CHAPTER 4: GENERATING ALTERNATIVES

Chapter outline

- Brainstorming
- Generating alternative design concepts
- Creating mockups for user testing

Once you have begun to research and define the problem, it's time to start generating solutions, an activity that continues in one form or another throughout the design process. Notice that we speak of solutions in the plural. Why bother to generate multiple solutions, when the best one may seem obvious to you? Here are just a few reasons:

- To stimulate your team's creativity. It's the most important reason for generating alternatives because it allows team members to approach the problem from different directions, build on each other's ideas, and then choose the solution that combines the best of those ideas.

- To make the design process more efficient. Focusing on one design concept is like putting all your eggs in one basket: If, after months of work, your design doesn't pan out, you've wasted a lot of time and effort. By testing, eliminating, adding, revising, and refining several alternatives, you learn early on which ideas work and which don't.

- To narrow down users' preferences and more efficiently assess their needs. Giving users several solutions to test helps you better understand what they need, which elements of your designs best meet those needs, and which features should be eliminated, changed, or added. Ask users general questions about their needs, and they'll tell you what they *think* they like. Show them several designs and let them compare them, and you'll get more helpful, specific answers.

- To improve the design's ability to achieve multiple objectives. By generating a variety of alternatives that incorporate different functions, you can use the best features of each. For instance, if one alternative is easy to use and another is more durable, you can figure out how to incorporate features of both into the same product.

NOTE: Rather than have each team member develop his or her own design and then compete to see who's the "winner," it's more productive to work together on each alternative, and then take the best elements of each to produce your final design.

The next sections take you through the process of creating alternatives by brainstorming, generating multiple design concepts, and making mockups. The following chapter explains how to gain valuable information from those alternatives through user and performance testing.

4.1 BRAINSTORMING

Good engineering design requires creativity in developing solutions to problems. But our own ingrained attitudes can interfere with our ability to think creatively. A voice inside our head may censor ideas by saying, "Well, it's always been done that way, so that must be the best solution." Or, "That idea will sound too weird to my team." Or, "Let's just evaluate and reject each possible solution until we figure out the right one."

To get beyond these restrictive attitudes, designers use the tried-and-true technique of brainstorming. Developed in the 1930's by advertising executive Alex F. Osborne, brainstorming involves generating a large number of ideas quickly, a process which sets off a chain reaction of creative thinking.

Brainstorming is especially useful at the start of the design process, when you want to be open to as many perspectives as possible. In the later stages, brainstorming is effective when you need to generate alternatives or possible modifications of a design, or when you get stuck at any point in the design process.

The goal of brainstorming is to generate as many ideas as possible in a limited amount of time. Two other steps usually follow it: clustering brainstormed ideas according to similarities, and then evaluating those clusters.

4.1.1 Ground rules for brainstorming sessions

IDEO, a leading international design firm, recommends that teams follow these rules for brainstorming (copyright IDEO Product Development, used with permission):

1. Defer judgment. This is the hardest rule to follow, in part because we're used to making quick judgments. But quick judging tends to block our flow of ideas and dampens the spirit of the session, making other people hesitate to contribute their ideas.
2. Build on the ideas of others. You'll quickly learn that you don't need a whole idea to keep things going. Half an idea will work just fine, because someone else will pick up on what he or she thought you meant and turn it

into something else. The secrets of success are being generous with your own ideas and picking up on others' half-baked (or even fully baked) ideas.

3. One conversation at a time. It gets exciting when several people can't wait to get their ideas out on the table, but to keep the energy flowing and frustration at a minimum, the facilitator must remind participants to let the first person get his or her idea out before going on to the next person.
4. Stay focused on the topic. The thrill of the chase can often lead far from the design problem at hand. To avoid straying too far afield, convey that seemingly off-topic idea in a way that relates. These unplanned force-fits can be a delightful surprise.
5. Encourage wild ideas. Get radical, improbable, unrealistic, impractical, primitive, and even dangerous in your thinking. Your wild ideas are a great way to spark solutions in fellow brainstormers.
6. Quantity, not quality. Your goal is to generate as many ideas as possible, not just "good" ideas. See above for inspiration.
7. Draw it. A picture really is worth a thousand words when it comes to helping explain a concept and recording it in detail. Pictures also allow you to see connections between ideas that words may not reveal. Be sure you sketch each idea and number your sketch.

4.1.2 Facilitator guidelines

Brainstorms don't just happen; someone has to lead them. That person is the facilitator, who needs to:

1. Prepare for the brainstorm. Collect objects that are relevant to the problem you are brainstorming about. For example, if you're brainstorming about a soda vending machine, bring several unopened bottles and cans of soda and loose change. Also bring plenty of paper and colored pens or markers, as well as a snack (M&Ms work well). Being well prepared and keeping a high level of energy at the session will increase the success of the brainstorming.
2. Break the ice. Do five minutes or so of game playing, then have everyone sketch something simple but relevant. For a brainstorm on soda vending machines, for example, have everyone spend 30 seconds sketching a Coke bottle, the pull-tab on a soda can, or the front of a vending machine. As the brainstorm proceeds, keep it light and spirited.
3. Write a one-sentence problem statement on the board. If the problem is complex, break the concept into simple parts and brainstorm each one. For example, if your design problem is to create a curbside mailbox that withstands car crashes, vandalism, and attempted thefts, brainstorm each of these objectives separately.
4. Keep participants aware of the rules and focused. To counteract participants' difficulty in following the "defer judgment" rule, maintain a positive attitude and make only positive statements. Try to turn negative

comments into positives, and questions into concepts to explore. If someone insists on shooting down ideas, say something like, "The next time he says that, just ignore him."

5. Keep encouraging participants to sketch their ideas. In fact, insist on it by saying, "Draw that for me," or just "Draw it!"
6. Make sure all ideas are recognized. Make sure only one person talks at a time and that anyone with an idea gets to voice it. If two people express an idea at the same time, ask one to stop talking and let the other continue; then come back to the first.
7. Record the ideas. The recorder must also serve as the interpreter, quickly choosing the right words to capture each idea. Each idea should be accompanied by a sketch. Assign a number to each idea and make sure that number also appears on the sketch.
8. Keep the ideas flowing. When talk starts to slow down, repeat or rephrase the problem statement, or try building on an idea that's already been suggested. Encourage participants to think about related products or other technologies that could be used. Have a few sub-topics or variations on the main problem statement ready to present if needed.

4.1.3 Example of a brainstormed list of ideas

Below is a list of over 75 ideas brainstormed by an EDC team (Donahue, Galfi & Sileika, 2006) designing a device to enable users with spinal cord injuries who have limited use of their hands and wrists to drink directly from beverage containers. Notice how the students viewed the problem from various angles: attaching the device to the hand or arm, attaching it to the container, and placing the container back on the table. In addition, they paid attention to aesthetic considerations and came up with some far-out ideas.

Example 4.1: Brainstormed list

1. magnet chain
2. adjustable straps
3. handled clamp
4. motorized string
5. bite switch
6. Theraband
7. fingertip magnets
8. brace attachment
9. snap bracelet with buttons
10. rollerblade clip or straps
11. magnetized glove
12. magnetized mitten
13. strap around palm
14. hand bracket
15. glove
16. glove with inset
17. high friction materials—rubber, sticky hand
18. disk on palm
19. pouch
20. glove with elastic band
21. stretchy material
22. convex attachment
23. clamps with roller blade clip

24. clamps on palm
25. electrical actuator
26. turn off electricity to disengage
27. vacuum
28. blood pressure cuff
29. release lever
30. rubber band
31. adjustable backpack strap
32. Super Glue
33. duct tape
34. spatula with back ridge
35. track on forearm
36. platform next to table
37. suction cups
38. clear plastic
39. lightweight—titanium
40. keep close to hand
41. use back of hand
42. hidden inside sleeve
43. use the wrist brace
44. use less metal
45. skin colored
46. personalize (logos, tie dye, write on)
47. screw mechanism
48. electric bite switch
49. switch/joystick combination
50. capo
51. 5-point harness; 2-point harness
52. seatbelt
53. camera battery pack
54. spring on floppy drive
55. big surface to activate spring
56. wire guide
57. elastic harness
58. mechanical roller blade clip
59. seatbelt button
60. two clamps, one stationary
61. funnel attachment
62. clamp
63. multiprong clamp
64. ring clamp
65. Kelly clamp (forceps)
66. roller blade clamp
67. bumper
68. wire wrap
69. ratcheting clamp
70. scoop
71. squeeze clamp
72. beanbag grip
73. pneumatic grip
74. Velcro
75. memory metal
76. memory foam
77. cell phone holder
78. magnetic clamp
79. fingertip magnet
80. twisty tie
81. lariat

4.1.4 Clustering the brainstormed ideas

Because it's difficult to work with a long list of ideas, the next step is to cluster them so you can see connections.

There's no one right way to cluster ideas, but some common ways are to group them according to user requirements, cost, and functionality, to name a few. As you cluster and recluster, you will discover a wealth of ways to solve design problems.

After their brainstorming session, the beverage container team clustered their ideas in this way:

Example 4.2: Clustering the ideas generated in a brainstorm

Attaching to user

adjustable straps
brace attachment
snap bracelet with buttons
strap around palm
glove
glove with inset
track on forearm
velcro
twisty tie

Attaching to container

handled clamp
motorized string
magnetized glove
magnetized mitten
Theraband
disk on palm
rollerblade clip or straps
ring clamp
hand bracket
pouch
glove with elastic band
convex attachment
rubber band
seatbelt
funnel attachment
wire wrap
beanbag grip
pneumatic grip
memory metal
memory foam
cell phone holder
lariat

Securing container

magnet chain
fingertip magnets
high-friction materials—rubber, sticky hand
stretchy material
elastic harness
clamps with roller blade clip
clamps on palm
electrical actuator

vacuum
blood pressure cuff
adjustable backpack strap
Super Glue
duct tape
suction cups
screw mechanism
two clamps, one stationary
multiprong clamp
kelly clamp (forceps)
ratcheting clamp
squeeze clamp
magnetic clamp

Putting down container

spatula with back ridge
platform next to table
bumper
scoop

Releasing container

bite switch
turn off electricity to disengage
release lever
electric bite switch
switch/joystick combination
capo
5-point harness; 2-point harness
camera battery pack
spring on floppy drive
wire guide
big surface to activate spring
mechanical rollerblade clip
seatbelt button

Using discreetly

clear plastic
lightweight—titanium
keep close to hand
use back of hand
hidden inside sleeve
use wrist brace
use less metal
skin colored
personalize (logos, tie dye, write on)

As with brainstorming in general, the purpose of clustering is to choose categories that will help you generate design concepts.

4.2 GENERATING ALTERNATIVE DESIGN CONCEPTS

Now you are ready to convert the most promising ideas from the categorized brainstorm list into alternative design concepts that you can test on users and/or in a laboratory or other controlled environment. At this point you should be developing at least three design alternatives that are significantly different enough to give you good information in testing.

Some teams develop alternatives by having each team member come up with an idea. This unsystematic approach, however, simply pits ideas against each other and doesn't allow members to build on each other's ideas.

To develop alternative design concepts:

1. Decide on which criteria you will use to choose which brainstormed ideas to keep and to eliminate. Generally, these criteria focus on cost and feasibility. That is, you'll eliminate those ideas that are probably too expensive to meet the client's constraints and are technologically beyond your capabilities. Discuss each idea in the clustered brainstorm list, eliminating those that do not meet your established criteria.
2. Choose the best remaining ideas. There are a number of ways to do this: Discuss each idea until the team reaches consensus on whether to keep or eliminate it. Or, have each team member vote for a designated number of ideas in each cluster; the ideas that receive the most votes are chosen. Or, have each team member rank each idea in a cluster on a numerical scale; the ones with the highest totals are chosen.
3. Group the best ideas under the functional requirements they fulfill. You may have identified functional requirements when you created categories for clustering your brainstorm ideas, or you may have to develop new categories. The beverage container team decided on four functional requirements that were sufficiently complex and critical to serve as the focus of the initial round of testing. Here is their list of requirements and best brainstormed ideas:

   Example 4.3: Key requirements and best brainstormed ideas

Attaching to user	Attaching to container	Securing container	Releasing container
• Brace attachment • Glove • Strap around palm	• Pouch • Roller blade clip • Ring clamp	• Elastic harness • Rubber support • Stretchy material • Ratcheting clamp	• Wire guide • Release lever • Springs • Elastic band

4. Make an alternatives matrix. To decide how the different ideas can be combined to create alternatives, make a matrix: one axis has the major

design functional requirements, and the other has the alternatives. (See Example 4.4 below.) The cells in the matrix contain ideas you listed in step #3. Below is the matrix created by the beverage container team. To generate the alternatives matrix, the team asked themselves the following questions:

5. How might the brainstormed ideas fit together logically? In the matrix below, for instance, alternative #2, the "glove," is low-tech, relying on fabric and elastic. In contrast, alternative #1, the "ratchet," is a more mechanical design, relying on clamps and braces.
6. The team also thought about the key questions they wanted the alternatives to answer. They decided that the key questions were these: Will users be able to operate a highly mechanical device, or will they prefer something simpler? What kind of device will feel most comfortable to users? What kind of device will most securely grip and release the container? They mixed and matched the ideas into alternatives that would best allow them to answer those questions.
7. Next the team asked, "Which brainstormed ideas for features do we want to test now and which might be put on hold?"
8. Finally, they did not use all of the ideas listed in step #3, but instead kept them as possibilities for later testing.

Example 4.4: Alternatives matrix for beverage container project

	Attaching to user	Attaching to container	Securing container	Releasing container
Alt 1: Ratchet	Brace attachment	Ring clamp	Ratcheting clamp	Release lever
Alt 2: Glove	Glove	Pouch	Stretchy material	Elastic band
Alt 3: Harness	Strap around palm	Roller blade clip	Elastic harness	Wire guide

Sometimes, brainstormed ideas will not fit neatly into one set of alternatives. In that case, create two or more sets of alternatives. A team designing an alarm system to warn of malfunctions in an intravenous pump (Dickerson, Lee, O'Connell & Powers-Maher, 2007), generated two sets of alternatives, one with visual signals and one with audio:

Example 4.5: Two alternatives matrices for intravenous pump alarm project

Visual alarm alternatives

	Location on pump
Alternative #1	Half screen
Alternative #2	Full screen
Alternative #3	Tubing station
Alternative #4	Handle

Audio alarm alternatives

	Melody pattern	Instrument
Alternative #1	C-E-G	Brass
Alternative #2	C-F#-C	Clarinet

4.3 CREATING MOCKUPS FOR USER TESTING

Mockups are two- or three-dimensional objects that embody your concepts in a physical form and that are developed fairly early in the design process to test key functions, thus giving you valuable information to make decisions about your design.

4.3.1 Guidelines for creating mockups

1. Sketch your mockup ideas first. Drawing your ideas helps you to clarify exactly what you want each mockup to do and to look like. Sketches will also help to communicate your mockup ideas to your instructors and to people in the shop who may help you refine and construct them.
2. Keep your mockups low-tech. The mockups for your initial design alternatives should be constructed quickly from easily available materials. For example, a team designing a patio chair for people with back ailments created miniature mockups out of foamcore to get users' reactions to their concepts. The team designing a traffic flow plan for a local school used an easy-to-learn drawing program called Visio to mock up three alternatives. By using this fast, low-tech approach, you can get your design concepts out to users quickly and learn about their needs and preferences early on without wasting time on fine details that may be eliminated after the first round of user testing.
3. Include enough detail so users can perform (or simulate) the tasks you want to observe. A team designing space for a university department meeting room used foamcore to make a two-foot-square model of the room plus varying sizes of rectangles and squares to represent tables,

chairs, shelves, computers, etc. These movable “furnishings” allowed the team to easily set up the room-model in different ways to represent their alternative designs, and in each case allowed users to rearrange them as they saw fit. The team recorded users’ comments and photographed each final arrangement so they could analyze user preferences later.

4. Include only the parts of the design that you want to learn about through testing. A team designing a wind-resistant beach umbrella didn’t want to put time and effort into creating a separate mockup to test the design of the base, the pole, and the canopy. Instead, they focused on one component at a time in their mockups. They retrofitted different bases onto a standard beach umbrella and asked users to insert and secure each one into the sand. Then they repeated the procedure in mocking up their ideas for the pole and the canopy. When the team wanted to test whether their umbrella designs inverted in the wind, they had to mock up only the various canopies for testing, not the base and poles.

Mockups are useful in testing alternatives throughout the design process. Near the end of the project, you will build a “prototype” that embodies the key functions and aspects of the appearance of your final design.

Note on working with shop professionals

You will find that the professionals who work in the shop are invaluable mentors for helping you develop mockups as well as prototypes. Keep in mind, however, that they are there not to build your mockups but to offer advice and technical assistance as you plan and construct. They are also very busy, conducting shop training sessions and working with many different users of the shop, from EDC teams to graduate students. Therefore, you should observe the following guidelines in working with the shop mentors:

- Schedule an appointment by email. Since the shop professionals are so busy, offer several possible days and times. Use a respectful tone.
- When you have ideas for mockups, prepare planning sheets that include detailed sketches, ideas for materials, and questions you will use the mockups to answer. These planning sheets are available in the classrooms and can be downloaded from the EDC Blackboard website.
- When you want to leave class to work on mockups in the shop, check with your instructors first. Explain exactly what you intend to accomplish. They may ask you to do some planning before you leave class (for instance, make drawings or formulate precise questions).
- Allow more time than you think you need to work on your mockups and final prototype. It's not uncommon for students to budget two hours for a mockup that ends up taking two days to build.
- When you need to order an item through the shop, allow sufficient time for the shop professionals to place the order and for the item to be shipped. Talk with your instructors and a shop professional first to

make sure that you really need the item and that it will arrive in time. Don't assume that all materials will arrive the next day.

- Clean up after yourself. This is a matter not only of common courtesy but of safety: the more clutter in the shop the more likely students are to slip up and hurt themselves.

Once you have built mockups, you are ready to learn from them by doing user and performance testing. These activities are discussed in the next chapter.

4.4 REFERENCES

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