Chapter 4.
Workshop Procedures

Summary: Three sustainable design methods were taught in workshops to students and professional design teams. They were The Natural Step, Whole System Mapping, and Biomimicry. All student workshops were 1.5 hours long; professional workshops were either two hours or four hours long.

4.1. Summary and Background of Design Methods Studied

The Natural Step uses the idea of “Backcasting” to start with the goal (Awareness / Vision activity) of perfect sustainability (as defined by the Four System Conditions mindset), perform a gap analysis between it and the present situation (Baseline activity), ideate new possibilities (Creative Solutions activity), and choose what to act on (Decide by Priorities activity), using the Three Prioritizing Questions mindset. The four-hour, 1.5-hour, and two-hour versions of the workshop contained all the same activities and mindsets. The Five Levels mindset (which supports the Backcasting activities) was not taught in any version of the workshops, due to time limitations and its lack of inclusion in all publications (The Natural Step, 2016). The Natural Step was developed by Karl Heinrich Robèrt beginning in 1987, with development continuing to this day (Robèrt, 1991), (Baxter et al., 2009). In fact, the core mindset of the Four System Conditions was revised in 2015 after this study began; they are now called the Four Sustainability Principles and are slightly reworded. For continuity reasons, this study continued using the earlier version.

Whole System Mapping visually maps the product's system (Draw Whole System Map activity), then uses Life-Cycle Assessment (LCA activity) to find environmental hot-spots, which inform the Prioritized Design Spec activity and mindset. In four-hour workshops, participants performed estimated LCAs for their products; in 1.5 hour and two-hour workshops, they were shown a slide with LCA graphs of common product categories to guide priorities. Then the Brainstorm on System Map activity ideates solutions, using the system map to ensure ideas for everything in the system (Brainstorm All System Nodes mindset) and to push more radical ideas by ideating ways to skip steps in processes or eliminate physical components of the system (Brainstorm to Eliminate Steps mindset). Finally, winning ideas are chosen by comparing them to the design spec (Decide activity). In four-hour and two-hour versions, a decision matrix was used to formalize this process; in 1.5 hour versions for students, participants simply voted intuitively. Whole System Mapping was developed by Jeremy Faludi for the Autodesk Sustainability Workshop in 2010 (Faludi, 2015) as a way to make systems thinking more concrete for practitioners, and as a way to integrate LCA into the early stages of design.
Biomimicry has been taught many different ways over the decades. The version taught here first redefines the design problem to be solved (Define Problem Biologically activity). Then inspiration is sought in nature (Nature as Model, Nature as Mentor mindsets), first through physical objects (Discover Models in Life and Learn Life Model Strategies activities), then online via AskNature.org (Discover Model Strategies Online activity). Next, practitioners brainstorm how to manufacture product versions of those biologically-inspired strategies (Translate to Buildable Things activity). Resulting solutions can be tested for compatibility with nature (Nature as Measure mindset, Choose Nature's Principles activity), and Nature's Principles are also used for ideation (Brainstorm from Principles activity). In four-hour versions of the workshop, participants both tested for compatibility with nature and ideated from Nature's Principles; in 1.5-hour and two-hour versions, they only ideated from the principles. The version of Biomimicry performed here was adapted by the author from the Biomimicry Institute's version (Benyus, 1997), (Baumeister et al., 2013), and was published in the Autodesk Sustainability Workshop in 2010 (Faludi and Menter, 2013). Other variants of Biomimicry design practice include a six-step “Design Spiral” (Baumeister et al., 2008), an eight-step “DesignLens” (Baumeister et al., 2013), and various biomimetic design guides (Vogel, 2000), (Santulli and Langella, 2010), including some that are a hundred years old (Thompson, 1917).

Personal communication with one of the principals at Biomimicry 3.8, source of the Design Spiral and DesignLens, verified that these and other variations of Biomimicry are used, each with different advantages and disadvantages.

4.2. Workshop Procedures

4.2.1. Universal Materials and Procedures

For all workshops, participants used Post-it notes, markers, and either a whiteboard or large sheet of paper (40” x 60” or larger) to write and sketch on. Photographs were taken of these at the end of each activity for each design method, so progress could be tracked throughout workshops. Each professional workshop began with ten to fifteen minutes of participants completing consent forms and pre-surveys if they had not already done so, and ended with ten to fifteen minutes of participants completing post-workshop surveys; for student workshops, participants completed consent and pre-surveys before workshops began, and completed post-surveys after workshops disbanded. Each four-hour workshop contained a ten to fifteen-minute break in the middle, while shorter workshops did not.

4.2.2. The Natural Step

The Natural Step does not publish directions for leading workshops, so this study's author contacted representatives of The Natural Step Canada and The Natural Step Italy for instructions. These instructions did not include operational specifics (where / how to use Post-it notes, whiteboards, paper, etc.), so the author operationalized the activities using his own judgment and experience leading other design workshops. The Natural Step workshops proceeded as follows:

- Lecture to explain method [10 minutes for 1.5 hour and two-hour versions, 15-20 minutes for four-hour version]. This included The Natural Step Funnel, Four System Conditions,
and Backcasting mindsets (Baxter et al., 2009). Participants drew a table on their large sheet of paper, with columns for the four activities (Awareness, Baseline, Creative Solutions, Decide by Priorities) and rows for the Four System Conditions. They were encouraged not to draw lines dividing the rows, because there is often overlap between System Conditions, but many participants did so.

• Awareness / Vision activity [10-20 minutes for 1.5 hour and two-hour versions, 40-60 minutes for four-hour version]. Participants wrote or sketched on Post-its and placed them in the “Awareness” column of the table, to set goals for how their product and its manufacturing would meet all Four System Conditions in a perfect sustainability future. They were reminded to not write specific design solutions, but design specifications. Any solution idea Post-its were placed in the Creative Solutions column for later. In four-hour versions, participants also consolidated and clarified specifications, grouping and/or writing new Post-its after the initial round of Post-its was complete. See Figure 4.1.

![Figure 4.1 Photograph example of the Awareness / Vision activity for a clothing product. Color of Post-its is irrelevant. The one Post-it in the “Concepts” column was a design idea which emerged early from Awareness ideation.](image)

• Baseline activity [15 minutes for 1.5 hour and two-hour versions, 20-30 minutes for four-hour version]. Participants placed Post-its in the Baseline column of the table to analyze how far their product currently is from their vision of a perfect sustainable future. One or more Post-its were recommended for each Post-it in the Awareness column. Figure 4.2
• Creative Solutions activity [15-30 minutes for 1.5 hour and two-hour versions, 30-40 minutes for four-hour version]. Participants brainstormed specific solutions to address their Baseline gaps between current reality and their ideal sustainability future. See Figure 4.3.

Figure 4.2 Photograph example of the Baseline activity for the same product.

Figure 4.3 Photograph example of the Creative Solutions activity for the same product. The table's column is labeled “Concepts” for brevity.
• Decide by Priorities activity [20-30 minutes for 1.5 hour and two-hour versions, 30-45 minutes for four-hour version]. Participants used a modified form of “dot voting” (TheDesignExchange, 2017) to choose winning ideas according to the Three Prioritizing Questions; instead of voting with dots, each participant wrote one “V” on each Creative Solution Post-it that they felt moved toward the ideal vision, an “I” on each that provided good return on investment, and “P” on each that provided long-term as well as short-term Progress. Each participant voted with three of each letter (nine votes total) on various Post-its in the Creative Solutions / Concepts column. Then design solutions with the most votes were either moved to the Decide column of the table, or participants consolidated or modified ideas and put new Post-its in the Decide column. Ideas in the Decide column were teams’ final choices of what to move forward on in the design process after the workshop. See Figure 4.4

![Figure 4.4 Photograph example of the Decide activity for the same product.](image)

• Sharing Solutions activity [5 – 10 minutes, only for workshops with multiple teams]. Long workshops with multiple teams working in parallel had one representative from each team summarize the team's design ideas and insights to the group as a whole, so participants could glimpse the variety of solutions.

4.2.3. Whole System Mapping

• Lecture to explain method [10 minutes for 1.5 hour and two-hour versions, 15-20 minutes for four-hour version]. This included the video “Whole Systems and Lifecycle Thinking” from the Autodesk Sustainability Workshop (Faludi et al., 2010), and slides explaining the subsequent activities.
• Draw System Map activity [15-20 minutes for 1.5 hour and two-hour versions, 40-45 minutes for four-hour version]. Participants wrote or sketched system elements on Post-it notes and arranged them on a large sheet of paper or whiteboard, drawing on the sheet/ whiteboard as desired, to map out the product's rough bill of materials, life cycle stages, user context/usage, and, if applicable, other products the target product is used with. See Figure 4.5.

![Figure 4.5 Photograph example of the Draw System Map activity for an electronic medical device. At left are raw materials, manufacturing, and transport; at center left is the bill of materials; center right is product use and context; at right is end of life.](image)

• LCA and Priorities activity [10-20 minutes for 1.5 hour and two-hour versions, 45-60 minutes for four-hour version]. The type of activity varied by workshop duration:
  o In 1.5 hour and two-hour versions, a slide displayed LCA graphs of four common product categories (large electrical appliances, small portable electronics, frequently-washed apparel, and housewares/furniture) and the rough percent of impacts due to raw materials and manufacturing, transport, lifetime energy use, and disposal. Participants chose the graph (or combination of graphs) most relevant to their product, and wrote down that graph's largest impact (e.g., materials or lifetime energy) as their top priority for sustainability. Then they decided on and wrote down two other business priorities for their product (such as cost and user experience), and ranked all three priorities by importance. Finally, they wrote these priorities as a problem statement to brainstorm from. See Figure 4.6.
  o In four-hour versions, participants were led through an estimated LCA of their product, using the web-based software SustainableMinds, or if internet access was insufficient, the Ecolizer 2.0 PDF lookup table and a pre-prepared Excel spreadsheet to calculate and graph results as they were manually entered from looking up in Ecolizer. In each case, the workshop facilitator entered all data and coached participants to list a rough bill of materials for their product, estimating masses and material composition, as well as product shipping and energy use. Based on estimated LCA results, participants wrote down their product's largest impact (e.g., materials or lifetime energy) as their top priority for sustainability. Then they decided on and wrote down two other business
priorities for their product (such as cost and user experience), and ranked all three priorities by importance. Finally, they wrote these priorities as a problem statement for brainstorming.

![Priorities Example]

*Figure 4.6 Photograph example of the Priorities activity for the same product (priorities listed in order of importance).*

- Brainstorm on System Map activity [20-30 minutes for 1.5 hour and two-hour versions, 30-45 minutes for four-hour version]. Participants brainstorm new solutions on the system map. They are asked to generate at least one idea for every node (Post-it) in their system map, and asked to generate at least two ideas that eliminate some system nodes. See Figure 4.7

![Brainstorm on System Map Example]

*Figure 4.7 Photograph example of the Brainstorm on System Map activity for the same product. Blue, pink, and orange Post-its are new ideas, while yellow Post-its are the system map.*
• Decide by Priorities activity [25-30 minutes for 1.5 hour and two-hour versions, 30-45 minutes for four-hour version]. For all workshops versions, participants used dot voting (TheDesignExchange, 2017), with each participant drawing a dot on a brainstorm Post-it for each of their three votes. The top three to five ideas were then isolated (Post-its moved or newly written). The type of activity varied by workshop duration:
  o For 1.5 hour and two-hour workshops, participants then discussed these ideas to choose a single winner or combine ideas into a hybrid winning idea.
  o For four-hour workshops, participants were led through a decision matrix, using a pre-prepared Excel spreadsheet the facilitator projected and entered data into according to the participants' decisions. The decision matrix's columns were the top design ideas, the rows were the design priorities from the earlier activity. First, the weights (multiplying factors) for each priority were determined by participants, on a scale of 1 – 5. Next each design idea was rated by participants according to how well it would meet each priority on a scale of 1 – 5, with the facilitator entering numbers into the spreadsheet. The spreadsheet calculated scores to show the overall winning idea, and the facilitator asked participants to discuss whether they agreed with the results or had further thoughts. See Figure 4.8.

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*Figure 4.8 Screen shot of a decision matrix from the four-hour version of the Decide by Priorities activity, for a furniture product.*

• Sharing Solutions activity [5-10 minutes, only for workshops with multiple teams]. Long workshops with multiple teams working in parallel had one representative from each team summarize the team's design ideas and insights to the group as a whole, so participants could glimpse the variety of solutions.

4.2.4. Biomimicry

• Lecture to explain method [10-15 minutes for 1.5 hour and two-hour versions, 15-20 minutes for four-hour version]. This included a physical demonstration of Lotusan “self-cleaning” paint, based on the structure of lotus leaves, in addition to listing several other examples of biomimicry in products and buildings. It described the mindsets Nature as Model, Nature as Measure, and Nature as Mentor, and listed two ways to perform biomimicry: directly from mentors, and indirectly from general principles. (The latter was not described in detail until later in the workshop.)
• Define Problem Biologically activity [7-15 minutes for all versions]. Participants discussed the problem(s) they wanted to solve in their product, and then wrote the biological reframing of it on a large sheet of paper or whiteboard. See Figure 4.9.

![Biological Problem: What elements of nature or animals have hydrophobic properties?](Image)

*Figure 4.9 Photograph example of the Define Problem Biologically activity for a clothing product.*

• Discover Models in Life and Learn Life Model Strategies (“Seeing”) activity [15-20 minutes for 1.5 hour and two-hour versions, 25-35 minutes for four-hour version]. Natural specimens were passed out (lemon shark jaw, springbok horns, fox tail, bison teeth, snake skin, sea sponge, cicada exoskeletons, sea shells, and other items depending on number of participants). See Figure 4.10. Participants were asked to speculate on, discuss, and list / sketch the design strategies of the objects on Post-it notes, especially those relevant to their problem definition. Note: in two early executions of the workshop, this activity was performed before the Define Problem Biologically activity. This did not appear to change results notably.

![Biological samples](Image)

*Figure 4.10 Photograph of some of the biological samples used in the Models in Life activity.*

• Discover Models Online activity [15-20 minutes for 1.5 hour and two-hour versions, 20-30 minutes for four-hour version]. A five-minute lecture demonstrated the use of the AskNature.org website. Participants used their personal laptops to search the website for their problem definition, and wrote / sketched the design strategies (or other ideas they
created based on AskNature strategies) on Post-it notes. Discussion was encouraged, as was attention to existing products found on AskNature, and grouping of similar strategies. See Figure 4.11.

Figure 4.11 Photograph examples of the Discover Models Online activity. The left image shows final ideas for the same clothing product, while the right image shows the website AskNature.org with Post-it ideas stuck around the screen.

- Translate to Buildable Things activity [10-15 minutes for 1.5 hour and two-hour versions, 15-30 minutes for four-hour version]. Participants reorganized their biological design strategy Post-its into a single column. For each design strategy, participants brainstormed ways in which it could be physically built using existing technology and production methods, adding a new Post-it for each buildable idea. See Figure 4.12.
Figure 4.12 Photograph example of the Translate to Buildable Things activity for the same product; biological strategies are pink Post-its at left; buildable versions are yellow Post-its at right.

- Choose Nature's Principles and Brainstorm Nature's Principles activity [10 minutes for 1.5 hour and two-hour versions, 20-40 minutes for four-hour version]. A five- to ten-minute lecture was given describing principles of nature identified by experts, mostly “Life's Principles” from the Biomimicry Institute (Baumeister, 2013) and Steven Vogel's list of principles from the book Cats Paws and Catapults (2000). The type of activity varied by workshop duration:
  - For 1.5 hour and two-hour workshops, participants chose one or more principle(s) and briefly brainstormed new solutions based on it/them [5-10 minutes]. See Figure 4.13.
  - For four-hour workshops, participants first used dot voting to choose three to five favorite buildable ideas from the previous activity. Then they measured these three to five ideas against the Biomimicry Institute's chart of Life's Principles. Each principle had a checkbox, which participants checked if one of their design ideas fulfilled the principle [20-30 minutes]. Then participants chose one or more principle(s) and brainstormed new solutions based on it/them [15-20 minutes]. They were especially encouraged to choose principles which had not been fulfilled by their previous design ideas. See Figure 4.13.
Figure 4.13 Photograph example of the Choose Nature's Principles and Brainstorm Nature's Principles activity for the same product. At left, design ideas are measured against the Biomimicry Institute's chart of Life's Principles (four-hour workshops only), with several principles checked off. At right, brainstorming from the principles generates new ideas on blue post its (all workshop versions).

- Sharing Solutions activity [5 – 10 minutes, only for workshops with multiple teams]. Long workshops with multiple teams working in parallel had one representative from each team summarize the team's design ideas and insights to the group as a whole, so participants could glimpse the variety of solutions.