**ECE155: Engineering Design with Embedded Systems** Winter 2013

# Lecture 15 — February 5, 2013

*Patrick Lam* *version 1*

**The Creative Process.** We return to talking about the "synthesis" part (and some analysis) of the engineering design process. This part is creative, so we're going to talk about creativity.

Here are five steps in a typical creative process:

1. Gather information.
2. Make a concentrated mental effort to understand the problem.
3. Take a break (sleep, do something else, take a shower, etc.)
4. Discover the solution to the problem (often subconscious).
5. Write down the solution and refine it.

There is reason to believe that generating lots of alternatives (or, on a related topic, getting lots of practice developing skills[1][2]) is better than trying to come up with the one ideal solution.

**Brainstorming and Brainwriting.** Here are two techniques for generating ideas; you've probably heard of brainstorming.

The usual part of brainstorming is the synthesis part, where you write down all ideas. But there's also an analysis part, where you go over the ideas.

- Synthesis: come up with new ideas synthesizing the information; don't discount any ideas, just write them down.
- Analysis: look at all of the ideas (to some extent) and analyze them. Determine the most promising solutions.

Because unusual ideas show up, and aren't immediately discounted, they can help you come up with a variety of creative solutions, some of which might turn out to be practical.

Brainwriting is similar to brainstorming, but involves more paper.

- Write down tentative solutions on *solution sheets*.
- Each team member picks a solution sheet to refine.
- Exchange solution sheets until members run out of ideas.

Because you're writing things down, you can avoid dropping things on the floor.

[1] `http://www.lifeclever.com/what-50-pounds-of-clay-can-teach-you-about-design/`

[2] `http://www.lifeclever.com/talent-isnt-everything-7-habits-of-highly-effective-junior-designers/`

**Avoiding getting stuck.** Roger von Oech[3] produces a lot of output about creativity. According to him, here are some mistaken beliefs that people often have.

- There is only one right answer.
- The creative process must be logical.
- They must "follow the rules" even if the rules are unwritten.
- They must be practical and therefore inhibit their fantasies.
- They must avoid ambiguity and therefore stifle their imagination.
- They avoid new ideas for fear of making mistakes.
- Play is frivolous, and new ideas are hard work.
- They narrow their focus and miss ideas in nearby areas.
- They are afraid to look foolish by suggesting an unworkable idea.
- They are not creative.

## Evaluation

Moving on, let's talk about the evaluation phase of the design process. Now you have one or more candidate designs (design alternatives) and want to see how good it is.

A *design review* is an independent evaluation of a design alternative:

- act as a "sanity check" on the design; and
- are often conducted by evaluation teams consisting of clients and/or managers.

If all alternatives are bad (failed design reviews), the client might terminate the project.

Evaluation teams will consider the following questions:

- Does the design team have a thorough understanding of the purpose and goals of the design?
- Have all of the relevant requirements, criteria, and constraints been identified?
- Is the overall design plausible for meeting the design objectives?
- Does the overall design appear to meet the criteria specified?
- Is the (anticipated) performance of the design adequate?
- Are there any flaws in the analysis of the design?

**Design Alternatives.** Consider presenting more than one alternative at a design review[4]. In the presence of unclear requirements or in a large search space, having alternatives can help the customer pick the best alternative, rather than just saying "I don't like your solution". Also, trying to push bad designs forward can help you understand why those designs are bad.

[3] `http://www.creativethink.com`

[4] `http://www.microsoft.com/design/article.aspx?type=stories&key=design`

## Communication.

The last phase of the engineering design process (and many other creative endeavours) is communication. You haven't done anything if you don't (successfully) tell anyone about it. But communication is also important en-route.

**Communication between stakeholders.** The designers/implementers, managers, and clients need to communicate. Without communication, people tend to assume that things are going well, which can lead to unmet expectations and unpleasant surprises.

**Intra-team communication.** You also need communication within the design team. For a small team, communication helps with continuity and allows you continue the project even if an engineer leaves the company. (This is a key reason that extreme programming, which we'll see later, plays up communication so much). For a large team, communication is mandatory for making sure that all of the parts integrate and for tracking the schedule.

## Design Team Organization

Here are some considerations to keep in mind when organizing and managing design teams.

- Keep team sizes small; Amazon uses the "two-pizza" team concept, splitting large projects into smaller ones. Their team size is at most 8–10. Larger teams have too much coordination overhead.
- Consider how you want to divide responsibility. Extreme programming advocates collective code ownership; traditional models allocate responsibility for specific parts of the project to specific people.
- Ensure that each team member's contribution is important and that each team member understands how their part of the design contributes to the overall goal.
- Set up open communication, so that all members understand relevant schedules, deadlines, and intermediate objectives, and proactively track team members' progress. (Don't pester!)
- Encourage creativity when necessary, but make sure team members aren't going overboard.

**Potential dysfunctions.** Per Steve McConnell, *Rapid Development*, pp. 156–168, Microsoft Press, 1996.

- Lack of common vision
- Lack of identity
- Lack of recognition
- Productivity roadblocks
- Ineffective communication
- Lack of trust
- Problem personnel

**Typical Set of Design Groups.** Here are some design groups that a large organization might use.

- Development Group: tests the feasibility of new technologies and ideas.
- Design Group: refines a design to ensure manufacturability, reliability, safety, and efficient operation.
- Manufacturing Group: refines a design based on the results of the manufacturing process and the performance of test batches.
- Quality Control Group: monitors the quality of products in wide use.
- Customer Service Group: tracks the performance of products and ongoing maintenance performed for customers.

In reality, design groups work concurrently and must sometimes synchronize their work.

Development, design, manufacturing, quality control, and customer service tasks often require many groups to work together. Since these groups may have different goals and deadlines, consensus and cooperation may be difficult to achieve. (In fact, organizational inertia generally makes inter-group cooperation difficult, even without different goals and deadlines.)

Project management attempts to ensure that all groups work together as a cohesive unit. Time management is particularly important for any project with many cooperating teams; this includes scheduling meetings and deadlines.