

Engineering Design w/Embedded Systems

Lecture 15—Engineering Design Process II

Patrick Lam, PEng
University of Waterloo

February 5, 2013

The Creative Process: Synthesis/Analysis

5 steps in a typical creative process:

- 1 Gather information.
- 2 Make a concentrated 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.

Tips for Creativity

How do you get something good?

- generate lots of alternatives.

(a.k.a. getting lots of practice developing skills¹²)

Might not work as well:

- trying to come up with the one ideal solution.

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/>

Creativity: Brainstorming

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

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 be practical.

Creativity: Brainwriting

This is like brainstorming.

- 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.

Creativity: Pitfalls to Avoid I

Roger von Oech³ produces a lot of output about creativity. Here are some misbeliefs, according to him:

- 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.

³<http://www.creativethink.com>

Creativity: Pitfalls to Avoid II

More misbeliefs:

- 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 not creative.
- They are afraid to look foolish by suggesting an unworkable idea.

Evaluating Designs

You have one or more candidate designs (design alternatives) and want to see how good it is/they are.

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.

Questions for Evaluating Designs and Teams

- 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 review⁴.

- Life is often unclear.
- Alternatives: customer has a choice,
- rather than saying “I don’t like that!”

Trying to push bad designs forward can help you understand why those designs are bad.

⁴<http://www.microsoft.com/design/article.aspx?type=stories&key=design>

On Communication

Communication is the final phase in traditional engineering disciplines.

(Not so in software!)

- You haven't done anything if you don't (successfully) tell anyone about it.
- Communication is also important en-route.

Who To Communicate With?

- Between Stakeholders: Designers/implementers, managers, and clients.

Default assumption: things are going well.
May lead to unhappiness.

- Intra-Team Communication.
 - ▶ Small team: helps with continuity; allows you continue the project even if an engineer leaves the company.
 - ▶ Large team: mandatory for making sure that all parts integrate and for tracking the schedule.

Tips on Organizing Design Teams

- Keep teams small, e.g. “two-pizza” teams.
Larger teams have too much coordination overhead.
- Think about dividing responsibility.
- No useless work.
- Open communication; track 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

- **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.

Comments on Design Groups

Design groups work concurrently and synchronize with each other.

Groups have different goals and deadlines—consensus and cooperation may be difficult to achieve.

(Organizational inertia generally makes cooperation difficult, even without different goals and deadlines.)

Project management: get everyone working together.

Time management is particularly key.