Appendix A:
Educational Goals: Connections to Standards

Where applicable, each goal is followed by supporting standards.

1. Visitors will have fun playing and creating with technologies.

1a. Visitors will feel that they can create using technology.

1b. Visitors will be inspired by what others have created.

1c. Visitors will use technology to express themselves.

2. Visitors will learn about and experience the processes by which new technologies arise.

   Pearson & Young: "Participates, when appropriate, in decisions about the development and use of technology."

2a. Visitors will create an object or system using the engineering design process.

   ITEA Standard 11B: "Build or construct an object using the design process."

   ITEA Standard 9: "Students will develop an understanding of engineering design."

   MA DOE Standard 2.1, grades 6-8: "Identify and explain the steps of the engineering design process, i.e., identify the need or problem, research the problem, develop possible solutions, select the best possible solution(s), construct a prototype, test and evaluate, communicate the solution(s), and redesign."

   Pearson & Young: "Is familiar with the nature and limitations of the engineering design process."

2b. Visitors will learn about and/or experience other creative thinking tools and inventive processes.

   ITEA Standard 1D: "Technology is closely linked to creativity, which has resulted in innovation."

3. Visitors will perceive themselves as capable of understanding technologies.

   Pearson & Young: "Seeks information about new technologies."

3a. Visitors will see technology as marvelous but also comprehensible.

3b. Visitors will discover how things work by reading instructions, taking apart, putting back together, making observations and asking questions.

   ITEA Standard 12A: "Discover how things work (by taking apart, putting together)."

   ITEA Standard 11C: "Investigate how things are made and how they can be improved."

   Pearson & Young: "Can identify and fix simple mechanical or technological problems at home or work."

Educational Goals: Connections to Standards, cont.

4. Visitors will learn that technology is a human activity.

   ITEA Standard 1G: "The development of technology is a human activity and is the result of individual or collective needs and the ability to be creative."

   MA DOE Standard 12, grades 9-12: "Understand that the engineering design process is used in the solution of problems and the advancement of society."

   AAAS Standard 3C, grades 3-5: "Technology has been part of life on the earth since the advent of the human species. Like language, ritual, commerce, and the arts, technology is an intrinsic part of human culture, and it both shapes society and is shaped by it."

4a. Visitors will learn that inventing may be driven by the demands of the marketplace or by the inventor's awareness of possibilities for which no demand yet exists.

   ITEA Standard 6A: **"**Products are made to meet individual needs and wants."

   AAAS Standard 3A, grades 9-12: "Technology usually affects society more directly than science because it solves practical problems and serves human needs (and may create new problems and needs)."

4b. Visitors will learn that technology is the result of the human ability to be creative.

   ITEA Standard 1G: "The development of technology is a human activity and is the result of individual or collective needs and the ability to be creative."

4c. Visitors will learn that different cultures may have different needs or different responses to the same needs.

   ITEA Standard 1E: "Creative thinking and economic and cultural influences shape technological development."

   ITEA Standard 6D: "Throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies."

   ITEA Standard 6F: "Social and cultural priorities and values are reflected in technological devices."

   AAAS Standard 3B, grades 9-12: "The value of any given technology may be different for different groups of people and different points in time."

4d. Visitors will understand that there is no perfect design; all design involves trade-offs based on human preferences.

   ITEA Standard 8F: "There is no perfect design."

   ITEA Standard 8K: "Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other."

   Pearson & Young: "Appreciates that the development and use of technology involve trade-offs and a balance of costs and benefits."

   AAAS Standard 3B, grades 3-5: "There is no perfect design. Designs that are best in one respect (safety or ease of use, for example) may be inferior in other ways (cost or appearance)."

Educational Goals: Connections to Standards, cont.

5. Visitors will see that art and technology are related.

   ITEA Standard 3C: "Various relationships exist between technology and other fields of study."

5a. Visitors will learn that design, whether of a piece of artwork or a new technology, is a creative process.

5b. Visitors will learn that art is created using technologies, and will consider whether the resulting creations are also technology.

   ITEA Standard 3F: "Knowledge gained from other fields of study has a direct effect on the development of technological products and systems."

   ITEA Standard 3G: "Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function."

Messages

Main:

I can have fun playing with, understanding, and creating technologies.

1. I can design technologies using the same processes engineers and inventors use.
2. Designing art and designing technology both require creativity.

   ITEA Standard 8B: "Design is a creative process."
3. Everyone, including me, can be creative

   ITEA Standard 8A: "Everyone can design solutions to a problem."
4. There can be many different solutions to the same problem.
5. I can understand how technologies work.

Petroski, Henry. (2003). Early Education. Presentation at the 2003 Children's Engineering Convention. Retrieved February 13, 2007, from http://www.vtea.org/ESTE/resources/

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Appendix B:
Other Organizational Schemes Considered

In addition to the organizational scheme described in The Visitor Experience section of this document, a number of other schemes were developed and considered. In many cases, the team was able to incorporate the strongest elements of these schemes into the organizational scheme proposed in The Visitor Experience section of this document.

1. Creative People
2. Steps of the Engineering Design Cycle
3. Playground
4. Content Topics

In general, these schemes were rejected because they lacked cohesiveness or could be seen as exhibits about something other than technological creativity. In many cases, the team was able to incorporate the strongest aspects of these schemes into the scheme the team chose.

1. Creative People

Each component or cluster of components focuses on a creative person, such as an artist or inventor. Some of the people featured would be famous, others unknown.

Examples of possible people/sections:

Alexander Calder: Artifacts and images illustrate how Alexander Calder used his mechanical engineering training to invent new artforms, such as wire sculpture and mobile. Video from interviews with Calder draws out the details of his creative process. For the hands-on activity, visitors construct their own mobiles or wire sculptures.

Saul Griffiths: This Media Lab graduate won the Lemelson-MIT student inventor prize for his 3D printer that makes eyeglasses, designed for use in third world countries. This exhibit component shows some of Griffith's more whimsical creations, such as a 3D printer made from LEGO Mindstorms that prints in chocolate and "Howtoons," cartoons that give instructions for science experiments kids can do at home. In a video interview, Griffiths explains the origins of his ideas and discusses his design process. A CAD station with 3D printer gives visitors the opportunity to design and fabricate a small object to take home.

Other people featured include Karl Sims, Buckminster Fuller, Arthur Ganson, Felice Frankel, Kenneth Snelson, and the inventors of Play-Doh.

Advantages of this approach:

- The concept is concrete and transparent to the visitor, i.e., "This exhibit is about a bunch of different creative people."
- It highlights the human side of technology—technology is created by people.
- By presenting a wide range of ways to be "creative," the exhibit can encourage visitors to think of themselves as creative, whether as inventors or users of technology.
- It is scalable—it can easily be made larger or smaller by increasing or decreasing the number of people.

Other Organizational Schemes Considered, cont.

Disadvantages/challenges:

- There are experiences the team wants to include that aren't strongly associated with a person we want to include.
- There is a strong possibility of appearing unoriginal, depending on the people featured.
- There may be difficulty in finding a diverse group of people to feature.
- It seems like an exhibit about interesting people rather than an exhibit about technology.

Incorporation into the proposed organizational scheme

- Stories of creative people will be included in the exhibit, primarily in the context of the creative thinking tools and techniques.

2. Engineering Design Cycle

There are many different descriptions of the engineering design cycle. One possible way to describe it is

- stating the problem
- imagining solutions
- planning
- building
- testing a solution
- revising it based on the tests

Each stage of the process could form the basis of an area in the exhibit. Although some areas may focus on the same topic (e.g., build a car at one station and test it at another) others could be unrelated. For example, the "imagine" area focuses on a transportation issue but in the "plan" area, visitors work on a better birdhouse.

Examples:

Stating the problem: Visitors see examples of inventions that came about by looking at a problem in a completely different way. For example, when trying to come up with better "books" that could be used in literacy education in Africa, a car-battery-powered slide projector for use in night school classes was invented.

Imagining: Problems are posted, with a way for visitors to read what others have suggested and to contribute their own ideas. Related components could include a story of how the IDEO corporation makes use of brainstorming to come up with creative ideas that transform problems.

Revising: Rather than starting a design challenge completely from scratch, visitors get a partially functioning gadget and work on improving it.

Advantages of this approach:

- The exhibit is obviously about engineering.
- It emphasizes the process nature of technology as well as the products.

Disadvantages/challenges:

- It can be difficult to separate the stages of the design process into separate activities.
- It may be difficult to come up with activities for some of the stations.
- It is about a single aspect of technological creativity, ignoring sources of creative ideas and how technologies can be used creatively.

Other Organizational Schemes Considered, cont.

Incorporation into the proposed organizational scheme

- Engineering Design Labs giving visitors hands-on experience with the engineering design process will form a core part of the exhibition.

3. Playground

This approach offers a smorgasbord of experiences related to technology and creativity.

Exhibit Sections:

Open-Ended Workshop:
In the centerpiece of the exhibit, visitors could use materials such as K'Nex, LEGOs, and other construction toys to create an invention, art, or something the Museum hasn't even imagined. This would require Discovery Space-style staffing.

Technology-oriented experiences

- Fab Lab: Visitors use desktop computers and desktop tools, such as laser cutters, computer-controlled milling machines, or sign cutters, to design and make real things.
- Design Challenges: Several structured design challenges, like the Engineering Design Labs from Star Wars. It could also include a flexible space for use by the Design Challenges program.
- Inventor's Stories: This component employs an interactive, electronic interview database that allows visitors to chose to hear various stories about interesting design projects. Interviews focus on what inspired the inventors, what they were trying to achieve, how they came up with a design solution, what happened when they tested it, what trade-offs did they have to make, etc.
- How Things Work: Visitors practice the proper selection and use of tools, dissect products to see how they work, and learn to tinker and troubleshoot. Surrounding displays will demonstrate some common mechanisms, like the Museum's collection of Clark gear models. This also requires Discovery-Space style staffing.

Art-oriented experiences:

- Technology and Art: Mechanical art such as the work of Arthur Ganson and George Rhoads surrounds the workshop of the Museum's Artist-in-Residence.
- Media Studio: Visitors play with music synthesizers, TV cameras, animation software, and more to create things to display or take home.
- Art in Science: A display of imagery produced in the course of research or incorporating tools and concepts from science and technology.
- Human Computer Interfaces: Metafield Maze, an updated Virtual Volleyball, and the I/O Brush would be part of a cluster that explores new and emerging methods of human-computer interactions. Other immersive, reactive environments are incorporated throughout the exhibit.

Advantages of this approach:

- It is a very flexible framework that allows the team to include many types of experiences.
- It makes it easy to separate the activities that need staffing into a concentrated area.

Other Organizational Schemes Considered, cont.

Disadvantages/challenges:

- It lacks cohesiveness: what would visitors say the exhibit was about?
- It requires Discovery Space-style staffing, which may not be available for this project.

Incorporation into the proposed organizational scheme

- If staffing is available, the Open-Ended Workshop described here will be incorporated into the Making It Work section of Creativity Workshop.
- Technological art will be incorporated throughout Creativity Workshop. Inventor's stories will incorporated into the Creative Thinking Tools and Techniques section.
- EDLs and space for the Design Challenges Program will be incorporated into Making It Work.

4. Content Topics

The exhibit is divided into sections based on science/technology content topics.

Exhibit sections:

Light:

- I/O Brush from the MIT Media Lab
- One of Brian Knep's interactive light sculptures
- A design challenge involving the placement and timing of traffic lights
- The story of the invention of the laser

Sound:

- The Media Lab's music shapers
- Music synthesizers for visitors to create with
- Programmable musical stairs
- An interactive on how speakers and microphones work

Form/structure:

- Geodesic tents
- Bridge-building design-challenge

Motion and machines:

- Existing gear models
- Display of mechanical automata
- Rube Goldberg or Mousetrap-type design challenge
- Arthur Ganson sculpture

Advantages of this approach:

- Broad topics allow for some consistency while still allowing the team to change components as technology changes.

Disadvantages/challenges:

- It appears to be an exhibit about the content areas chosen, rather than about the processes that give rise to new technologies.

Incorporation into the proposed organizational scheme:

- High-tech art and immersive/reactive environments may be incorporated into the Art and Technology section.

Appendix C:
Engineering Design Processes

The engineering design processes in this table are drawn from a variety of museum exhibits and programs, as these were seen as more feasible for Creativity Workshop than the design processes used in college engineering textbooks and similar sources. The table also includes a few creative problem-solving processes. Looking at trends exhibited across the various processes provided insight and support for the development of the design process to be used in the Creativity Workshop exhibit.

The table illustrates several general patterns in design processes. The processes of curricula or other staffed experiences focus fairly evenly on all stages of the process. In contrast exhibits have more detail building, testing, and improving and less focus on asking, planning, and brainstorming. The creative processes focus primarily on defining the problem and coming up with possible solutions, rather than the building and testing of solutions. In Creativity Workshop, these aspects of the creative process are addressed more in the Creative Thinking Tools and Techniques section of the exhibit, rather than Engineering Design Labs.

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Museum of Science, Boston. *Design Challenges* program.

Museum of Science, Boston. *Engineering is Elementary* curriculum. (http://mos.org/eie/engineering_design.php)

Museum of Science, Boston. *Engineering the Future* curriculum.

Sciencenter, Ithaca, NY. *Tech City* traveling exhibition.

Museum of Science, Boston. *Star Wars: Where Science Meets Imagination* traveling exhibition.

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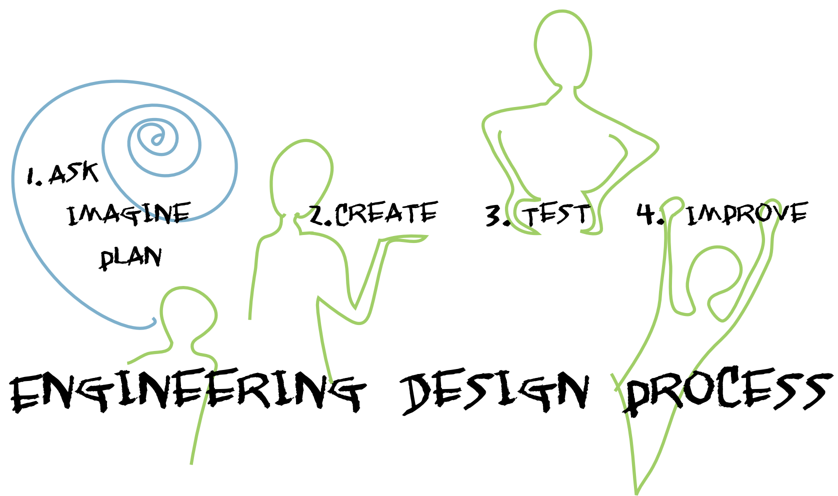

Creativity Workshop Design Process	Design Cycles from Curricula & Programs				Design Cycles from Exhibits			Creative Problem Solving		
	Design Challenge Learning (Tech)	Engineering is Elementary (MOS)	Engineering the Future (MOS)	Design Challenges (MOS)	Tech City (Sciencecenter)	Star Wars Engineering Design Lab (MOS)	Engineer It! (OMSI)	Isaksen & Treffinger	Fabian	Lumisdaine & Shelnutt
Ask, imagine, plan	**Conceptualize:** Identify problem, materials & constraints; brainstorm ideas and possible solutions	**Ask:** What is the problem?, What have others done?, What are the constraints?	**Identify** the problem;	**Ask:** research the problem	**Define** the problem			**Mess & data-** (fact-) **finding**	**Define** the target	**Brain-storming** (Explorers)
		Imagine: What are some solutions?; brainstorm ideas, choose the best one	**Research** the problem;	**Imagine:** Brainstorms all the possible solutions to the problem			**Think**	**Problem-finding**		**Gather** info, analyze data, define problem (Detectives)
			Develop possible solutions;					**Idea-finding**	**Search** for options	**Brainstorm** ideas (Artists)
	Construct & Test: Select a solution, design and construct, prototype, redesign or modify				**Design** a solution					
		Plan: Draw a diagram, make lists of materials you will need	**Select** the best possible solution(s);	**Plan:** Determine the best possible solution; sketch a design, begin to think about the size of your prototype and construction materials.				**Solution-finding**		**Elaborate** on ideas, practical solutions (Engineers)
Create						**Create a design** by physically piecing together and creating an object from materials provided.	**Build**			
		Create: Follow your plan and create it, test it out!	**Construct** prototypes and/or models	**Create:** Construct and test the prototype solution						
Test		**Improve:** Talk about what works, what doesn't, and what could work better, modify your design to make it better, test it out!	**Test** and evaluate;		**Test** the solution	**Test that design** and assess its success relative to a given goal	**Test**		**Check for fit**	
Improve	**Acquire knowledge:** Research, share solutions; reflect and discuss			**Improve:** Redesign and retest your prototype	**Evaluate** the solution	**Refine or redesign** the original creation	**Do it again**			**Improve ideas/** overcome flaws (Judges)
			Communicate the solutions; and redesign.		**Communicate** the solution to those who need to know			**Acceptance-finding**	**Take Action**	

Appendix D:

Background Research

These books, articles, and exhibitions strongly influenced the concept for the Creativity Workshop exhibition.

On technological literacy and technology education standards:

International Technology Education Association. (2002). *Standards for technological literacy: Content for the study of technology* (Second ed.). Reston, VA: International Technology Education Association.

Pearson, G., & Young, T. A. (Eds.). (2002). *Technically speaking: Why all Americans need to know more about technology*. Washington, DC: National Academies Press.

Garmire, E. & Pearson, G. (Eds.). (2006). T*ech tally: Approaches to assessing technological literacy*. Washington, DC: National Academies Press.

On creative/inventive tools and strategies:

Committee for Study of Invention. (2004). *Invention: Enhancing inventiveness for quality of life, competitiveness, and sustainability*. Retrieved February 13, 2006, from the Lemelson-MIT Program Web site: http://web.mit.edu/invent/report.html

Friedel, R. (n.d.) *Breaking through: The creative engineer.* Retrieved February 13, 2007, from http://www.eweek.org/site/nbm/intro.html

Root-Bernstein, R. & Root-Bernstein, M. (1999). *Sparks of genius: The thirteen thinking tools of the world's most creative people*. Boston, MA: Houghton Mifflin.

Smithsonian Institution. *Invention at Play* traveling exhibition.

Weber, Robert J. (1992). *Forks, phonographs, and hot air balloons: A field guide to inventive thinking*. New York: Oxford University Press.

On engineering and design processes:

Chicago Children's Museum. *Inventing Lab* exhibition.

Museum of Science, Boston. *Star Wars: Where Science Meets Imagination* traveling exhibition.

Ontario Science Center. *Weston Family Innovation Centre* exhibitions and programs.

Oregon Museum of Science and Industry. *Engineer It!* traveling exhibition.

Petroski, H. (1996). *Invention by design: How engineers get from thought to thing*. Cambridge, MA: Harvard University Press.

Spencer, D., Carroll, B., Huntwork, D., & John, M. S. (2003). *Findings from a summative study of the Sciencenter's Tech City exhibition*. Ithaca, NY: Sciencenter.

On creativity and education:

Amabile, Theresa M. (1989). *Growing up creative*. Buffalo, NY: Creative Education Foundation.

Resnick, M. (2006). Computer as paintbrush: Technology, play, and the creative society. In D. Singer, R. Golikoff, & K. Hirsh-Pasek, (Eds.), *Play = learning: How play motivates and enhances children's cognitive and social-emotional growth*. New York: Oxford University Press.

Appendix E:
Evaluation Plan

The Museum of Science, a national leader in evaluation-informed exhibit development, is committed to using evaluation throughout the exhibit development process to improve the visitor experience. The institution's evaluation process, which will be used for Creativity Workshop, includes front-end and formative evaluation to inform the exhibit development process, and summative evaluation to measure the extent to which the exhibition's goals were met and also inform future exhibitions at our Museum and other institutions.

Front-end evaluation for Creativity Workshop, discussed on p. 2, began with a review of previous research and evaluation findings, including an overview of engineering design and promoting creativity in museum programs and exhibitions. Questions about visitors' conceptions of creativity were investigated in further front-end evaluation, which included visitor interviews and surveys.

Formative evaluation for this project will focus on the usability of interactives and visitor understanding of the content. Project team members build prototypes of interactive exhibits; evaluators observe visitors using the prototypes and then interview them. The prototypes will be improved and re-evaluated iteratively until the interactives meet the goals set forth by the team. This process will help to ensure that the components developed are usable and understandable for the target audience, as well as accessible for visitors with a wide range of abilities and disabilities.

If requested, a remedial evaluation may be conducted after the exhibition is installed. This evaluation would identify aspects of the exhibition that are working well and those that need improvement based on the goals set forth by the team. Methods used may include tracking and timing, observations of visitor behavior while using the exhibit, visitor interviews, and interactive observations. Based on remedial evaluation results, evaluators would present the team with recommendations for changes to the exhibition to improve the visitor experience.

The summative evaluation, conducted at the conclusion of the project, will inform the project team of the extent to which the goals of the project were achieved. It may include tracking and timing, observations of visitor behavior while using the exhibit, visitor interviews, interactive observations, and audio or video recordings. The summative evaluation for Creativity Workshop will also address questions that will inform future exhibit and program development at the Museum of Science. These questions will be developed in cooperation with the project team based on the innovative tools or techniques developed for the exhibition, institutional needs, or knowledge gaps in the field.

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