

# Introduction to Design III

Presented by:

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**Professional Development Series Lecture (Specification Development) is in  
EE 270**

EPICS – Spring 2014

- At the end of this class period, you will be able to:
  1. Identify tasks and strategies that are effective for the conceptual, detailed, and delivery phases of the design process
  2. Identify how these tasks and strategies can be/were used in your project

1) What are example specifications from your projects?

# ***Design Specifications***

- Quantified
  - Measurable
  - Testable
- Objective quantities (based on some metric)
- A set of units should be associated with each specification

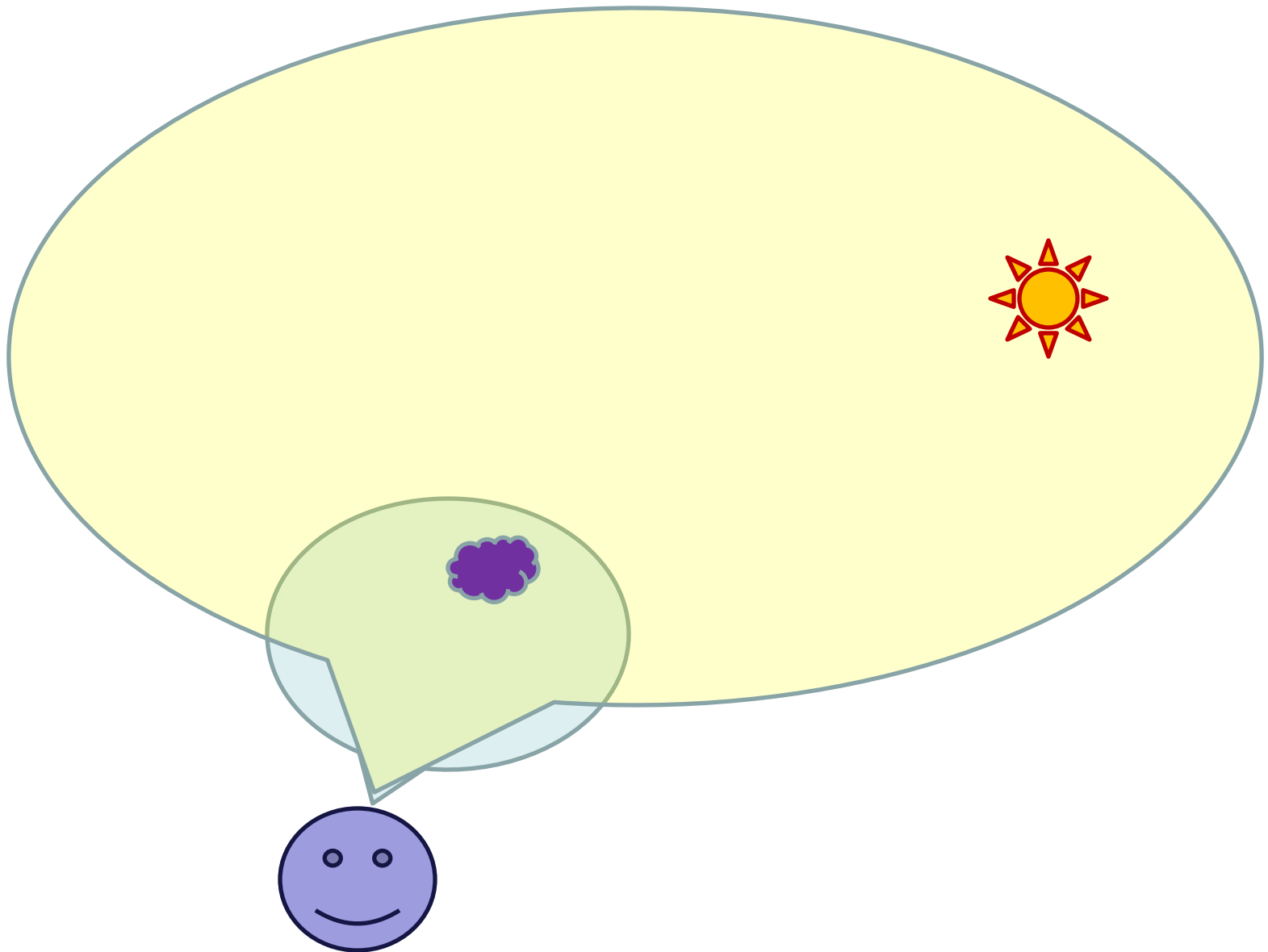
## Categories of Evaluation Criteria (Voland 2004):

- **Physical:** space allocation or dimensional requirements, weight limits, material characteristics, energy or power requirements
- **Functional/Operational:** acceptable vibration ranges, operating times, input/output requirements
- **Environmental:** moisture limits, dust levels, intensity of light, temperature ranges, noise limits, potential effects upon people or other systems that share the same environment
- **Economic:** limits on production costs, depreciation, operating costs, service or maintenance requirements, existence of competitive solutions in the marketplace
- **Legal:** governmental safety requirements, environmental or pollution control codes, production standards
- **Human Factors/Ergonomics:** strength, intelligence, and anatomical dimensions of the user

**Conceptual Design Phase:** Goal is to expand the design space to include as many solutions as possible. Evaluate different approaches and selecting “best” one to move forward. Exploring “how”.

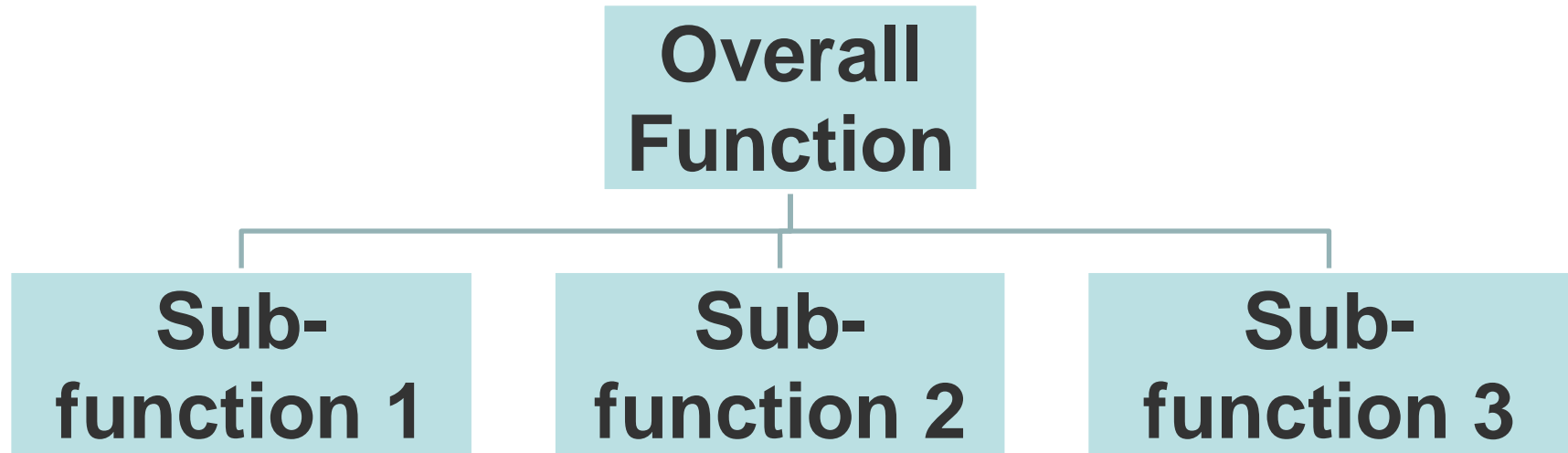
- Conduct Functional Decomposition
- Brainstorm several possible solutions
- Create prototypes of multiple concepts, get feedback from users, refine specifications
- Evaluate feasibility of potential solutions (proof-of-concept prototypes); select one to move forward

*Gate 3: Continue if project partner and advisor agree that solution space has been appropriately explored and the best solution has been chosen.*



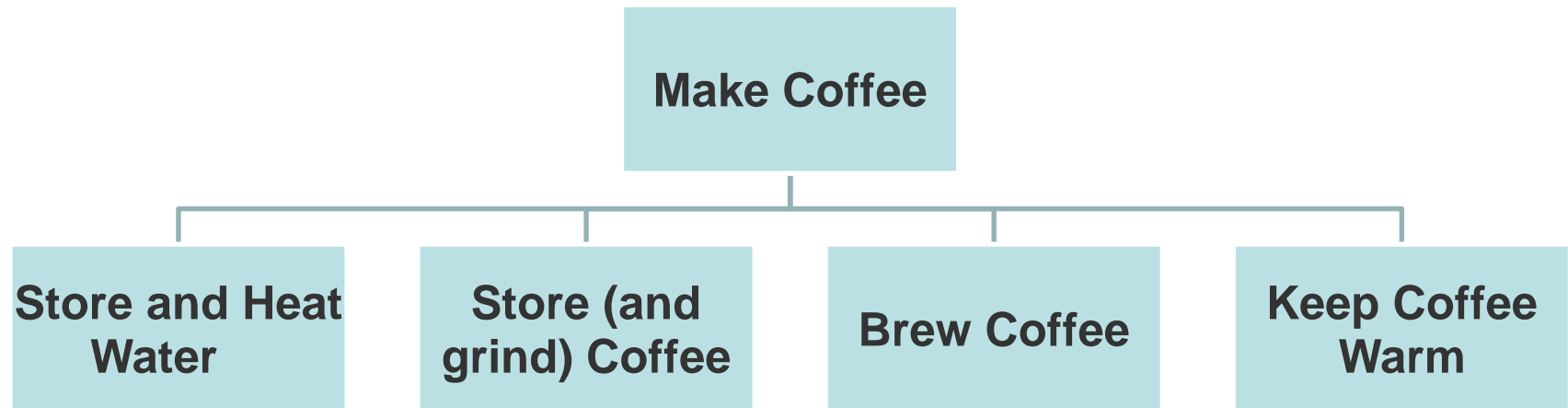
- Breaking tasks or functions of the system down to the finest level
- Create a tree diagram starting at the most general function of your system
  - What is the purpose of your system?
- Break this function down into simpler subtasks or sub-functions
- Continue until you are at the most basic functions or tasks



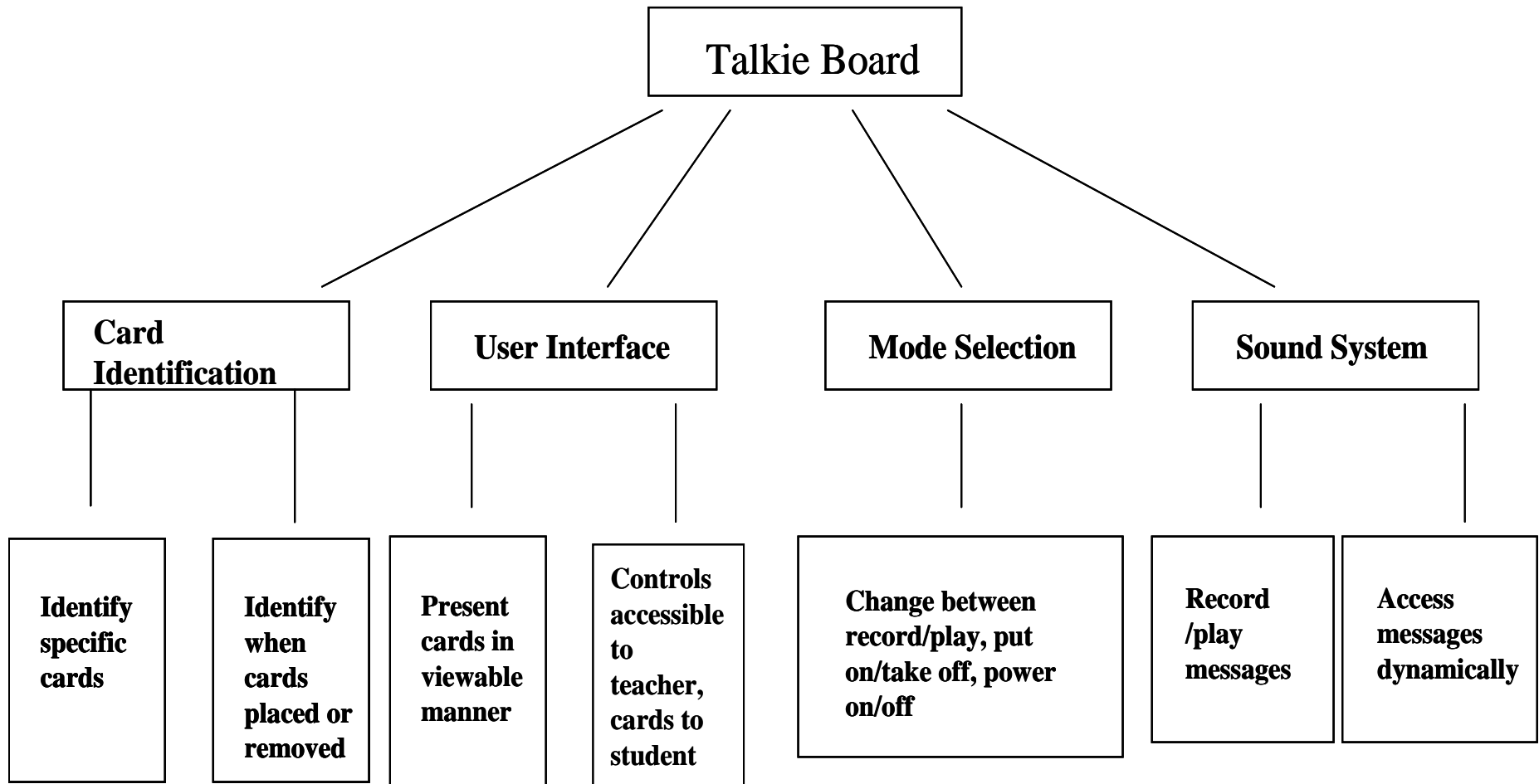


- Each function has a box with
  - An action verb
  - The object(s) on which the verb acts
  - Possibly a modifier giving details of the function
  - Known flows of materials, energy, control or information
- Consider WHAT not HOW

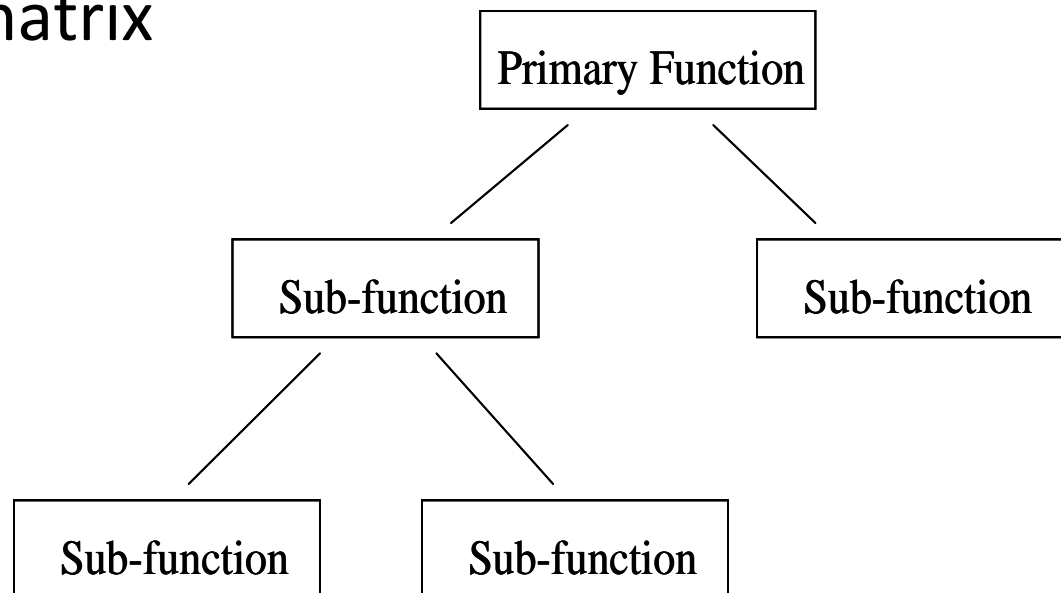
# ***Sample Diagram – Coffee Maker***



# ***Functional Decomposition Example***



- Take functional decomposition and brainstorm on each of the functions
  - How can we \_\_\_\_\_ ?
  - Capture the best of each idea
  - Rebuild the system as combinations
  - Morphological matrix



- **Substitute** – can you use a different method, device, or material or changed the environment?
- **Combine** – can you combine ideas together to produce a better idea?
- **Adapt** – what ideas are similar that could be emulated or adapted to fit the current need?
- **Modify, Minify, Magnify** – can you change the current idea, make it smaller or larger in some way?
- **Put to other uses** – can you use the idea in a new way?
- **Eliminate** – are there any ideas that have been shown to not work?
- **Reverse, Rearrange** – would an opposing idea give you additional information, or can you interchange the key elements of the idea to form a new one?

- Group of 6 people
- Each person writes down 3 ideas
  - Written description or graphical (sketches)
- Pass to right, next person adds to paper for 5 minutes..
  - Ideas can be new, extend, or modify original ideas
- No verbal communication during activity

# APPLY EXISTING MECHANISM IN NEW WAY

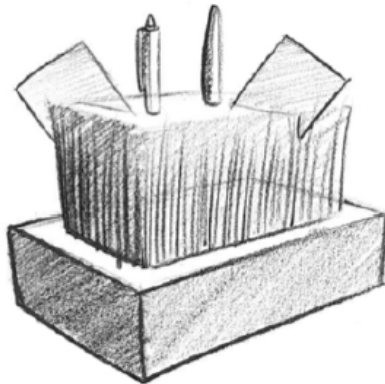
13



Consider whether existing products or their components can fulfill the desired function. This can facilitate reuse of existing products, make the design process more efficient, and expand the pool of options.

# APPLY EXISTING MECHANISM IN NEW WAY

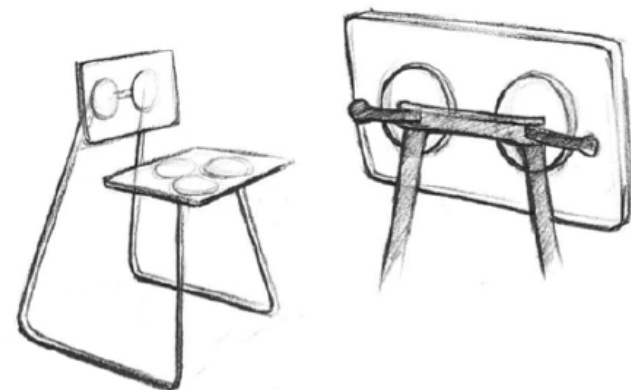
# 13

**PRATONZOLO***Max Battaglia*

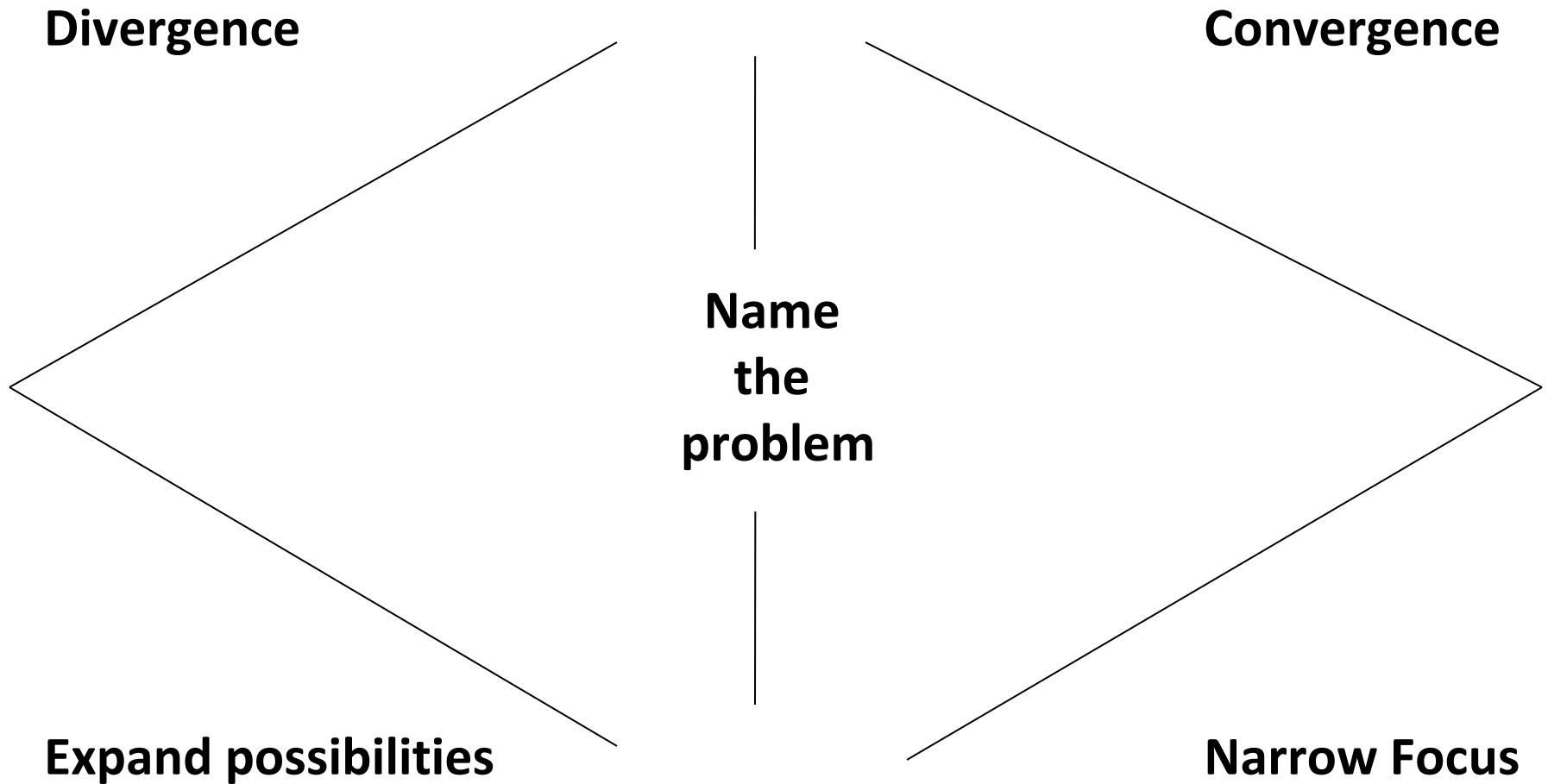
This desk organizer uses brush bristles to hold pens, pencils, and business cards.

**WANTUZ***Reha Erdogan*

Hand vacuum cups are used to transport large sheets of glass. Here, they are used to hold the seat and back of this chair in place.







## ***Decision Matrix***

- Table with alternatives
- Quantify categories and score alternatives
  - Importance in different categories
- Use judgment to do reality checks
- Leaves documentation of thought process of design
  - Can be shared in design reviews

## ***Decision Matrix***

		Ideas to be compared
Criteria for Comparison	Weights	Scores
		Totals

## ***Decision Matrix Example: Getting a Job***

Criteria	Wts	Co. A	Co. B	Co. C	Co. D
Location	5				
Salary	4				
Bonus	2				
Job	3				
Training	2				
Boss	2				
Totals					

## ***Decision Matrix Example: Getting a Job***

Criteria	Wts	Co. A	Co. B	Co. C	Co. D
Location	5	5	4	4	3
Salary	4	4	4	3	4
Bonus	2	3	4	3	4
Job	3	3	4	4	3
Training	2	4	4	3	3
Boss	2	5	4	3	4
Totals		70	68	60	58

**Detailed Design Phase:** Goal is to design working prototype which meets functional specifications.

- |  |
|--|
| <p>Common tasks</p> <ul style="list-style-type: none"><li>• Design/analysis/evaluation of project, sub-modules and/or components (freeze interfaces)</li><li>• Complete DFMEA analysis of project</li><li>• Prototyping of project, sub-modules and/or components</li><li>• Field test prototype/usability testing</li></ul> |
|--|

***Gate 4: Continue if can demonstrate feasibility of solution (is there a working prototype?). Project Partner and advisor approval required.***

## **DFMEA Steps**

1. Review the design
2. Brainstorm potential failure modes
3. List potential effects of failure
4. Rank failures (1 = Low, 10 = High)
  - a) Severity
  - b) Occurrence
  - c) Detection
  - d)  $RPN = \text{Severity} \times \text{Occurrence} \times \text{Detection}$
5. Develop action plan
6. Implement fixes
7. Revisit potential failure risks

**Example FMEA Worksheet**

Item / Function	Potential Failure mode	Potential Effects of Failure	S (severity rating)	Potential Cause(s)	O (occurrence rating)	Current controls	D (detection rating)	CRIT (critical characteristic)	RPN (risk priority number)	Recommended actions	Responsibility and target completion date
Fill tub	High level sensor never trips	Liquid spills on customer floor	8	level sensor failed level sensor disconnected	2	Fill timeout based on time to fill to low level sensor	5	N	80	Perform cost analysis of adding additional sensor halfway between low and high level sensors	Jane Doe 10-June-2011

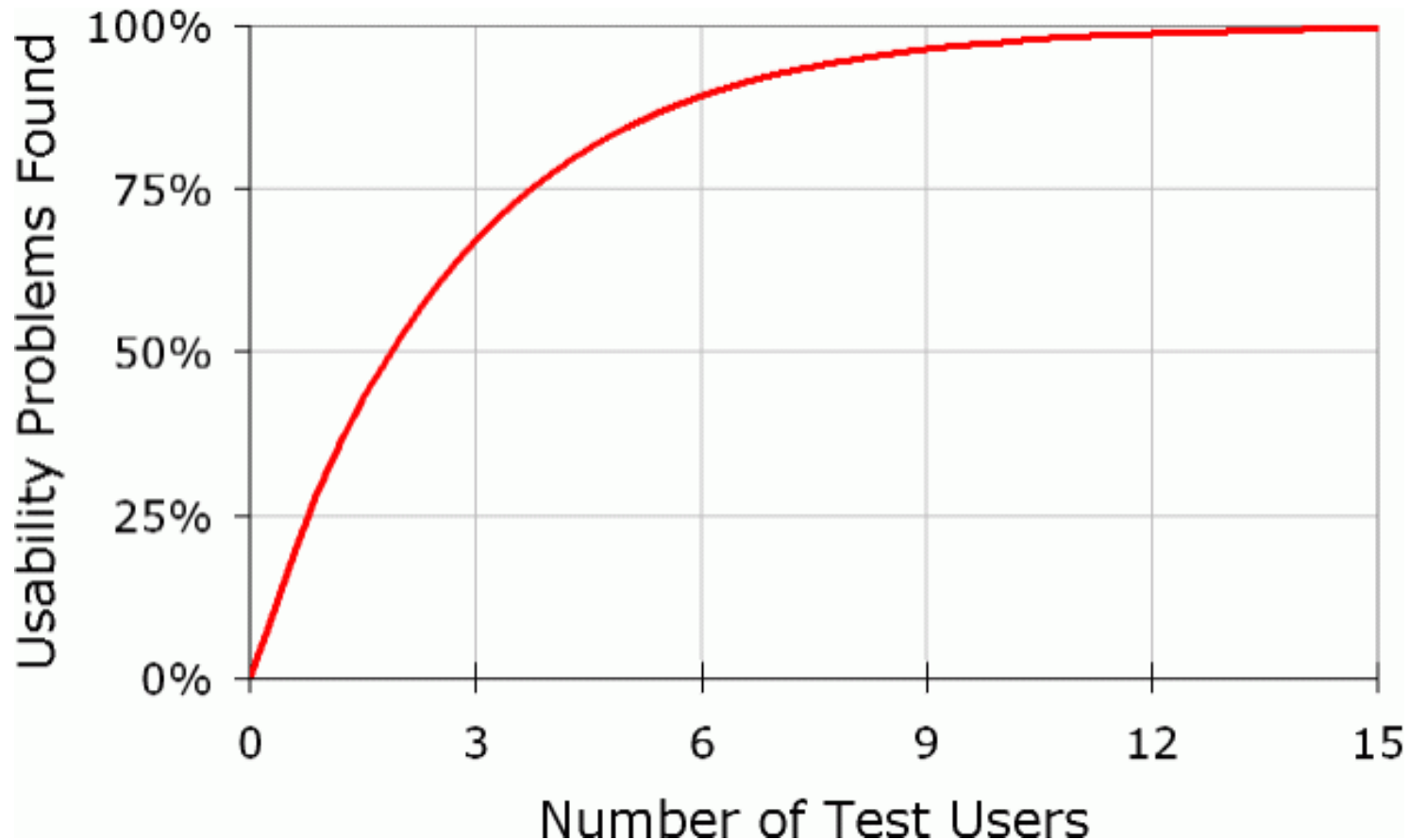
[http://en.wikipedia.org/wiki/Failure\\_mode\\_and\\_effects\\_analysis](http://en.wikipedia.org/wiki/Failure_mode_and_effects_analysis),  
accessed 22 Aug. 2011



## ***Five Usability Attributes***

- Learnability: Easy to learn to use
- Efficiency: Can be highly productive once user learns how to use product
- Memorability: Easy to remember so when return, do not have to relearn
- Errors: Low error rate; if do make errors, easy to recover. Catastrophic errors must not occur.
- Satisfaction: Pleasant to use; users like it.

Source: *Usability Engineering*, Nielsen, 1993



■ <http://www.useit.com/alertbox/20000319.html>

■ <http://www.nngroup.com/articles/how-many-test-users/>

## ***Inclusive Design***

- Motivated by many factors, including business reasons
- Design should not be more exclusive than basic task requires
- Moving beyond accessibility for people with disabilities to designing products that are usable by people of all ages and abilities

Source: Keates and Clarkson, 2003

## ***Inclusive Design: Scales***

- Motion
- Dexterity
- Reach and stretch
- Vision
- Hearing
- Communication
- Intellectual functioning

Source: Keates and Clarkson, 2003

# ***Locomotion capability scale***

**Consists of walking, stair climbing, bending and balance capabilities.**

Locomotion		Severity score
L1	Cannot walk at all	11.5
L2	Can only walk a few steps without stopping or severe discomfort/ Cannot walk up and down one step	9.5
L3	Has fallen 12 or more times in the last year	7.5
L4	Always needs to hold on to something to keep balance	7.0
L5	Cannot walk up and down a flight of 12 stairs	6.5
L6	Cannot walk 50 yards without stopping or severe discomfort	5.5
L7	Cannot bend down far enough to touch knees and straighten up again	4.5
L8	Cannot bend down and pick something up from the floor and straighten up again	4.0
L9	Cannot walk 200 yards without stopping or severe discomfort/Can only walk up and down a flight of 12 stairs if holds on and takes a rest/ Often needs to hold on to something to keep balance/Has fallen 3 or more times in the last year	3.0
L10	Can only walk up and down a flight of 12 stairs if holds on (doesn't need a rest)	2.5
L11	Cannot bend down to sweep up something from the floor and straighten up again	2.0

**Source: Keates and Clarkson, 2003**

**Considers picking up, carrying, holding and twisting capabilities.**

Dexterity		Severity score
D1	Cannot pick up and hold a mug of coffee with either hand	10.5
D2	Cannot turn a tap or control knobs on a cooker with either hand	9.5
D3	Cannot pick up and carry a pint of milk or squeeze the water from a sponge with either hand	8.0
D4	Cannot pick up a small object such as a safety pin with either hand	7.0
D5	Has difficulty picking up and pouring from a full kettle or serving food from a pan using a spoon or ladle	6.5
D6	Has difficulty unscrewing the lid of a coffee jar or using a pen or pencil	5.5
D7	Cannot pick up and carry a 5lb (2.5kg) bag of potatoes with either hand	4.0
D8	Has difficulty wringing out light washing or using a pair of scissors	3.0
D9	Can pick up and hold a mug of tea or coffee with one hand but not with the other	2.0
D10	Can turn a tap or control knob with one hand but not with the other/ Can squeeze the water from a sponge with one hand but not the other	1.5
D11	Can pick up a small object such as a safety pin with one hand but not with the other/Can pick up and carry a pint of milk with one hand but not the other/Has difficulty tying a bow in laces or strings	0.5

**A.37 Dexterity capability**  
Severity categories

**Source: Keates and Clarkson, 2003**

# ADA Accessibility Guidelines

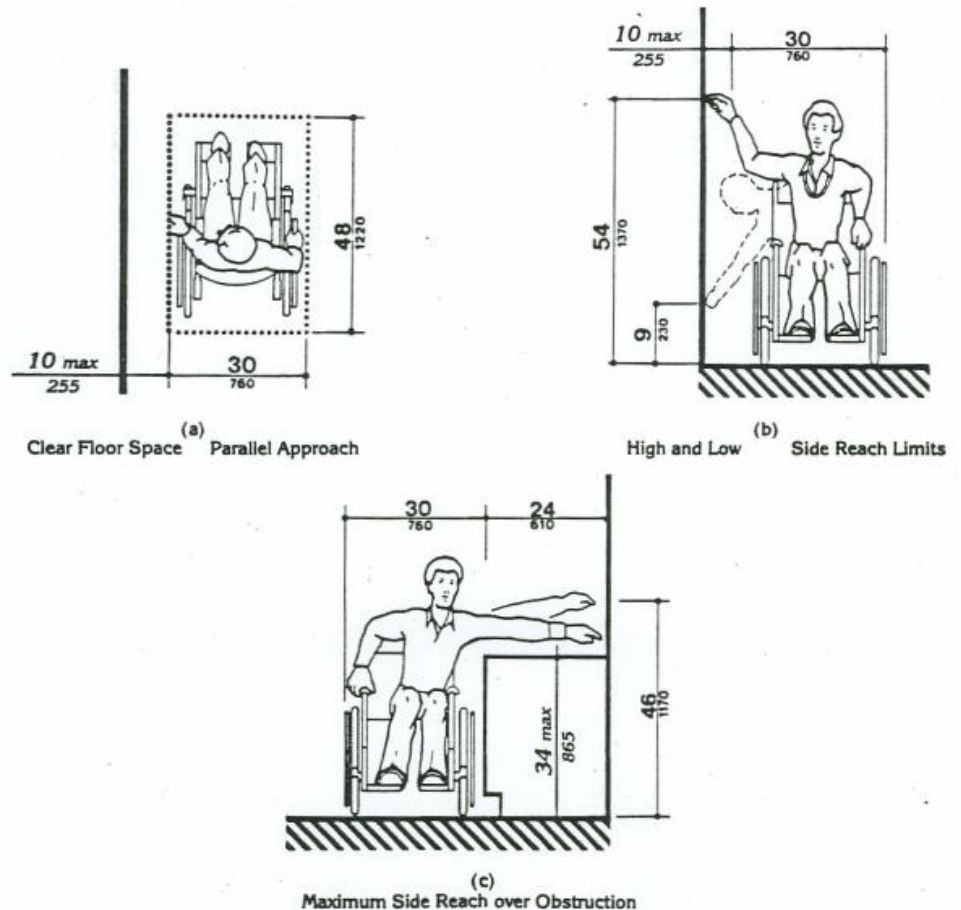


Fig. 6  
Side Reach

**4.3.7 Slope.** An accessible route with a running slope greater than 1:20 is a ramp and shall comply with 4.8. Nowhere shall the cross slope of an accessible route exceed 1:50.

**4.3.8 Changes in Levels.** Changes in levels along an accessible route shall comply with 4.5.2. If an accessible route has changes in level greater than 1/2 in (13 mm), then a curb

ramp, ramp, elevator, or platform lift (as permitted in 4.1.3 and 4.1.6) shall be provided that complies with 4.7, 4.8, 4.10, or 4.11, respectively. An accessible route does not include stairs, steps, or escalators. See definition of "egress, means of" in 3.5.

**4.3.9 Doors.** Doors along an accessible route shall comply with 4.13.



Figure 1: Anthropometric data of the human body. The figure consists of three diagrams: a standing male figure on the left, a seated male figure on the right, and a head/neck profile in the center. The standing figure is annotated with numerous measurements including height (177.7, 162, 148), weight (150, 135), and various limb lengths. The seated figure shows measurements for sitting height (117.2, 105.2, 95.2), hip width (15.8, 13.9, 12.4), and other seated dimensions. The head/neck profile includes visual limits, eye movements, and head movement ranges. Tables for 'Reach Addition' and 'Reach Subtraction' are provided at the bottom left. A 'Temple Catapult Lines' diagram is at the bottom right.



- Visibility
- Feedback
- Affordance
- Mapping
- Constraint
- Consistency
- <http://www.slideshare.net/gelvan/design-principles>

■ Can I see it?



Google

Google Search

I'm Feeling Lucky

## ***Norman's Design Principles: Feedback***

- Design should show effect of an action
- Both positive and negative (not just an error)
- Examples:
  - Indicator lights
  - Comments boxes
  - “Time Remaining”
  - Clicks/sounds
  - Tactile

## ■ How do I use it?

- Perceived and actual properties of an object that give clues to its operation

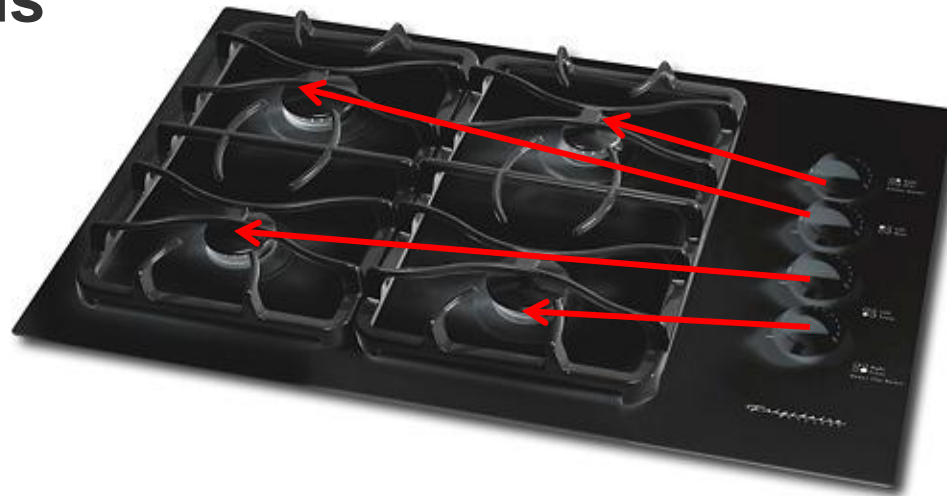
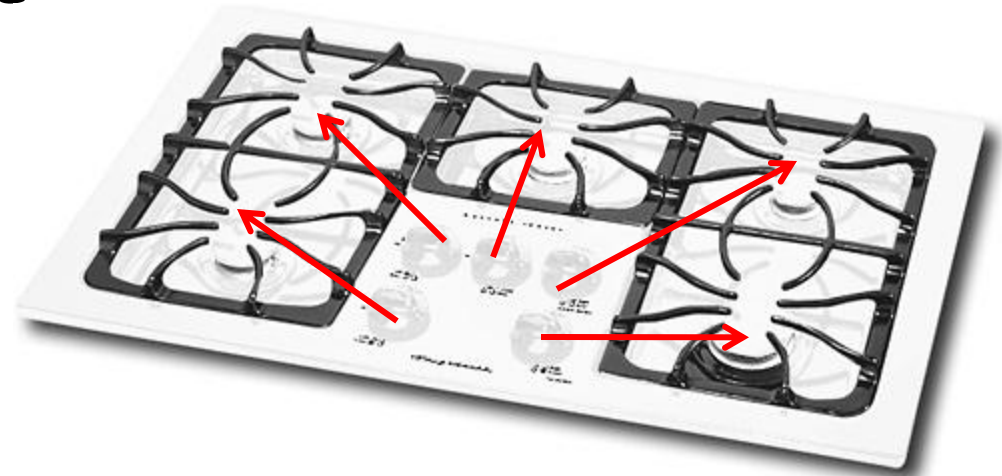


- Why do you think this door needs to be labeled “PUSH”?



# *Mapping: knowledge in the world*

Which stovetop  
is it easier to  
remember  
which knob is  
for which  
burner?



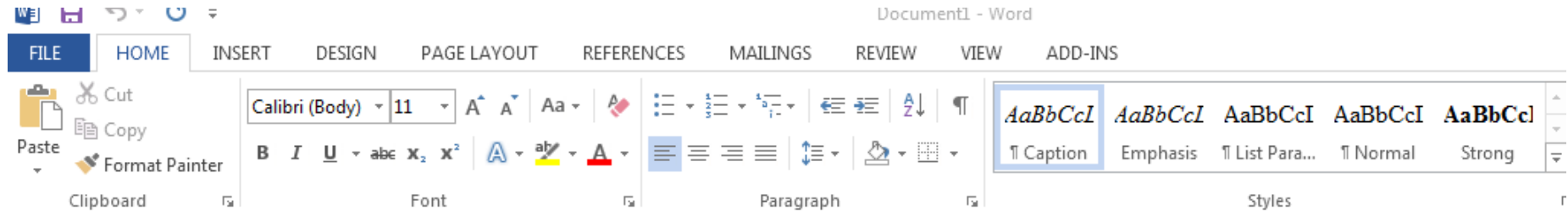


## ***Norman's Design Principles: Constraints***

- Make it impossible or very difficult to make an error or make the consequences of the error as minimal as possible







**Delivery Phase Tasks:** Goal is to refine detailed design so as to produce a product that is ready to be delivered! In addition, the goal is to develop user manuals and training materials.

Common tasks: Complete user manuals/training material  
Complete usability and reliability testing  
Complete delivery review

*Gate 5: Continue if Project Partner, Advisor and EPICS Admin agree that project is ready for delivery!*

Delivery Checklist:

<https://sharepoint.ecn.purdue.edu/epics/teams/Public%20Documents/Delivery%20Checklist.doc>

## Service/Maintenance Phase Tasks

Common tasks: Evaluate performance of fielded project  
Determine what resources are necessary to support and maintain the project

***Gate 6: Project Partner and Advisor approve continued fielding of project. If not, retire or redesign.***

**Retirement or Redesign**

- Due: By lecture next week (February 17th)
- Complete survey:  
[https://purdue.qualtrics.com/SE/?SID=SV\\_bfkSy1MjBvLX1pr](https://purdue.qualtrics.com/SE/?SID=SV_bfkSy1MjBvLX1pr)



## Teams

### Teams

#### Documents

EPICS FAQ

Public Documents

Shared Documents

#### Pictures

Shared Pictures

#### Lists

ARMS 1095 Calendar  
(Software Lab)

ARMS 1098-B Calendar  
(Tools)

ARMS 1098-C Calendar  
(Ross)

Academic Calendar

Tasks

TA Office Hours

#### Discussions

Team Discussion

Recruitment Managers

Teams , EPICS Purdue

### Fall 2013

aaee apps bgi ced csi disc evei gaps glass glee haiti halp hfh hfic ims is lsme miee nees  
ns odos p2l slac soap svat tlbgc voss wcgi wise wrm zoo

Lab Info Team Leaders

### Announcements

#### Ethics Survey Link NEW

9/16/2013 3:19 PM

by Zoltowski, Carla B

New students: Please complete the following survey prior to the Ethics Lecture on September 23:  
[https://purdue.qualtrics.com/SE/?SID=SV\\_8tUeChBRhPJ7o3j](https://purdue.qualtrics.com/SE/?SID=SV_8tUeChBRhPJ7o3j)

#### Design any kind of frame and bolt it together...

7/23/2012 11:21 AM

by Martin, Guy L

Design any kind of frame and the company will cut and notch it for you and all you have to do is bolt it together, and they're right in Indiana! I thought this would be useful to any teams that need a frame but don't want to mess with cutting and welding.

...

#### How to Schedule a Room

9/20/2011 10:50 AM

by Martin, Guy L

Left column under "Lists", select the calendar for the room you'd like to schedule. Create a new item on the calendar. Enter a title, the date and time, and save.



Links (right-click)

READY Purdue —

**Attendance, fill in your name, PUID and true for #1**

**Need to turn in individually to TA/Instructor**