Idea generation (15-20 minutes)**
   - Use heuristics to generate ways to achieve each of the functions, and/or develop concepts that represent different combinations of these function solutions
4. **Reflection (7-10 minutes)**
   - Allow students to debrief and share their experience in small groups, then have each group report their experiences to the class
   - Solicit successes and problem cases, and work through at least one problem case with the class

MATERIALS NEEDED

- Design Heuristics cards (3-5 per student)
- Idea generation sheets (optional)
- Design problem statement or concept solution(s)

COMPLEMENTARY METHODS

- Morphological analysis
- Functional decomposition
- Product dissection

INSTRUCTIONAL SYNERGIES

- Discussion of systems and system components
- Demonstrate how to design within existing constraints

VARIATIONS

Teaming

This variation can allow for teams to work together in generating a functional decomposition or morphological analysis, using consensus building to create a sufficient understanding of the existing subcomponents and their functions. After the analysis is performed and a list of functions has been generated, ask the teams to divide the subcomponents identified among the team members. Then, ask the students to first generate concepts that address their subcomponent individually using heuristics, and then confer with their team members to recombine and iterate on their concepts using sorting techniques and heuristics.

Product Dissection

This variation encourages hands-on discovery of subcomponents through physical dissection of an existing product. First, ask teams to carefully dissect an existing product, sorting the components into categories or types. Then, ask each teams to select a component (or set of components) to ideate on for the remainder of the exercise. Teams may divide-and-conquer with multiple components, or select a single component and ideate individually, then recombine their concepts at the end, evaluating how well the subcomponent addresses the desired function in the original product.

Complex Systems

This variation prompts students to decompose their design goals into tangible and non-tangible/process components, encouraging consideration of a fuller array of components found within complex systems. Ask individuals or teams to apply Design Heuristics to tangible components, helping them recognize where options for exploration might exist. Then, you can ask students to extend this approach to consider non-tangible aspects of the system, including potential analogues inspired by Design Heuristics that allow them to recognizing options for non-tangible system components.