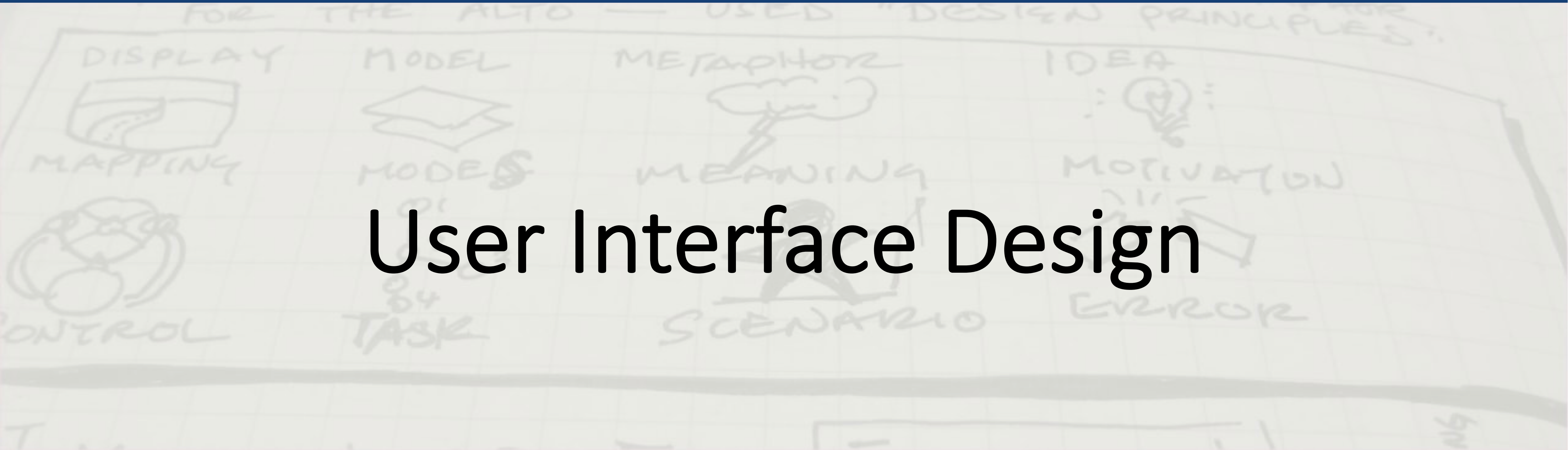


User Interface Design

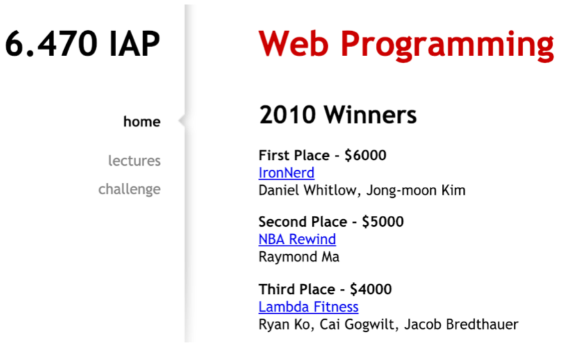
Prof. Lydia Chilton
COMS 4170
17 January 2024

http://coms4170.cs.columbia.edu/2024-spring/

I’m Lydia.

- I’ve been faculty at Columbia for 6 years.
- I was originally an Econ major, but I decided I wanted to be able to build stuff that **solve** the problems I was studying in econ, so I switched to CS.
- Research include:
  - AI + Design
  - LLMs for Journalism
  - AI generated Art
- My only hobbies are my girls, Anya (3) and Ksenia (1).

I’ve been teaching Web Dev & UI for 15 years



6.470 IAP

home

lectures

challenge

Web Programming

2010 Winners

First Place - $6000
IronNerd
Daniel Whitlow, Jong-moon Kim

Second Place - $5000
NBA Rewind
Raymond Ma

Third Place - $4000
Lambda Fitness
Ryan Ko, Cai Gogwilt, Jacob Bredthauer

MIT
2008 - 2010

TA’d AI courses

Univ of Washington
2012 - 2013

HCI design studio

CS 247 · Spring 2017

Stanford
2014 - 2016

User Interface Design

COMS 4170 · Spring 2019

Advanced Web Design Studio

COMS 6998 · Fall 2018

Columbia
2017 - now

4170 Staff

- Prof. Chilton
    - Office hours: Mondays 2:30-3:30 (after class) in CEPSR 612
    - Please come to my office hours! Ask me anything:
        - Programming questions
        - Debugging help
        - Stupid questions
        - Personal questions
        - Anything that will help you learn in this class I will attempt to address in a helpful and judgment free way.
- 20 TAs for ~400 students
    - You’ll be put in sections of ~22 students.
    - Get to know your TA and the students in your section!

Class Goals

- We want you to be able to **build interfaces** that suit and needs and abilities of users.
- We want to convince that **design is process to solve real world problems** in computer science and beyond**.**

- We want to you be **engaged** in the class by interacting with the staff and your fellow students.
- We want you to make a habit of **thinking about users**.

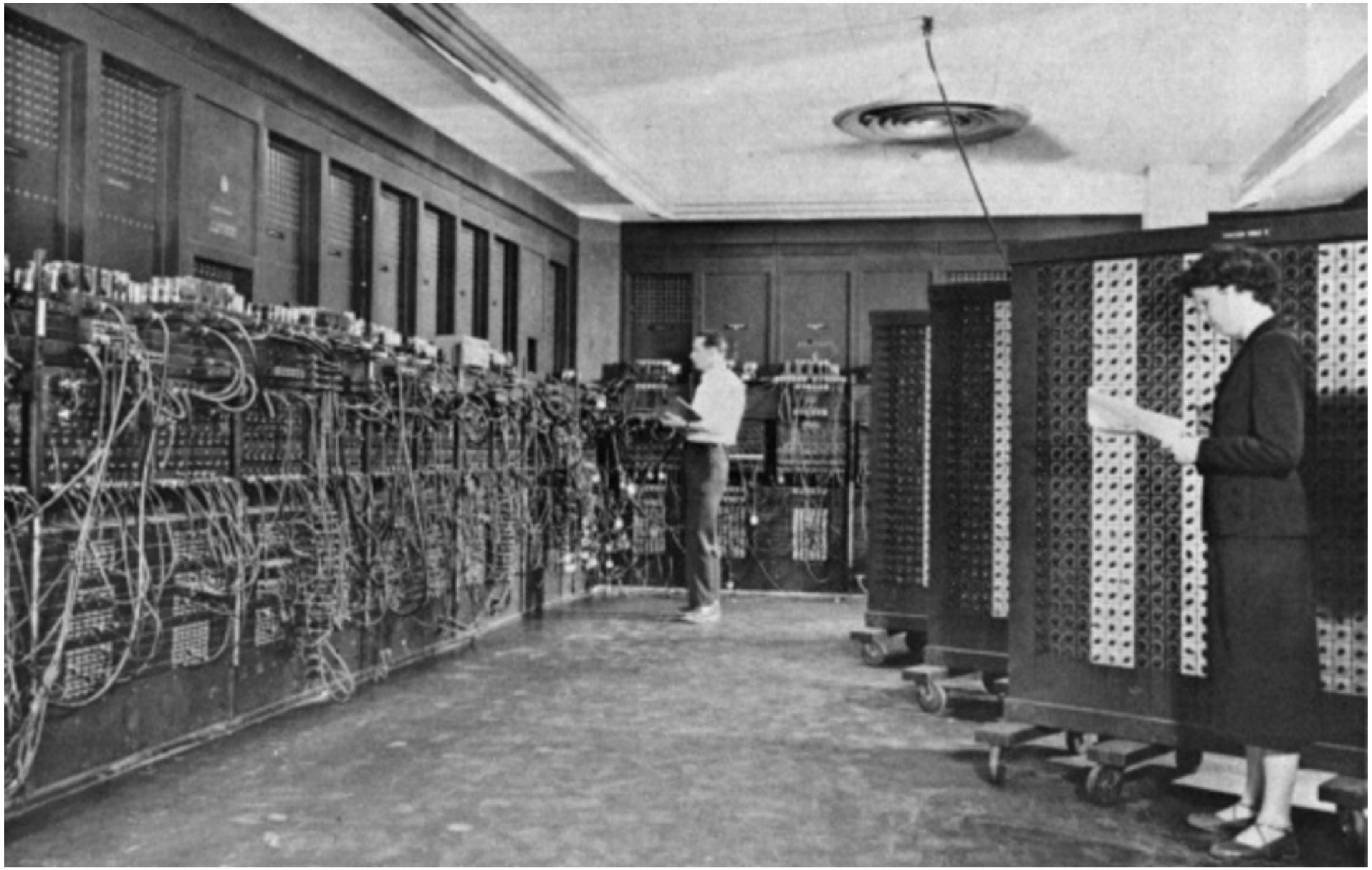
Why are UIs important?

1613 – 1940s

Computers: people who performed calculations

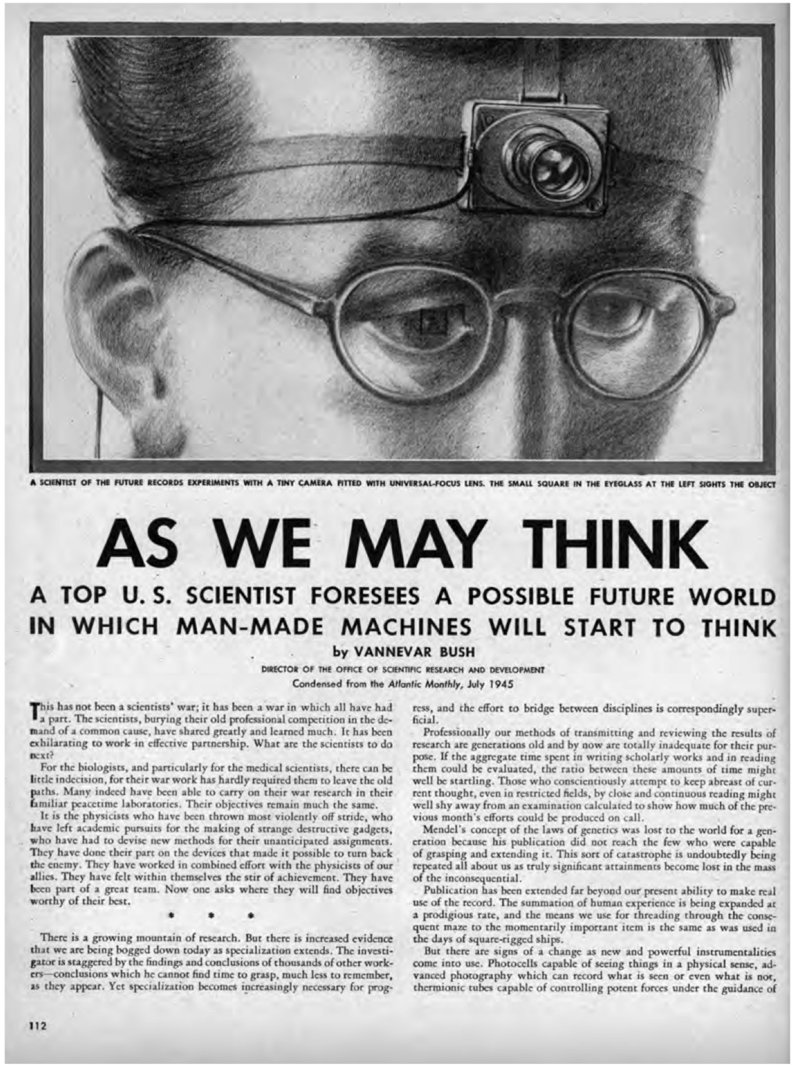
1940s – 1960s

Computers: Tools for Calculation and Symbolic Manipulation



1945

Computers: tools to augment human cognition
Vannevar Bush’s vision of computers



A SCIENTIST OF THE FUTURE RECORDS EXPERIMENTS WITH A TINY CAMERA FITTED WITH UNIVERSAL-FOCUS LENS. THE SMALL SQUARE IN THE EYEGLASS AT THE LEFT SIGHTS THE OBJECT

AS WE MAY THINK

A TOP U. S. SCIENTIST FORESEES A POSSIBLE FUTURE WORLD IN WHICH MAN-MADE MACHINES WILL START TO THINK

by VANNEVAR BUSH

DIRECTOR OF THE OFFICE OF SCIENTIFIC RESEARCH AND DEVELOPMENT

Condensed from the *Atlantic Monthly*, July 1945

This has not been a scientists' war; it has been a war in which all have had a part. The scientists, burying their old professional competition in the demand of a common cause, have shared greatly and learned much. It has been exhilarating to work in effective partnership. What are the scientists to do next?

For the biologists, and particularly for the medical scientists, there can be little indecision, for their war work has hardly required them to leave the old paths. Many indeed have been able to carry on their war research in their familiar peacetime laboratories. Their objectives remain much the same.

It is the physicists who have been thrown most violently off stride, who have left academic pursuits for the making of strange destructive gadgets, who have had to devise new methods for their unanticipated assignments. They have done their part on the devices that made it possible to turn back the enemy. They have worked in combined effort with the physicists of our allies. They have felt within themselves the stir of achievement. They have been part of a great team. Now one asks where they will find objectives worthy of their best.

* * *

There is a growing mountain of research. But there is increased evidence that we are being bogged down today as specialization extends. The investigator is staggered by the findings and conclusions of thousands of other workers—conclusions which he cannot find time to grasp, much less to remember, as they appear. Yet specialization becomes increasingly necessary for progress, and the effort to bridge between disciplines is correspondingly superficial.

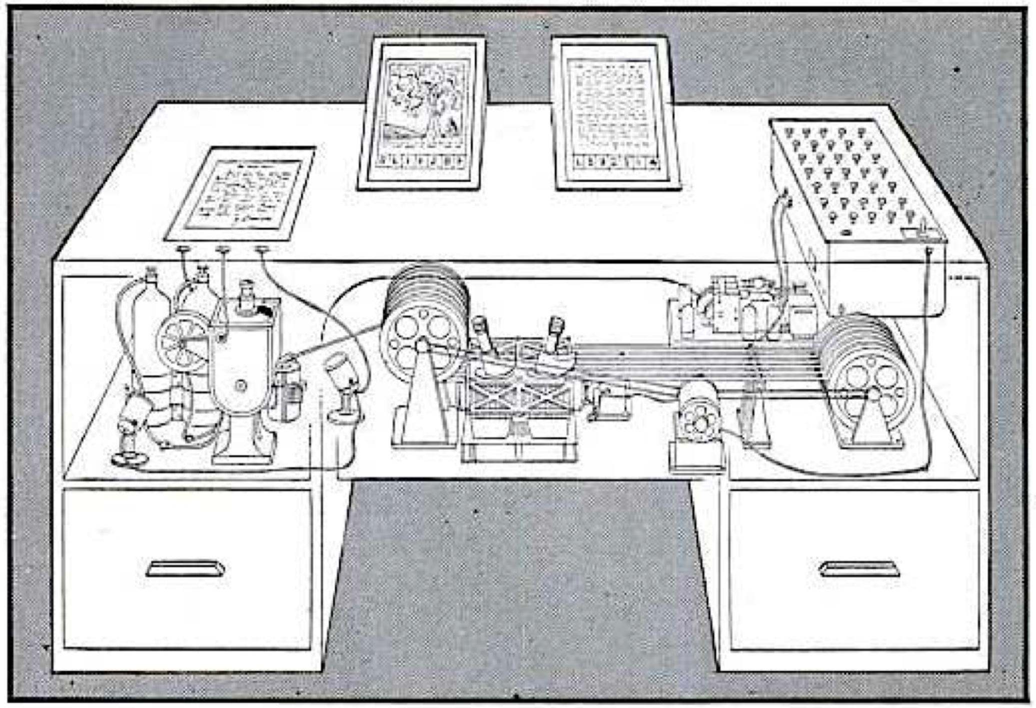
Professionally our methods of transmitting and reviewing the results of research are generations old and by now are totally inadequate for their purpose. If the aggregate time spent in writing scholarly works and in reading them could be evaluated, the ratio between these amounts of time might well be startling. Those who conscientiously attempt to keep abreast of current thought, even in restricted fields, by close and continuous reading might well shy away from an examination calculated to show how much of the previous month's efforts could be produced on call.

Mendel's concept of the laws of genetics was lost to the world for a generation because his publication did not reach the few who were capable of grasping and extending it. This sort of catastrophe is undoubtedly being repeated all about us as truly significant attainments become lost in the mass of the inconsequential.

Publication has been extended far beyond our present ability to make real use of the record. The summation of human experience is being expanded at a prodigious rate, and the means we use for threading through the consequent maze to the momentarily important item is the same as was used in the days of square-rigged ships.

But there are signs of a change as new and powerful instrumentalities come into use. Photocells capable of seeing things in a physical sense, advanced photography which can record what is seen or even what is not, thermionic tubes capable of controlling potent forces under the guidance of

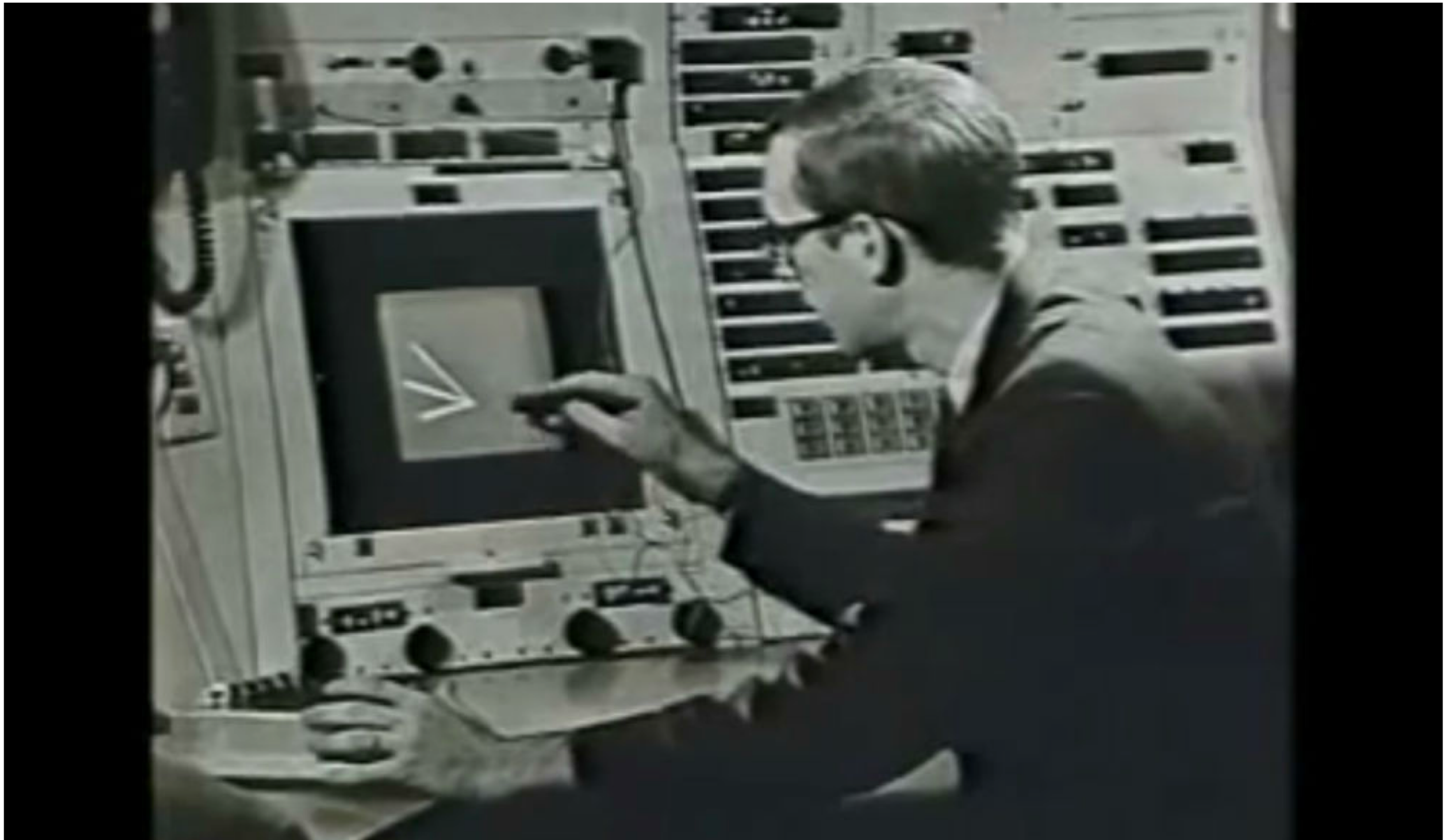
112



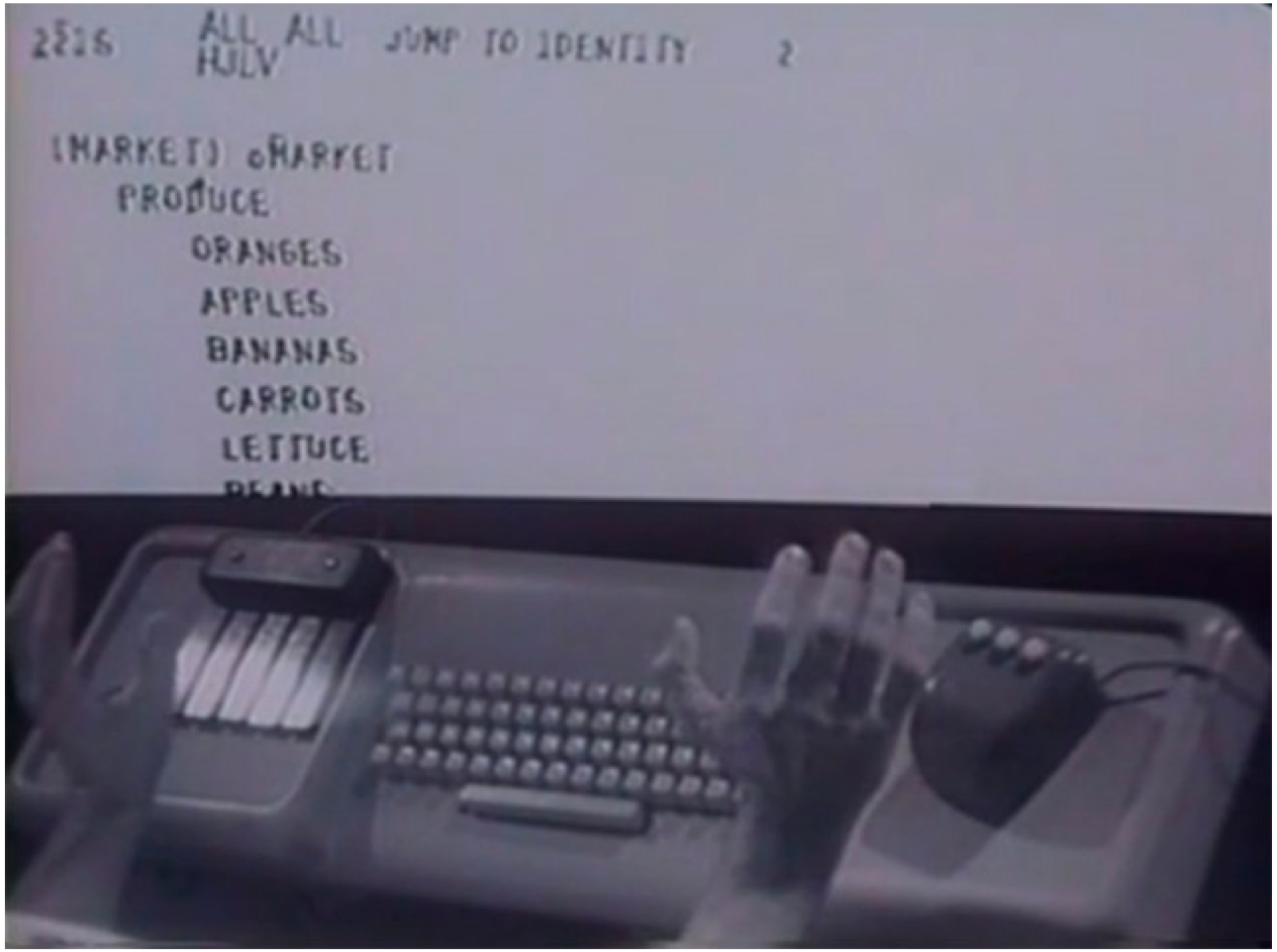
MEMEX in the form of a desk would instantly bring files and material on any subject to the operator's fingertips. Slanting translucent viewing screens magnify supermicrofilm filed by code numbers. At left is a mechanism which automatically photographs longhand notes, pictures and letters, then files them in the desk for future reference.

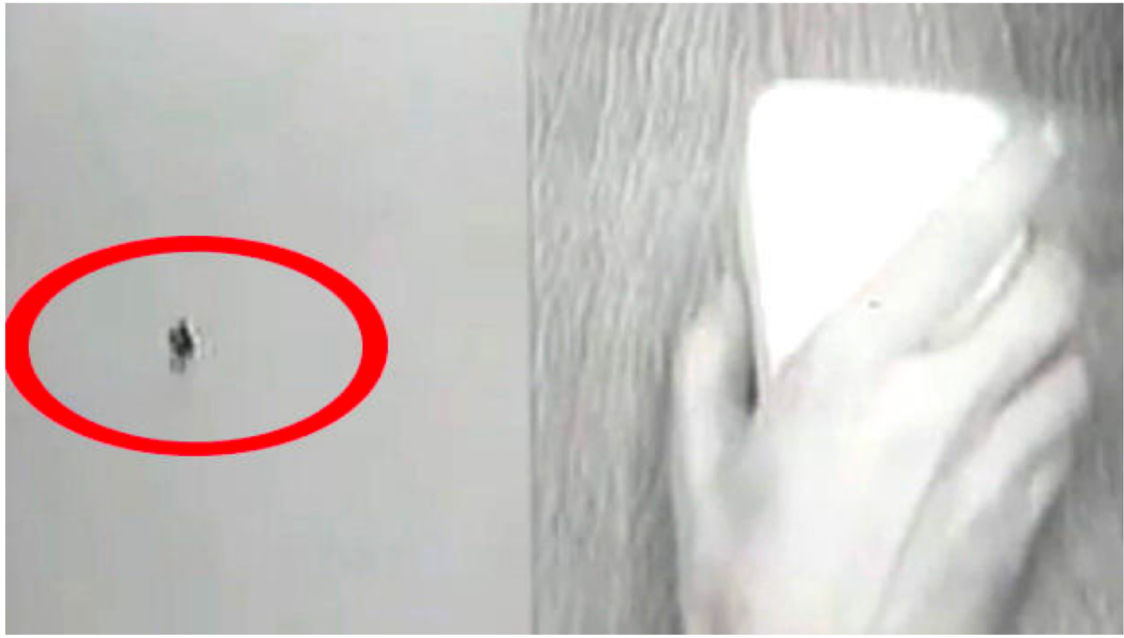
AS WE MAY THINK CONTINUED

1963: First Graphical User Interface
Ivan Sutherland's CAD software, Sketchpad



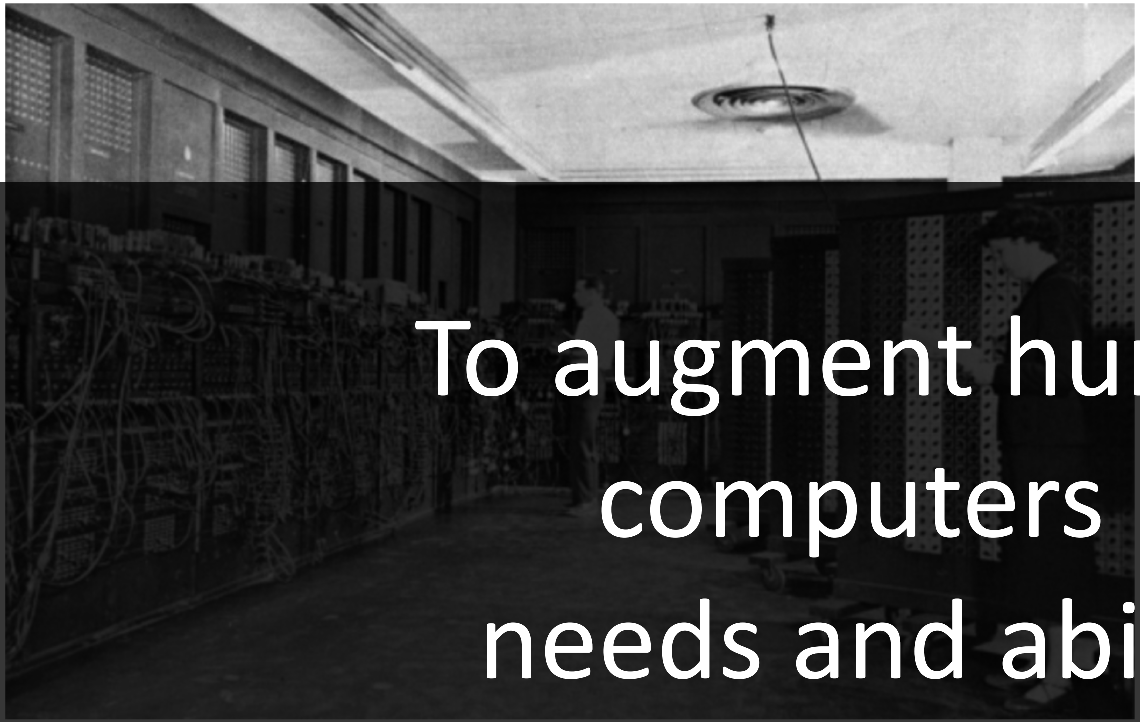
1968: Interaction devices for computer use. Douglas Engelbart’s mouse

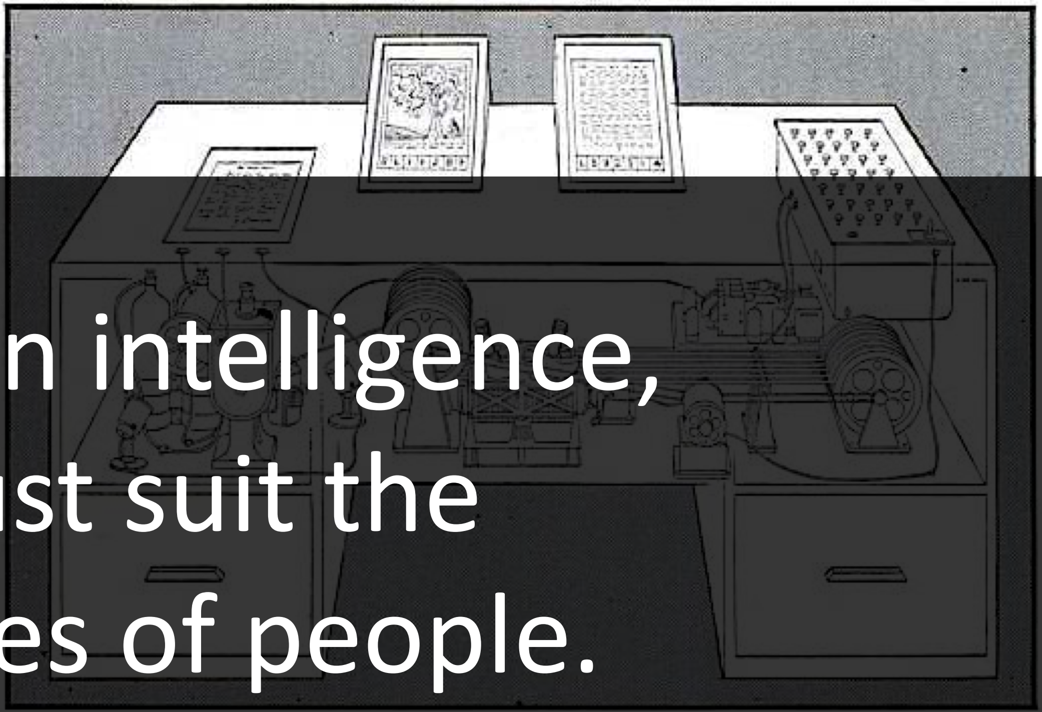




Computers are tools for calculation.

Computers are tools to augment human intelligence.





To augment human intelligence,
computers must suit the
needs and abilities of people.

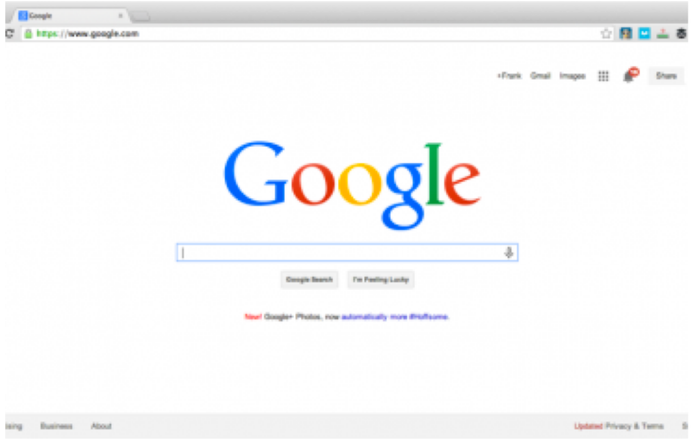
Computer-centric interface

Human-centric interface

The Internet: The Rise of Usability

For physical products, users did not get to experience the usability of the product until **after they bought it**.

For desktop software, users call expensive support centers, but the costs aren't "charged" to the software engineers, so they have **no motivation to ship great UIs.**



On the Web, users experience the usability of a site before they have committed to using it and before they buy it.

UI is now the primary "selling point" of software

Nielsen, Jakob. *Designing Web Usability: The Practice of Simplicity*. (1999)

What are we gonna learn in this class?

Part 1: Understand users and build websites that suit the needs and abilities.

- Learn UI principles and apply them to web programming
- Technologies include: HTML, JavaScript, CSS, Jquery, Bootstrap, Flask.
  - We will teach all these technologies. No web programming experience required.
  - General experience with programming and debugging is required.
- Weekly assignments
- An individual midterm project

Part 2: **Design useable systems** through **iteration** and feedback.

Group project to design and build a website that teaches a concept through interaction and feedback.

- Weekly assignments
- Completed by the group, turned in individually.
- Everyone in the group must have a working copy of the code running on their machine.
- Weekly assignments build up to the final deliverable.

You will be assigned to a TA group

- Your TA is your mentor. Get to know them!
- Your group will have ~22 students.
  - Some of them will be your project partners.
  - Get to know them!
- You can also come to any office hour you like.

Grading: this class is not curved.

90% <= **A** <=100%

80% <= **B** < 90%

70% <= **C** < 80%

60% <= **D** < 70%

F < 60%

No A+ grades will be given

Unlike most other classes, this class is designed so everyone can get 100% by showing up and doing the work.

Grade breakdown

- **Weekly Homework: 60%**
  - 12 homework assignments
  - Each homework worth 5% of grade
- **Individual Midterm Project: 10%**
  - Due March 8th at 11:59pm.
- **Group Final Project: 20%**
  - Due May 6th 11:59pm. No late assignment accepted.
  - At all. Not even one minute late.
- **Design Section Preparation and Participation: 10%**
  - In the design half of the class (after spring break). You will mainly learn by presenting your work and iterating on feedback from your TA.
  - It is essential to come prepared and actively participate.
  - If there is a week where you cannot make the regularly schedule time for your section meeting, email your TA in advance of the meeting and suggest 3 times in the next two days to schedule a make up.
- No final exam

Weekly HW deadlines

- Generally, assignments are due Tuesdays at 11:59pm.
  - There is a grace period, until 8am Wednesday morning.
- Assignments are meant to take 5-8 hours.
  - For people with web programming experience they often take 2-3 hours.
  - If you are spending significantly longer on assignments, come talk to me or a TA. We can help teach you programming and debugging strategies.
- There is also a short warm-up assignment due Fridays at 11:59pm
  - WTF????

Warm ups

- Warm ups help you get started early.
- With 400 people in this class, we can’t help everyone on the assignment the night before it’s due.
- We at least need to get installation issues out of the way.

- They are short. No more than 1 hr. If it takes you more than one hour, turn in whatever you have at 1 hr and finish the rest on the main assignment.
- If there is something you are having trouble with, email your TA early!
- If you honestly think this will impede your learning rather than help, email me, and we’ll work something out.

Late Policy for Homework

- **2 Late Passes**: You may turn in 2 main assignments up to 5 days late with no penalty or excuse needed.
  - You can be sick, you can be at your sister's wedding, you can be celebrating Orthodox Easter Monday with your in-laws, you can be interviewing for a job, you can be strolling TikTok all day.
  - I do not care why. You can manage your own time.
  - In the past, 2 late passes has been a reasonable amount of flexibility to give. If you think you need more (you have 12 religious holidays that all fall on Tuesday nights), email me before HW 1 is due.
  - This cannot be used on the midterm project or the final project.
- Each late assignments must be turned in no more than 5 days (120 hours) after the original deadline. There is no difference between an assignment being 1 hour late or 99 hours late.
- Past two late assignments, we will deduct 10% for every 24 hours late.

Cheating Policy

Can I use generative AI?

Can I use code from the web?

Can I work with my friends?

Yes. DO IT!

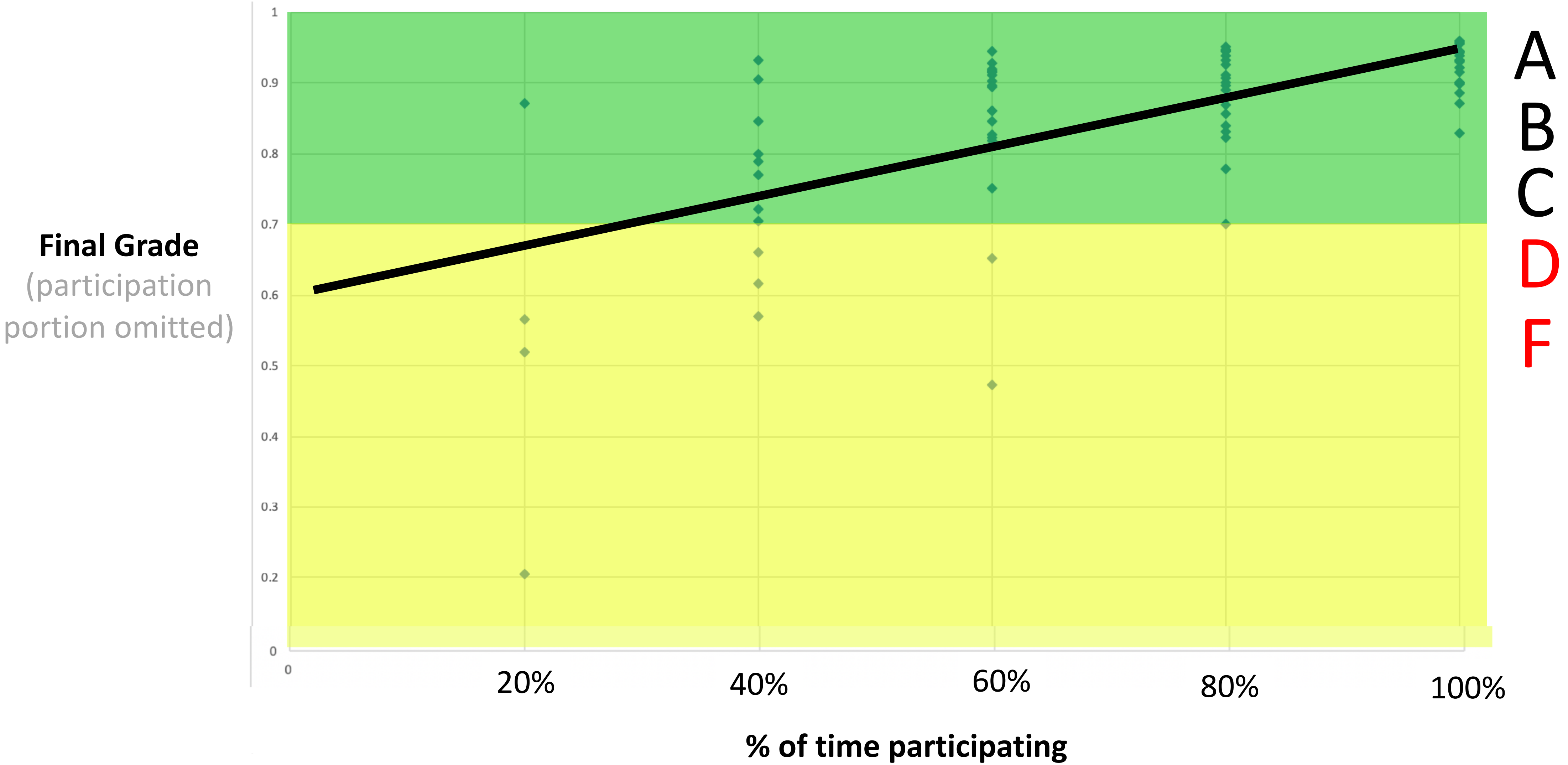
As long as you can demonstrate understanding, ownership of the code and designs you produce in this class.

If we have questions about your submission, we reserve the right to have you explain your code and thought process to us.

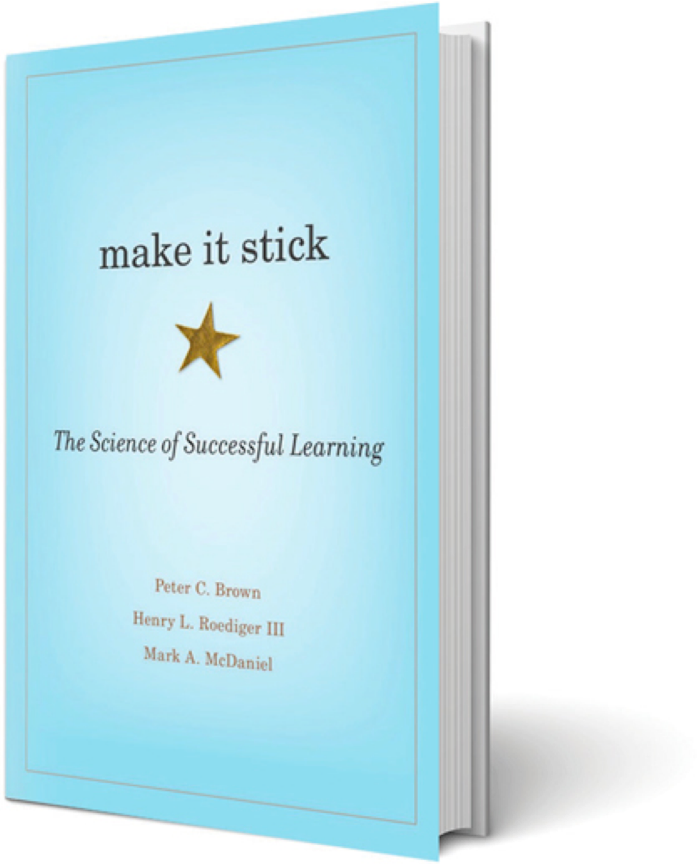
Participation is 10% of your grade

- During the second half of this class, you’ll have weekly feedback sessions with your TA.
- These are only effective if you come prepared and participate.
- So there are points for it.
- If you can’t make a feedback session, email your TA in advance and suggest 3 times in the next two days to schedule a make up.

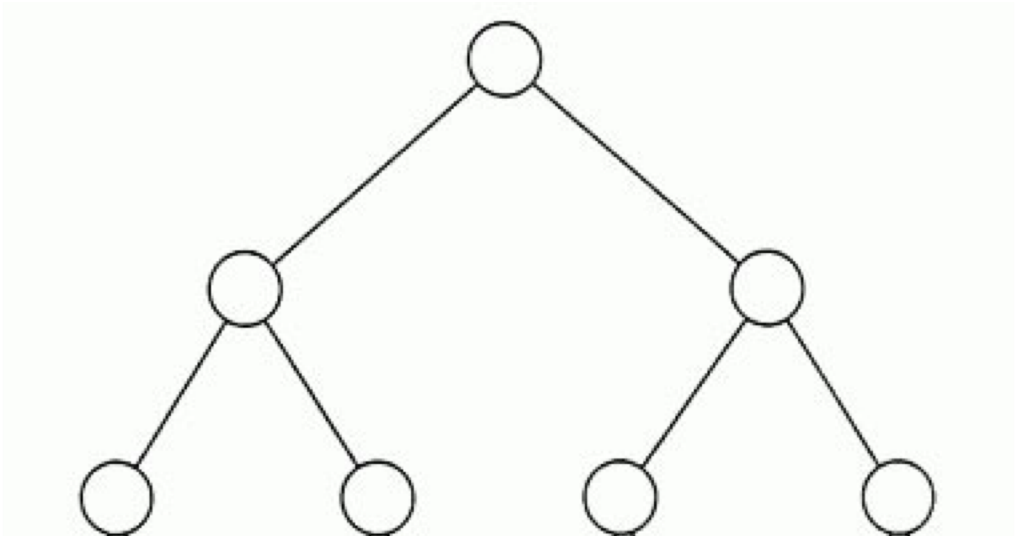
Why is participation 10% of my grade?



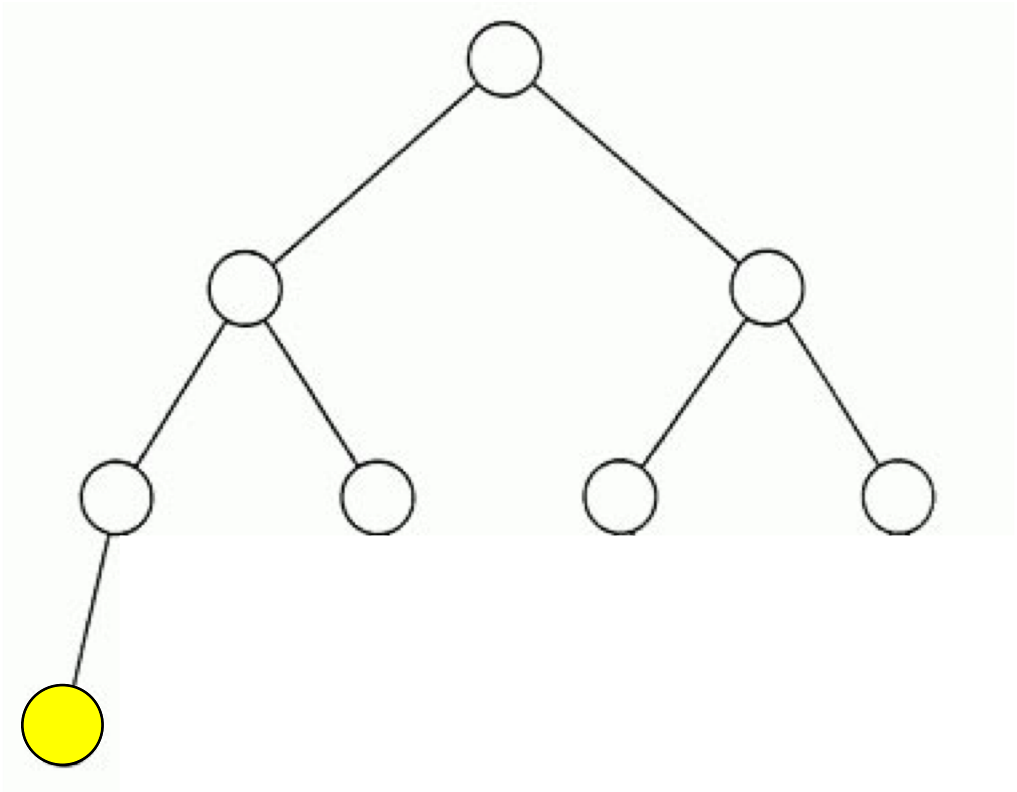
Two reasons why participation affects learning



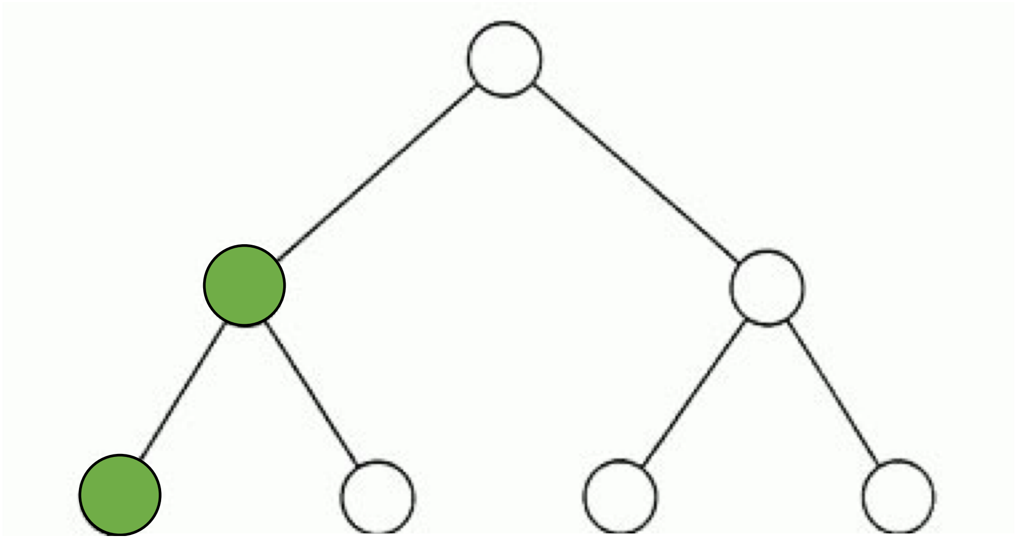
Human memory is tree-structured



New knowledge gets appended to the tree.

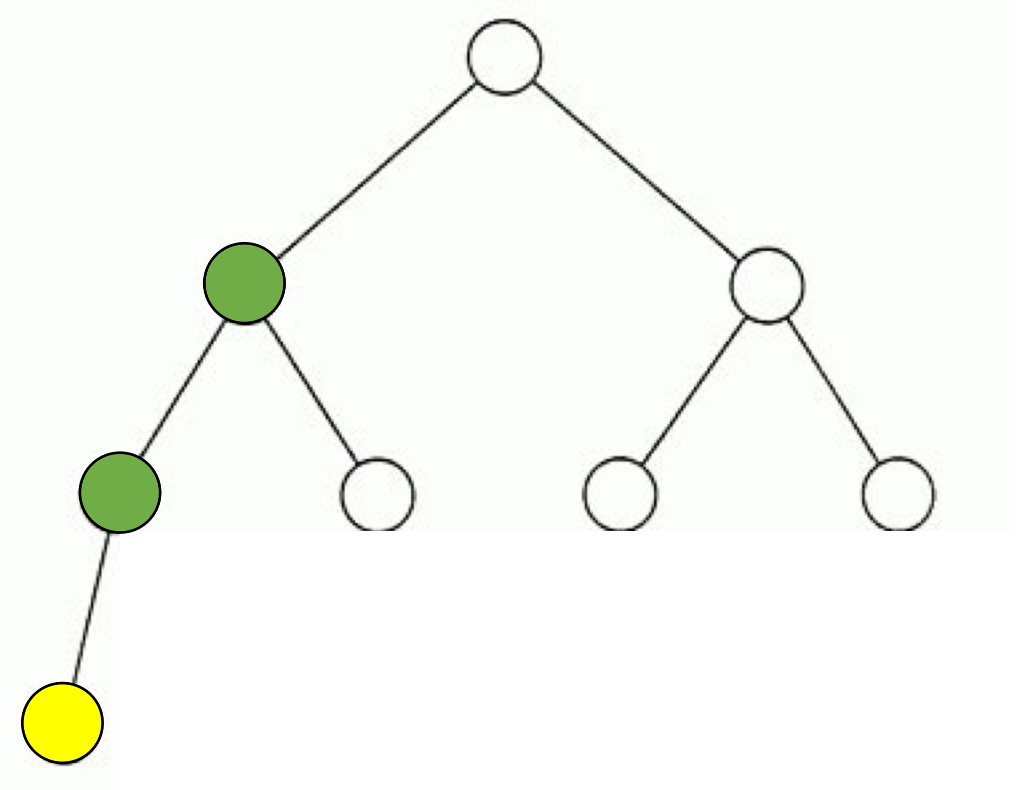


Where does new knowledge get appended?



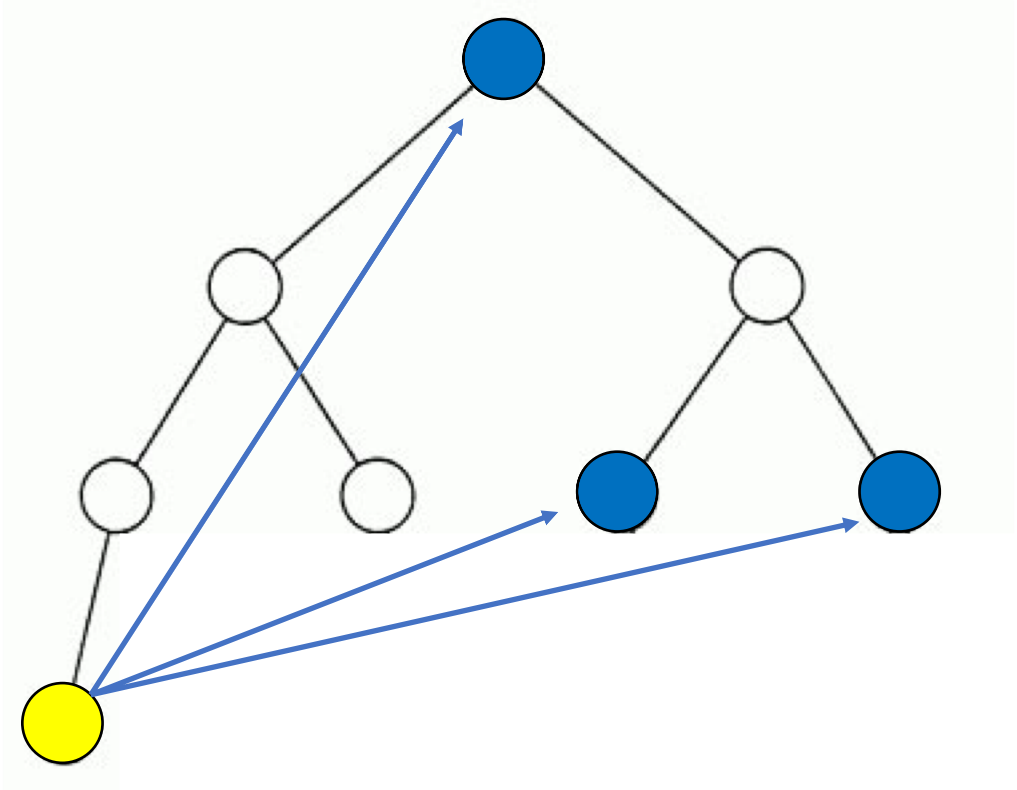
To where nodes of tree are currently active.

1. By guessing about new knowledge before it is presented, you warm up the right place to store it in memory.

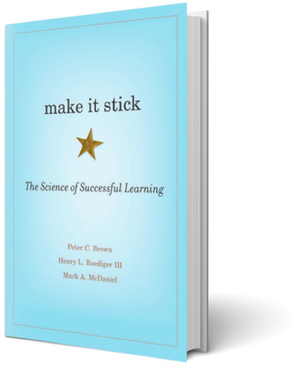


Generation: Guessing before you hear the answer

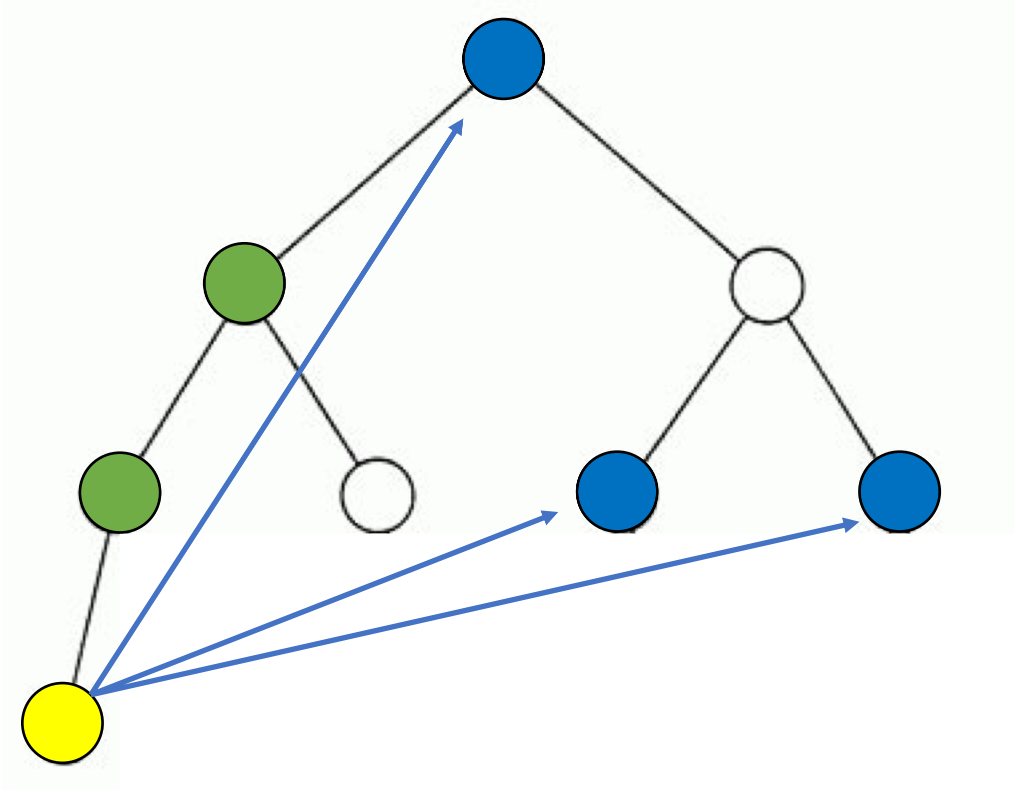
2. Once you hear the new knowledge, connect it to other knowledge so it will trigger at relevant times.



Elaboration: Relating new knowledge to old topics.



Generation & Elaboration

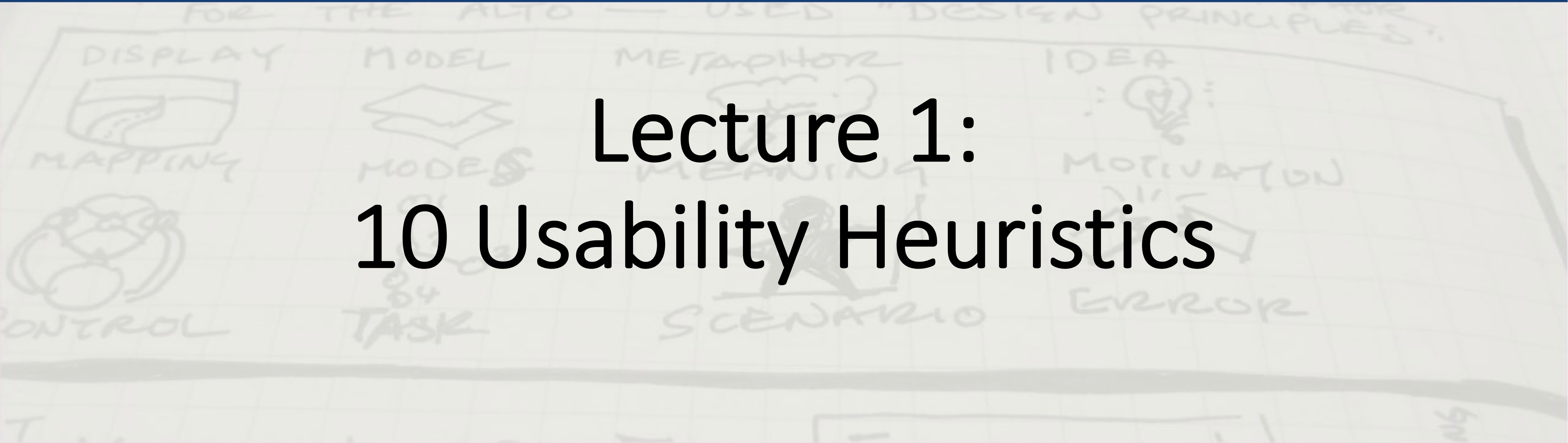


Guess about the new knowledge.
Must take risks, you will probably be (partially) wrong.

Relate new knowledge to old topics.
This aspect of participation is about providing insights.

Our goal is to help you learn useful skills and a profound way of solving real problems.

- We want you to make a habit of **thinking about users**.
- We want to convince that **design is crucial** to CS, the universe and everything
- We want to you be **engaged** in the class. Interact with us and your fellow students.

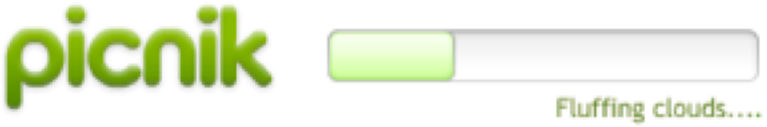


Lecture 1:
10 Usability Heuristics

Prof. Chilton
COMS 4170
17 January 2024

1. Visibility of system status

The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.



Fluffing clouds....

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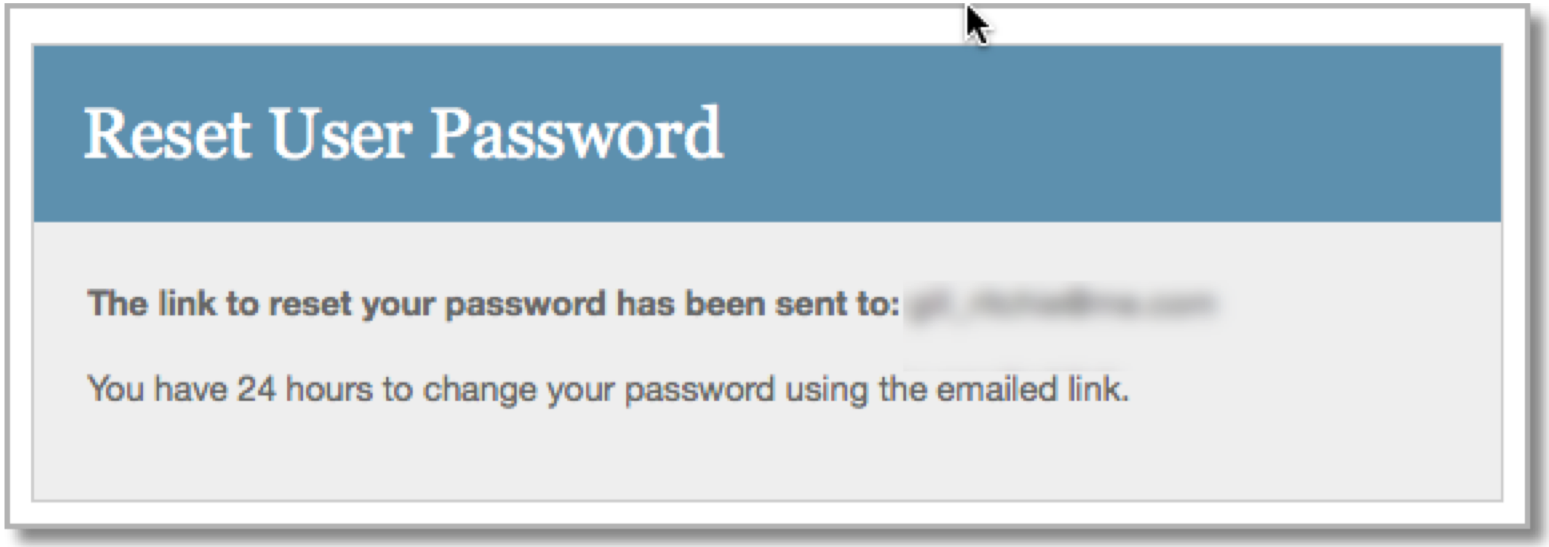

Reset User Password

The link to reset your password has been sent to: [redacted]

You have 24 hours to change your password using the emailed link.

1. Visibility of system status

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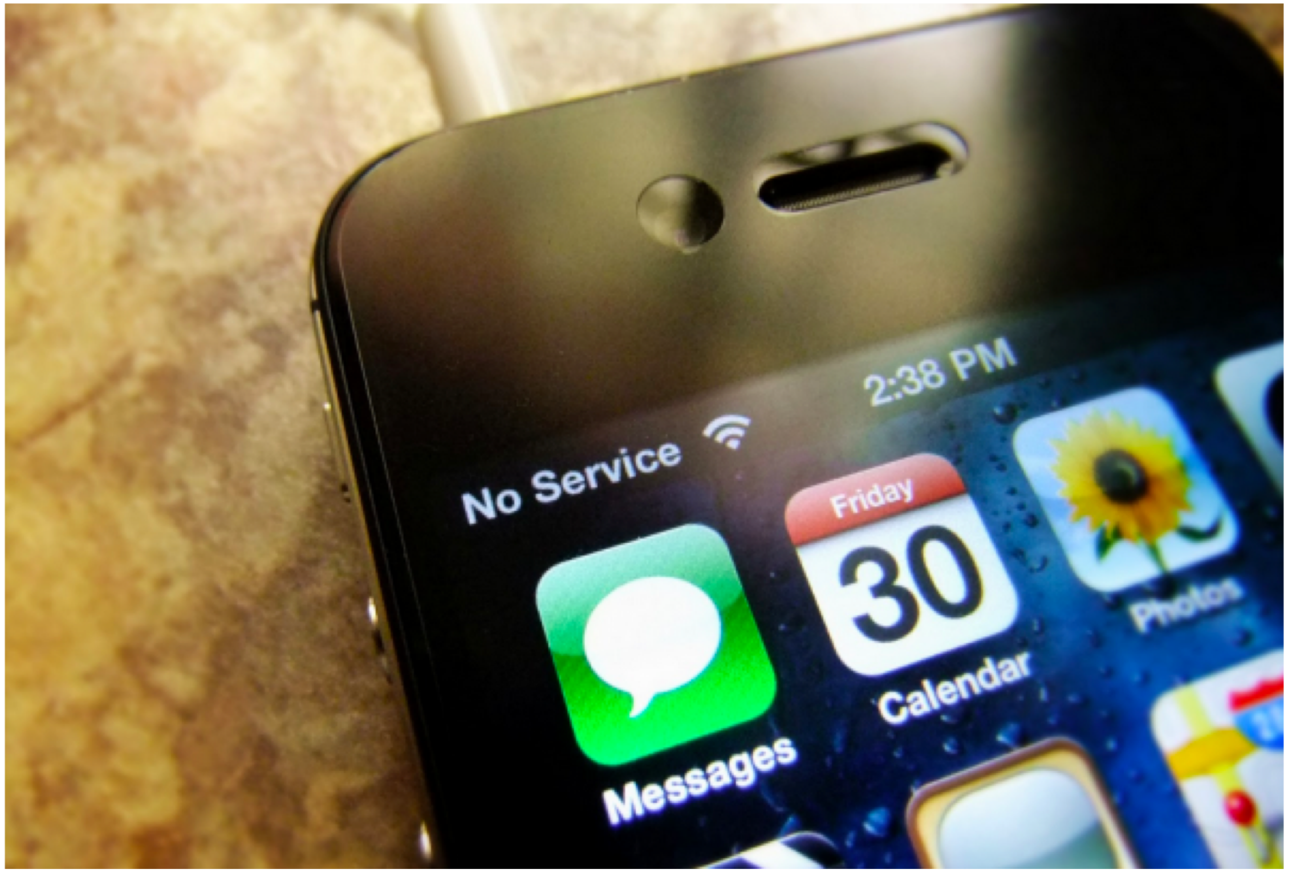

1. Violation: Visibility of system status

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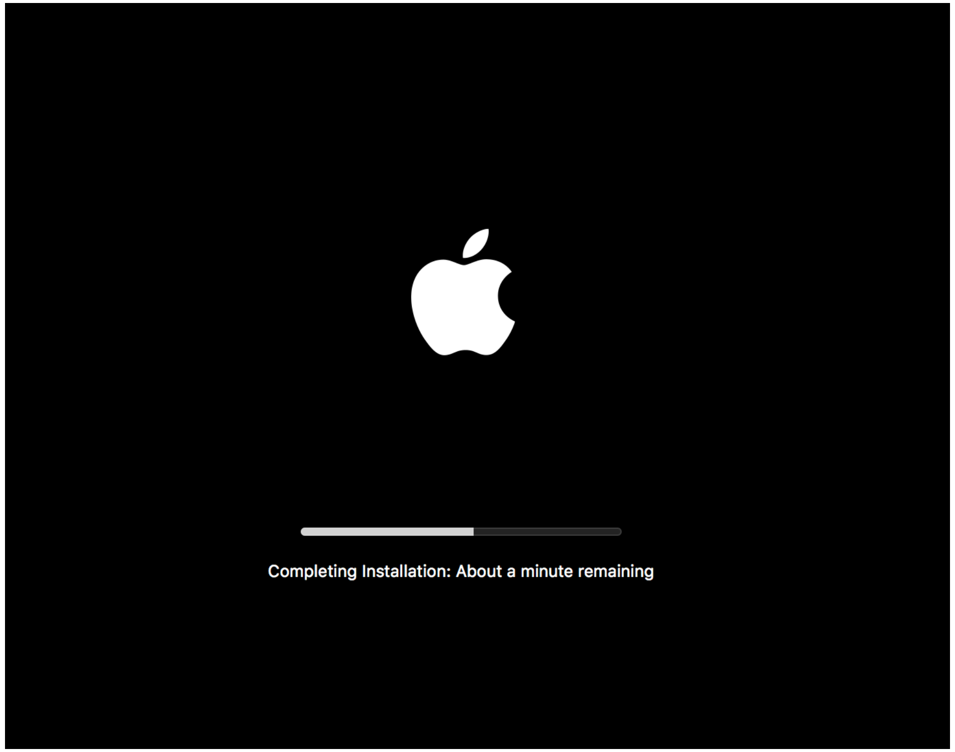
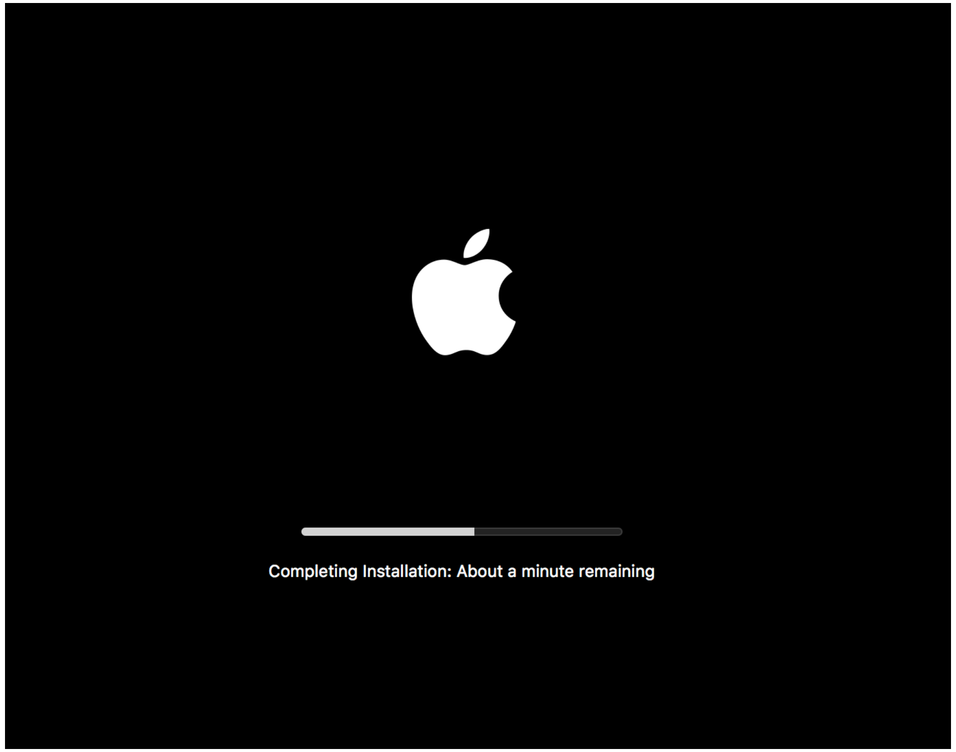


Completing Installation: About a minute remaining

4 hours later…



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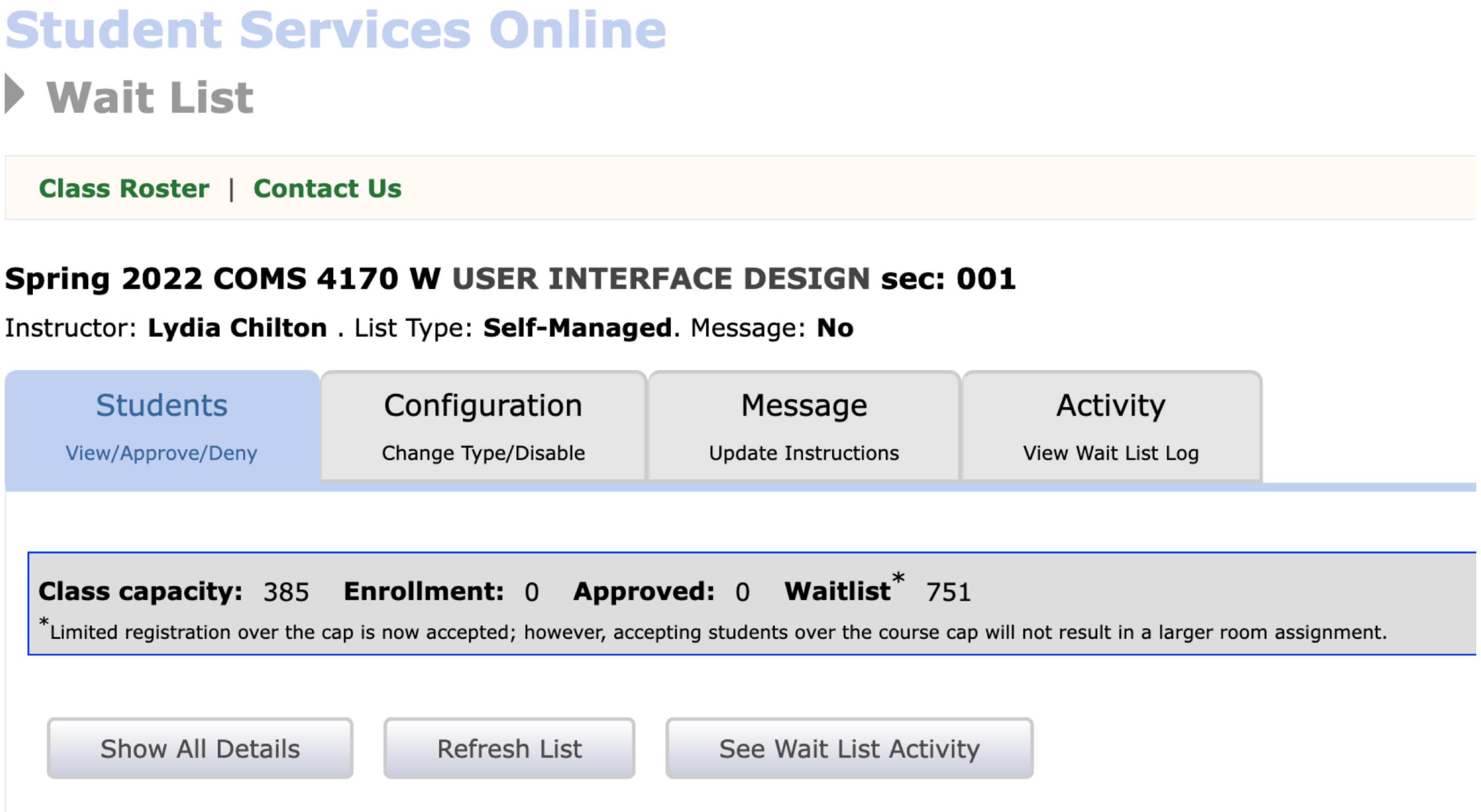


Student Services Online

Wait List

Spring 2022 COMS 4170 W USER INTERFACE DESIGN sec: 001

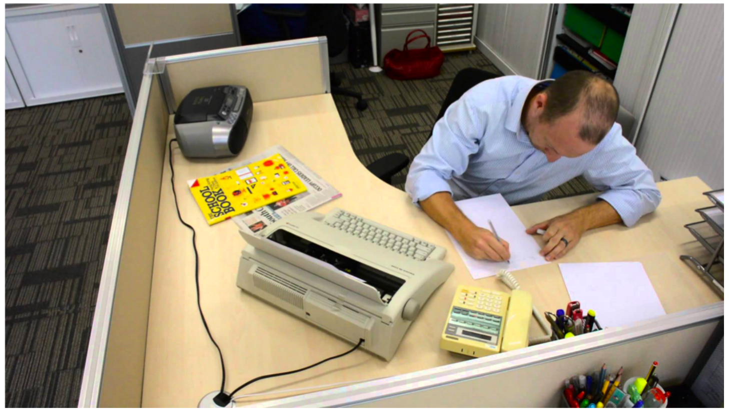
Instructor: **Lydia Chilton** . List Type: **Self-Managed**. Message: **No**

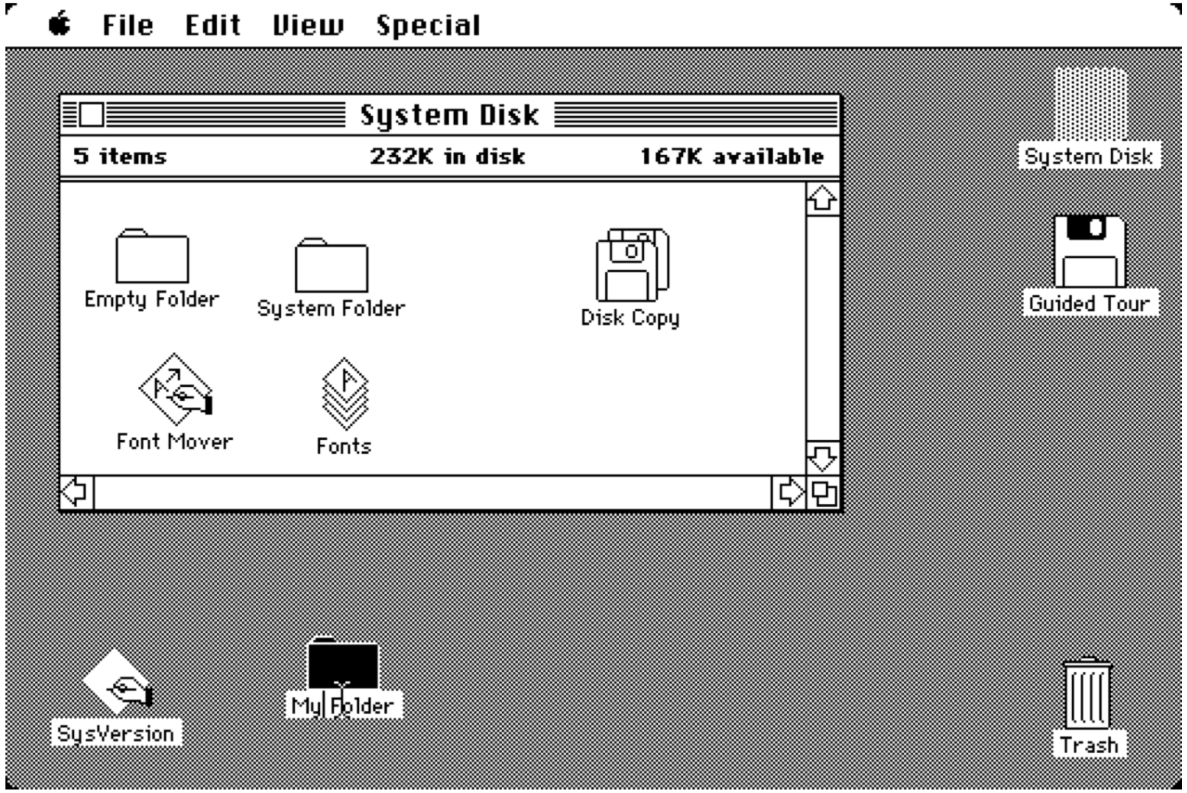
Class capacity: 385 **Enrollment:** 0 **Approved:** 0 **Waitlist*** 751

*Limited registration over the cap is now accepted; however, accepting students over the course cap will not result in a larger room assignment.

2. Match between system and the real world

The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms.





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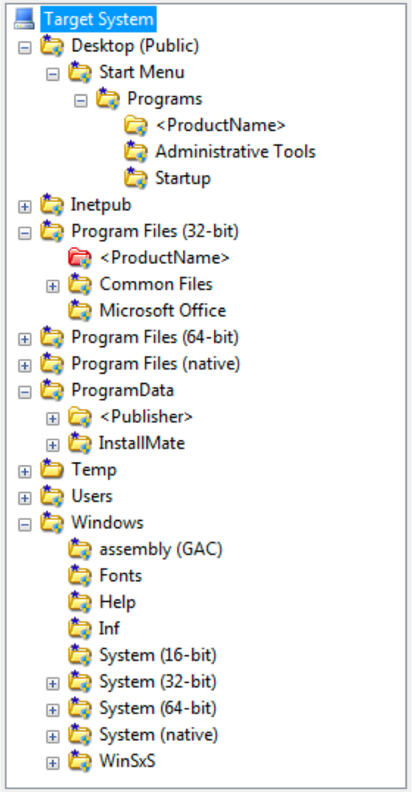

- Target System
  - Desktop (Public)
    - Start Menu
      - Programs
        - <ProductName>
        - Administrative Tools
        - Startup
  - Inetpub
  - Program Files (32-bit)
    - <ProductName>
    - Common Files
    - Microsoft Office
  - Program Files (64-bit)
  - Program Files (native)
  - ProgramData
    - <Publisher>
    - InstallMate
  - Temp
  - Users
  - Windows
    - assembly (GAC)
    - Fonts
    - Help
    - Inf
    - System (16-bit)
    - System (32-bit)
    - System (64-bit)
    - System (native)
    - WinSxS

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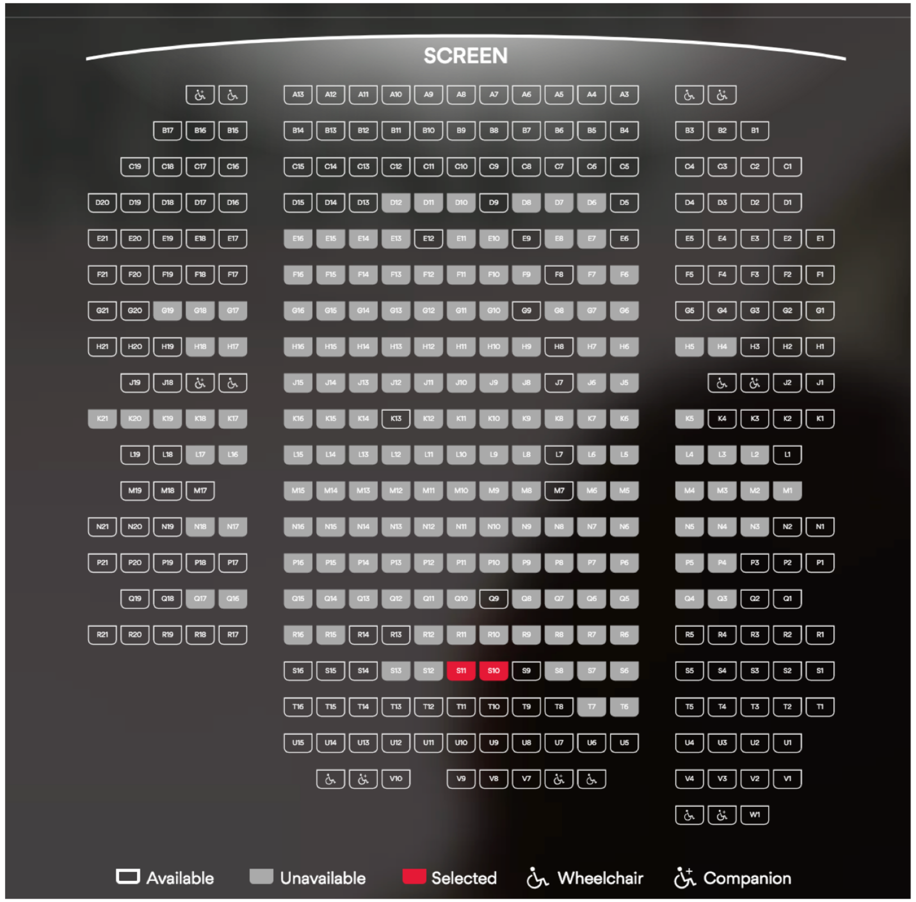

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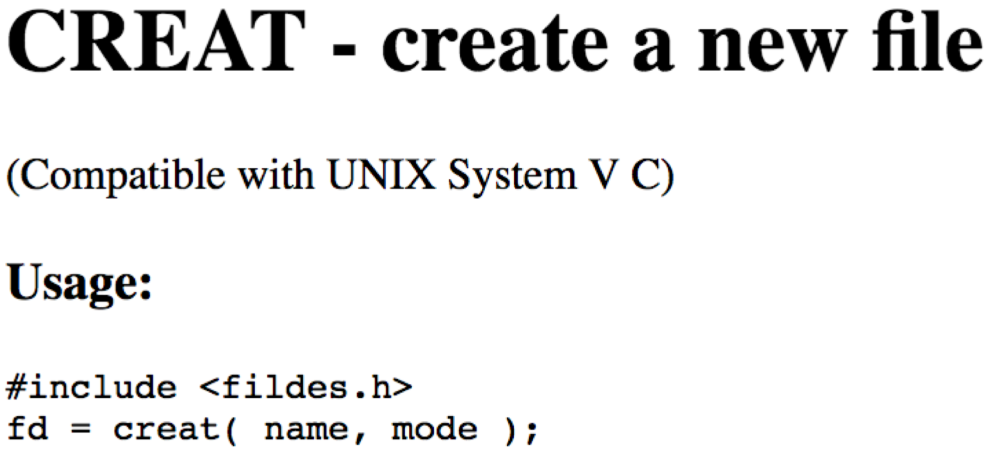


CREAT - create a new file

(Compatible with UNIX System V C)

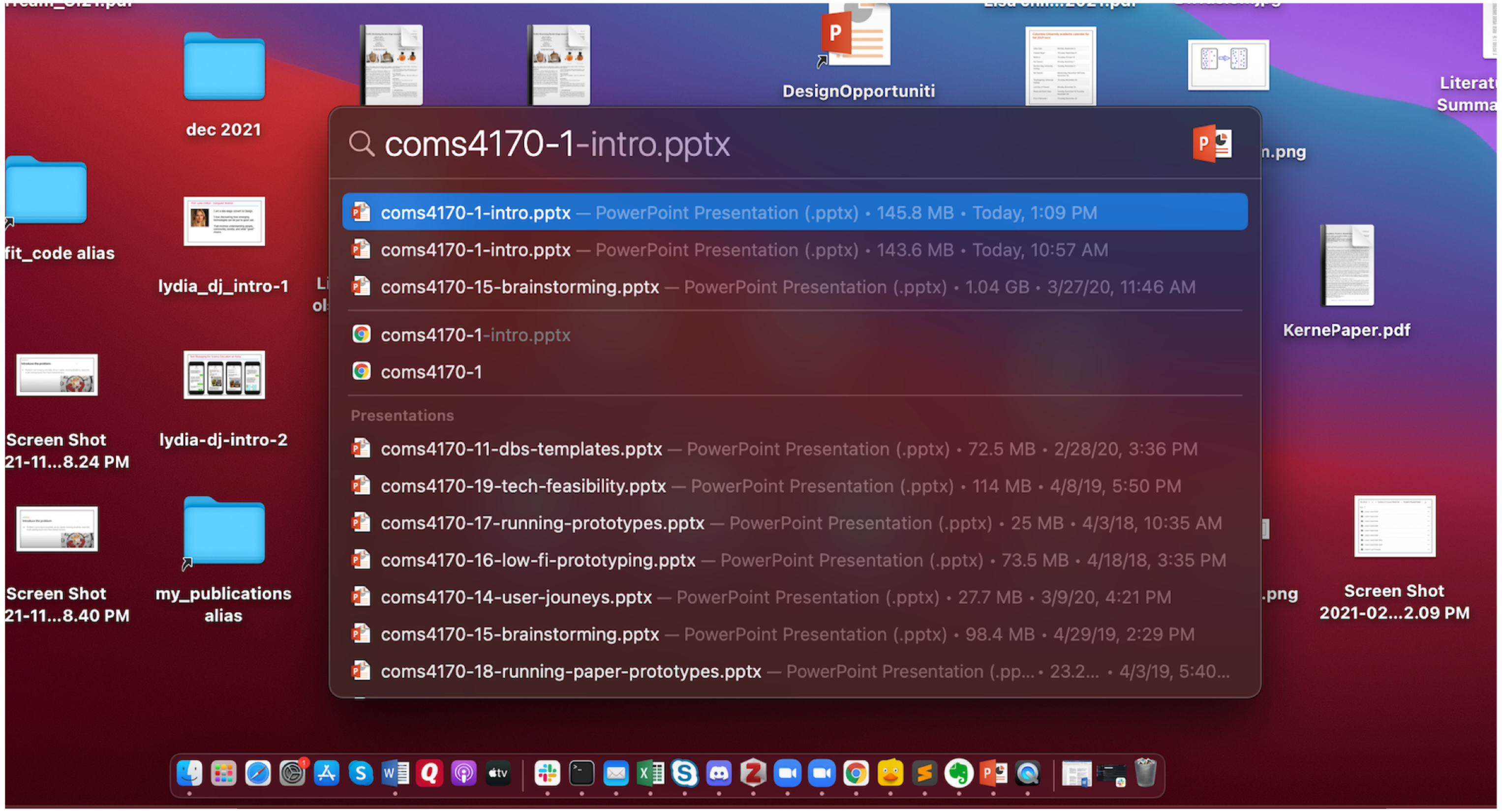
Usage:

```
#include <fildes.h>
fd = creat( name, mode );
```

"I'd spell creat with an e."

3. User control and freedom (Navigation)

Users should be able to quickly make choices, correct mistakes or backtrack on choices made. Support undo and redo.



coms4170-1-intro.pptx

coms4170-1-intro.pptx — PowerPoint Presentation (.pptx) • 145.8 MB • Today, 1:09 PM
coms4170-1-intro.pptx — PowerPoint Presentation (.pptx) • 143.6 MB • Today, 10:57 AM
coms4170-15-brainstorming.pptx — PowerPoint Presentation (.pptx) • 1.04 GB • 3/27/20, 11:46 AM

coms4170-1-intro.pptx
coms4170-1

Presentations

coms4170-11-dbs-templates.pptx — PowerPoint Presentation (.pptx) • 72.5 MB • 2/28/20, 3:36 PM
coms4170-19-tech-feasibility.pptx — PowerPoint Presentation (.pptx) • 114 MB • 4/8/19, 5:50 PM
coms4170-17-running-prototypes.pptx — PowerPoint Presentation (.pptx) • 25 MB • 4/3/18, 10:35 AM
coms4170-16-low-fi-prototyping.pptx — PowerPoint Presentation (.pptx) • 73.5 MB • 4/18/18, 3:35 PM
coms4170-14-user-jouneys.pptx — PowerPoint Presentation (.pptx) • 27.7 MB • 3/9/20, 4:21 PM
coms4170-15-brainstorming.pptx — PowerPoint Presentation (.pptx) • 98.4 MB • 4/29/19, 2:29 PM
coms4170-18-running-paper-prototypes.pptx — PowerPoint Presentation (.pp... • 23.2... • 4/3/19, 5:40...

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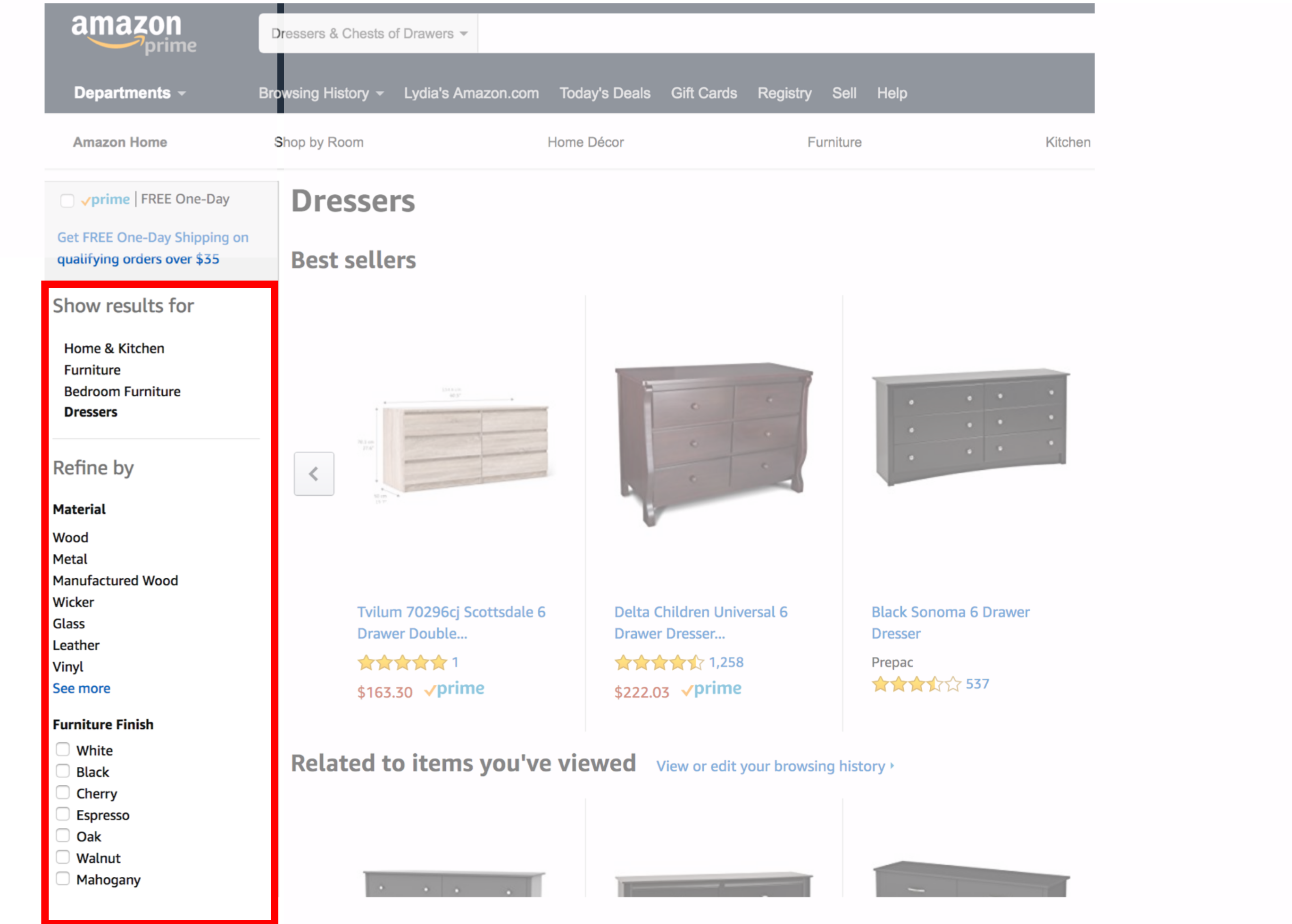
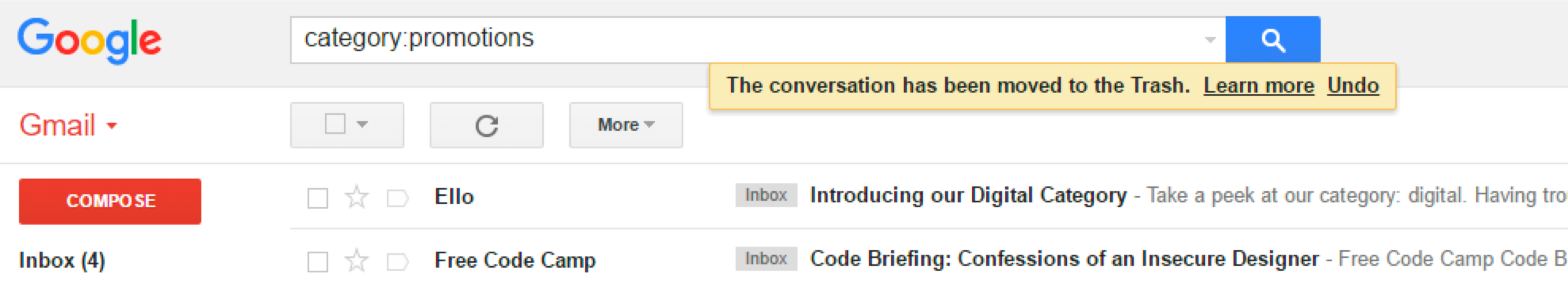


3. User control and freedom (Navigation)

Users should be able to quickly make choices, correct mistakes or backtrack on choices made. Support undo and redo.

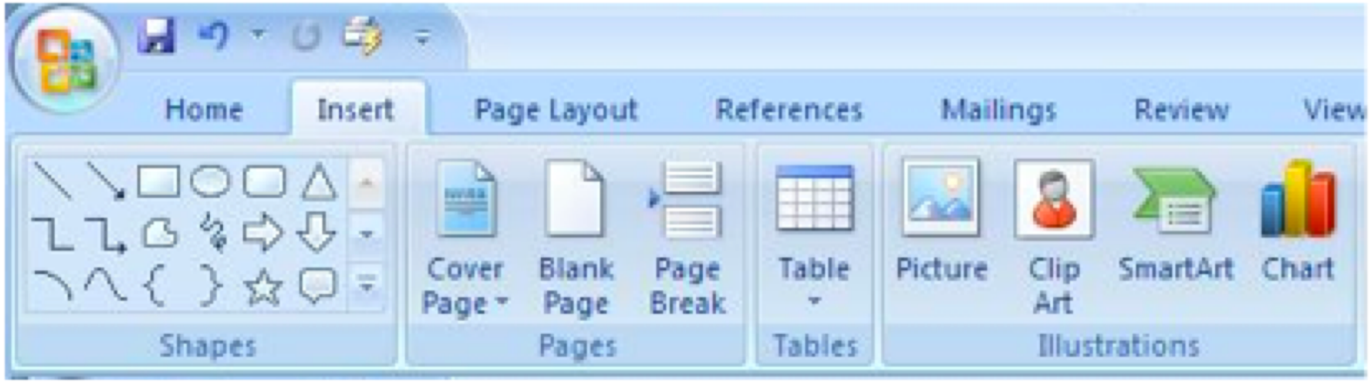


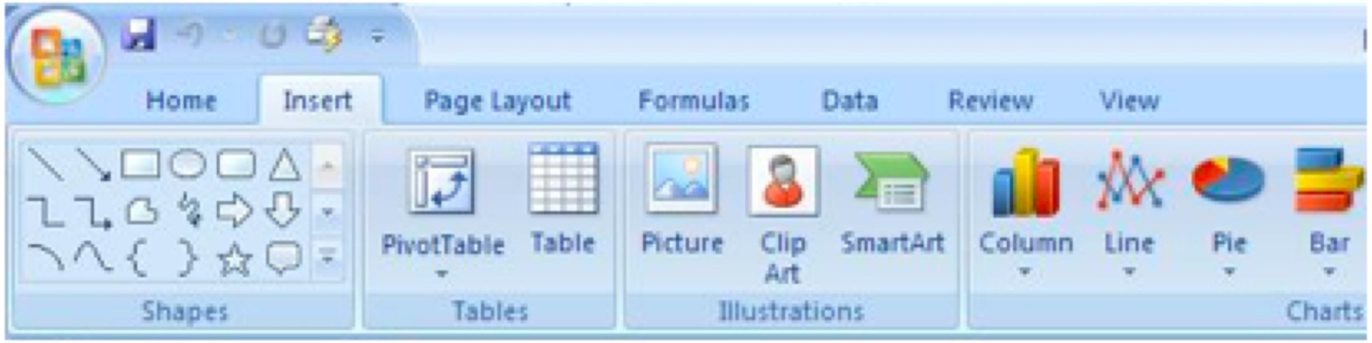
The conversation has been moved to the Trash. Learn more Undo

□ ☆	Ello	Inbox	Introducing our Digital Category - Take a peek at our category: digital. Having tro
□ ☆	Free Code Camp	Inbox	Code Briefing: Confessions of an Insecure Designer - Free Code Camp Code B

4. Consistency and standards

Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.





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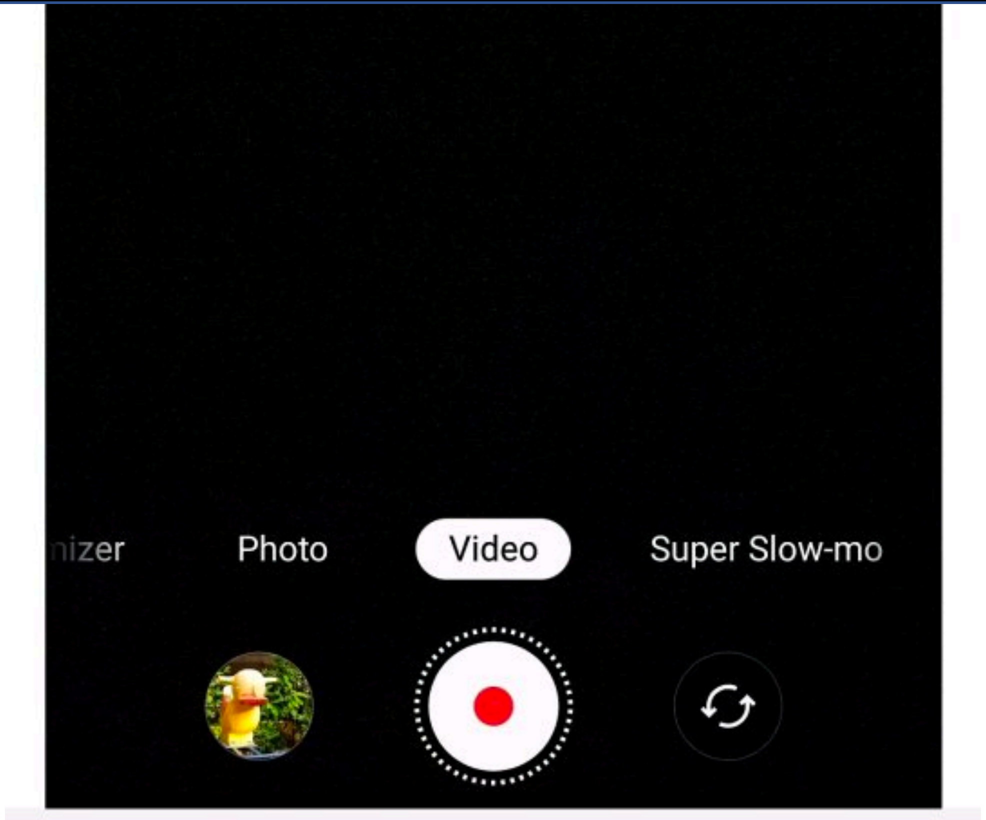
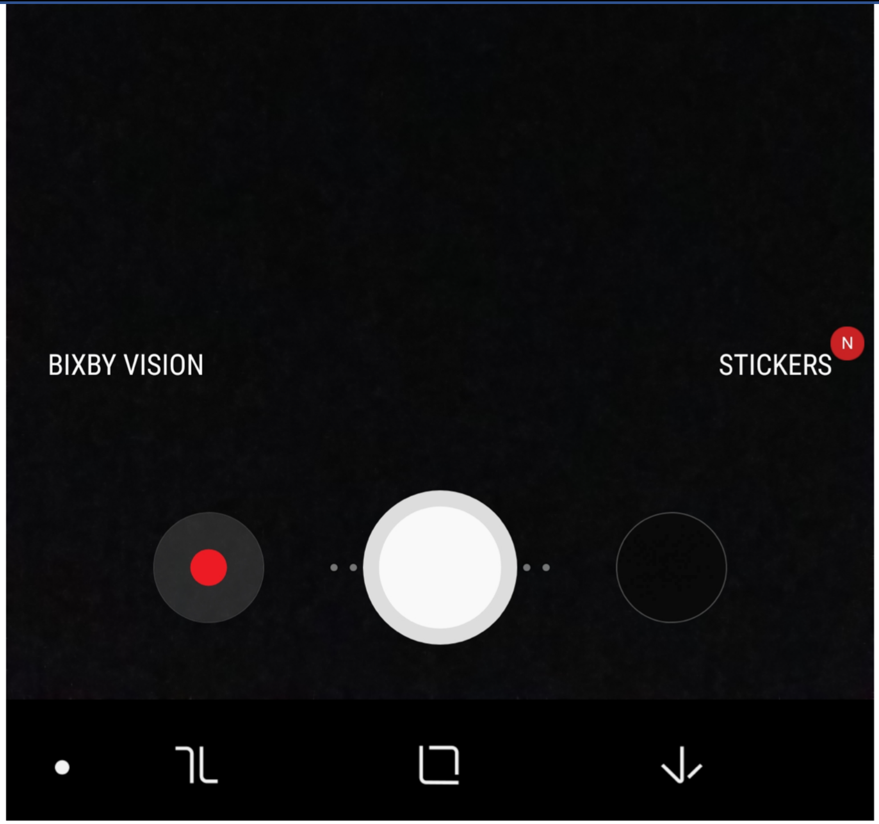
4. Violation: Consistency and standards

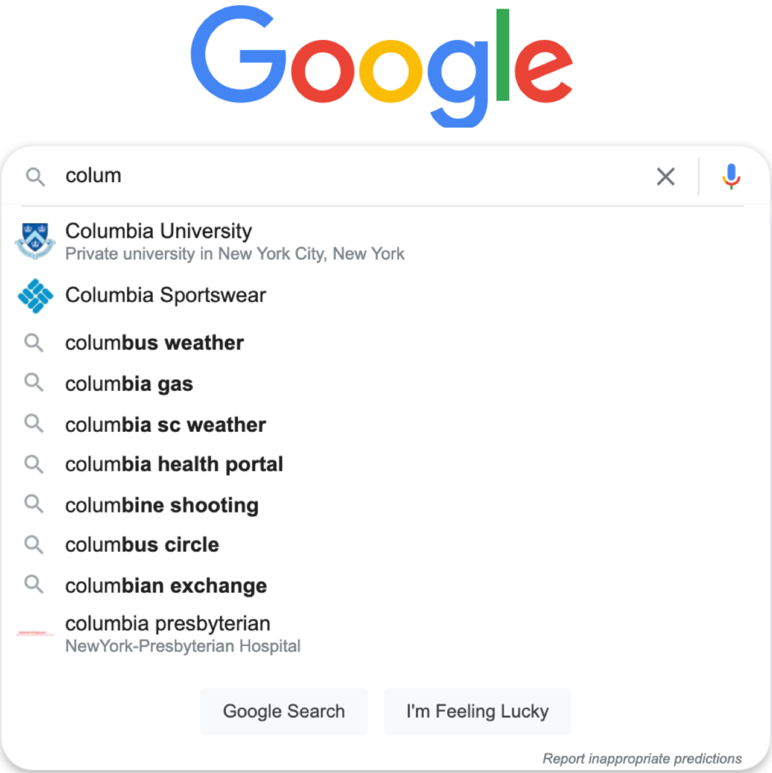
Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.





5. Error prevention

Even better than good error messages is a careful design which prevents a problem from occurring in the first place.



colum

Columbia University
Private university in New York City, New York

Columbia Sportswear

columbus weather

columbia gas

columbia sc weather

columbia health portal

columbine shooting

columbus circle

columbian exchange

columbia presbyterian
NewYork-Presbyterian Hospital

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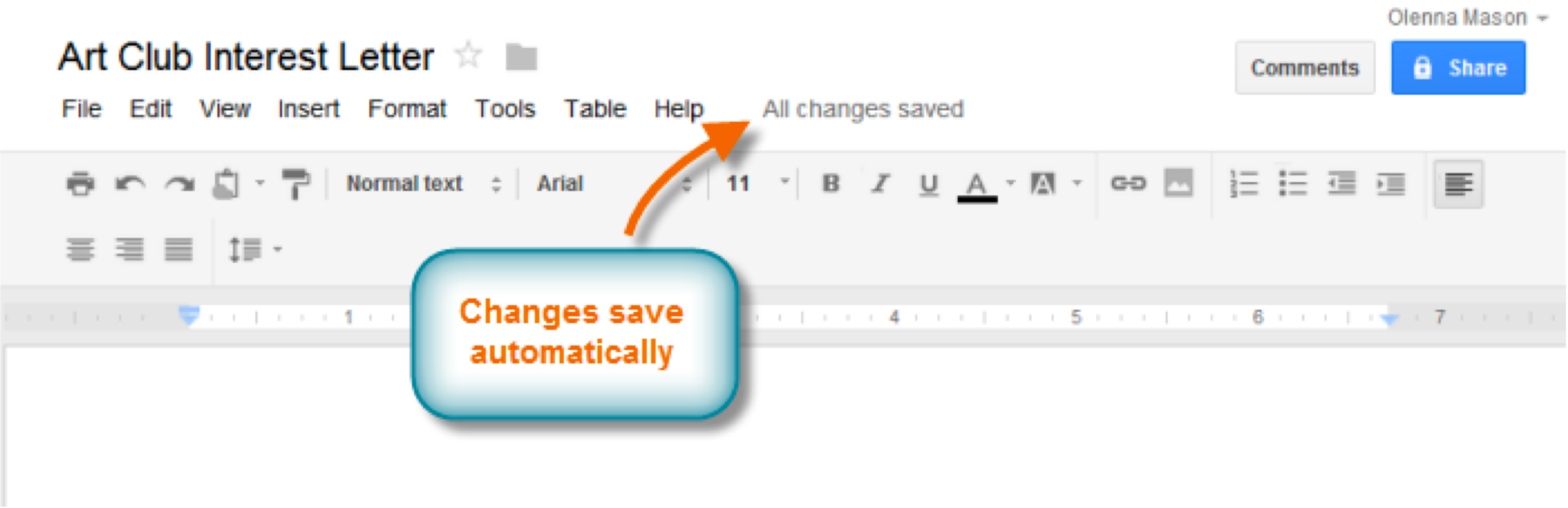

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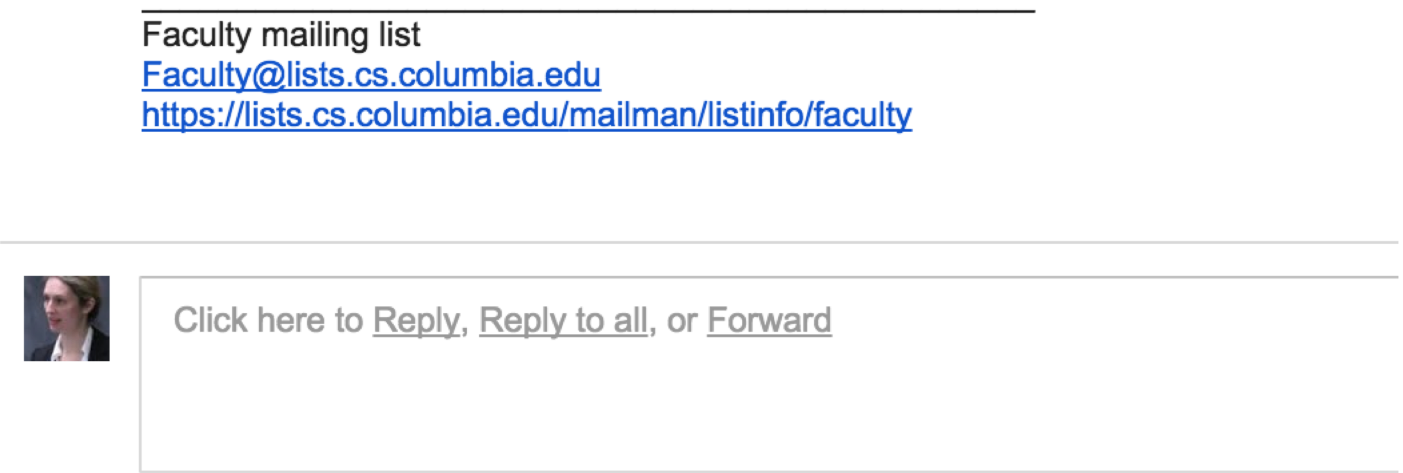
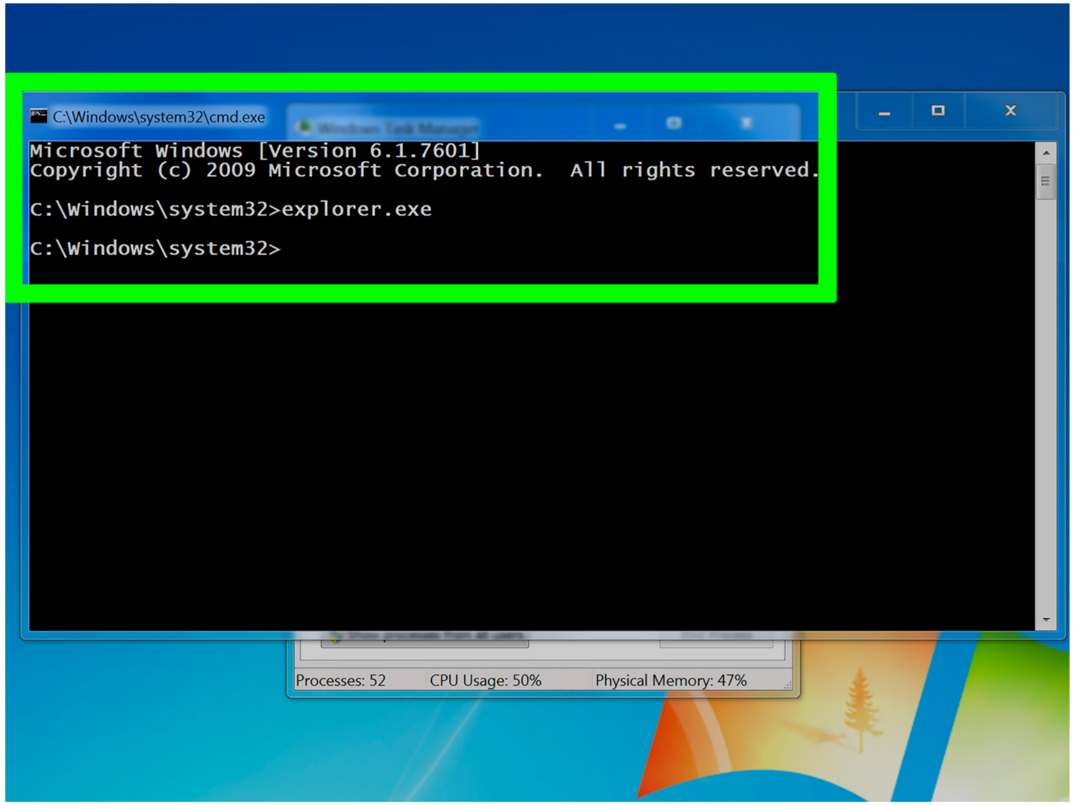


Faculty mailing list
Faculty@lists.cs.columbia.edu
https://lists.cs.columbia.edu/mailman/listinfo/faculty

6. Recognition rather than recall

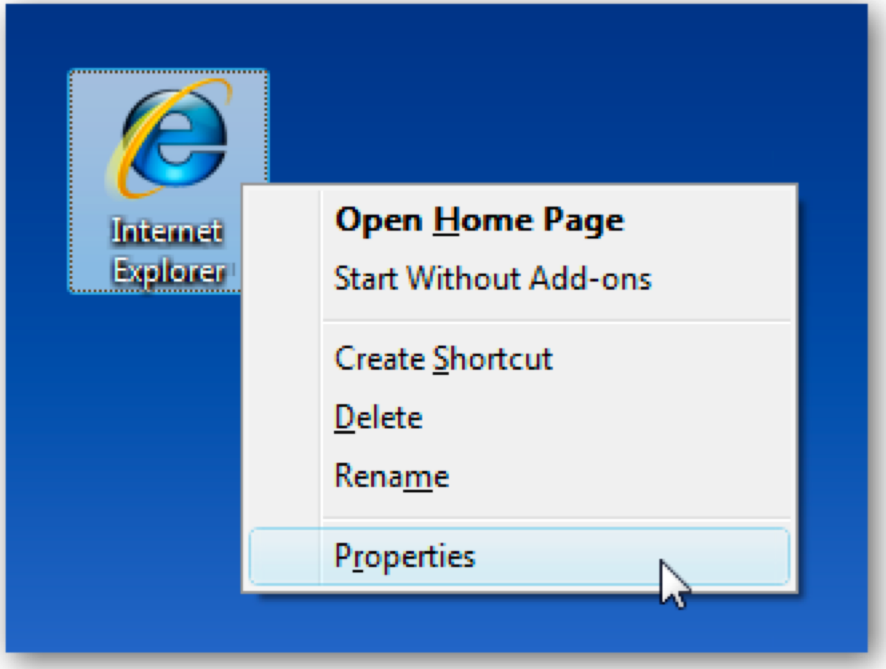
Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another.



```
Microsoft Windows [Version 6.1.7601]
Copyright (c) 2009 Microsoft Corporation.  All rights reserved.

C:\Windows\system32>explorer.exe

C:\Windows\system32>
```



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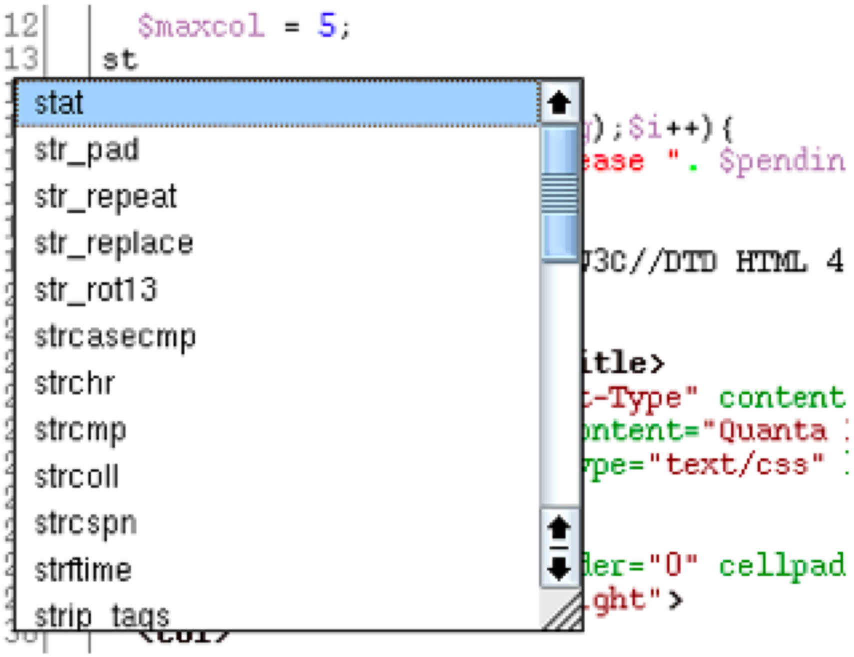
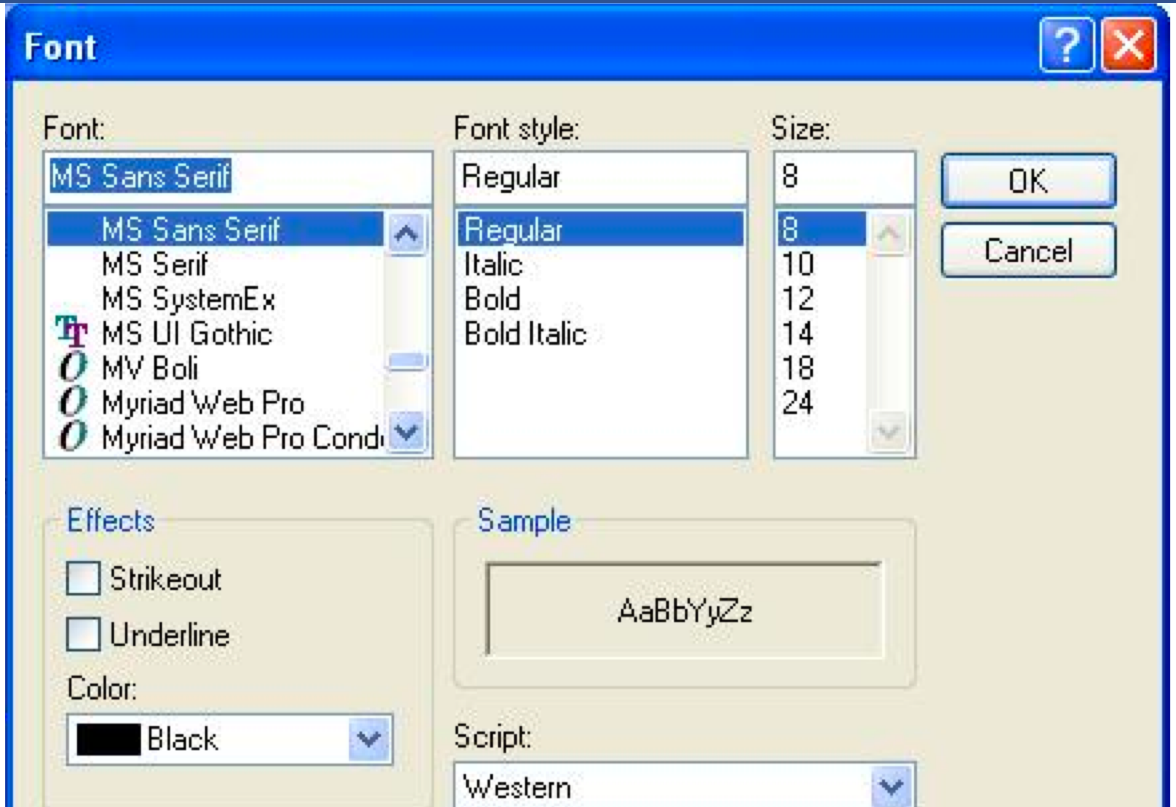


```
    $maxcol = 5;
st
```

```
);$i++){
ase ". $pendin

3C//DTD HTML 4

itle>
-Type" content
ntent="Quanta
pe="text/css"

er="0" cellpad
ght">
```

6. Violation: Recognition rather than recall

Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another.



Font: MS Sans Serif

Font style: Regular

Size: 8

Effects

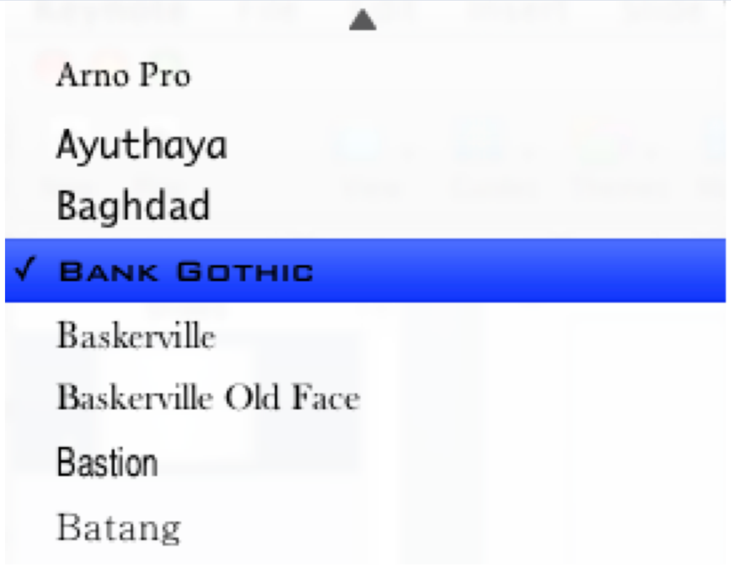
□ Strikeout

□ Underline

Color: Black

Sample: AaBbYyZz

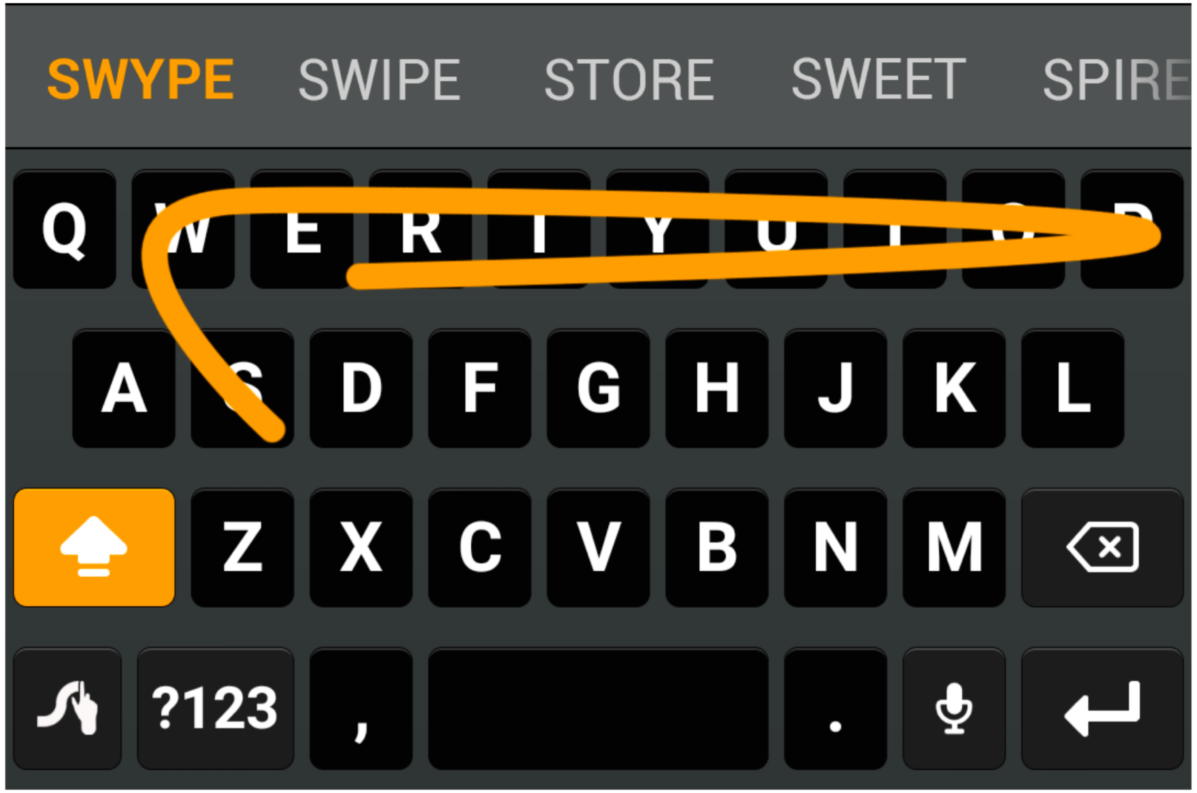
Script: Western



Much better!

7. Flexibility and efficiency of use

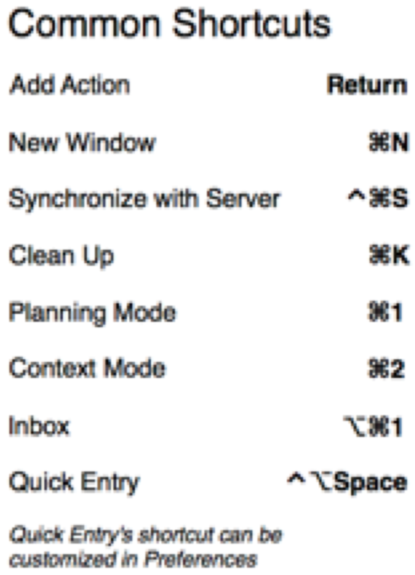
Accelerators — unseen by the novice user — may often speed up the interaction for the expert. Allow users to tailor frequent actions.



7. Flexibility and efficiency of use

Accelerators — unseen by the novice user — may often speed up the interaction for the expert. Allow users to tailor frequent actions.

Ctrl
Alt
Delete



Common Shortcuts

Add Action	Return
New Window	⌘N
Synchronize with Server	^⌘S
Clean Up	⌘K
Planning Mode	⌘1
Context Mode	⌘2
Inbox	⌥⌘1
Quick Entry	^⌥Space

Quick Entry's shortcut can be customized in Preferences

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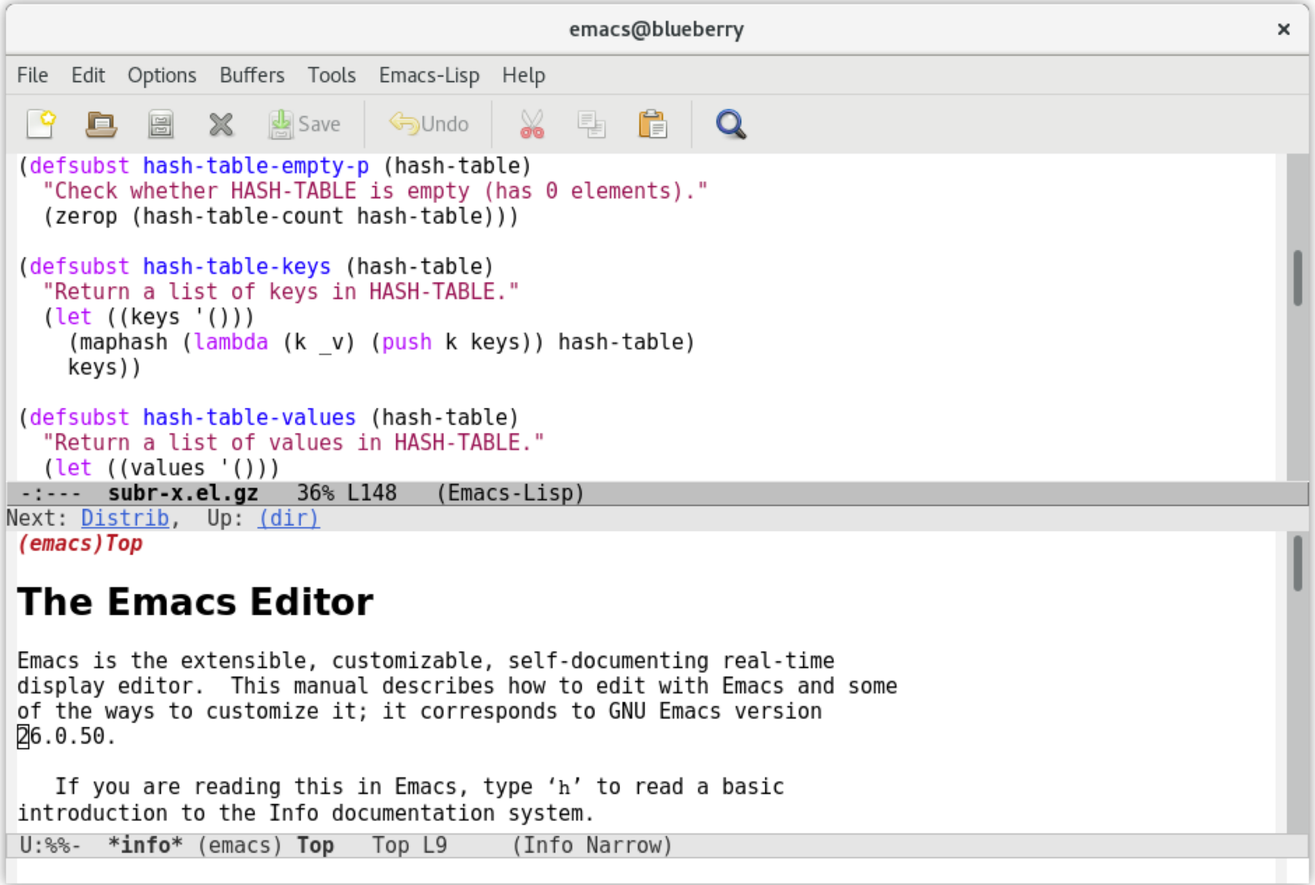
Accelerators — unseen by the novice user — may often speed up the interaction for the expert. Allow users to tailor frequent actions.



```
(defsubst hash-table-empty-p (hash-table)
  "Check whether HASH-TABLE is empty (has 0 elements)."
  (zerop (hash-table-count hash-table)))

(defsubst hash-table-keys (hash-table)
  "Return a list of keys in HASH-TABLE."
  (let ((keys '()))
    (maphash (lambda (k _v) (push k keys)) hash-table)
    keys))

(defsubst hash-table-values (hash-table)
  "Return a list of values in HASH-TABLE."
  (let ((values '()))
-:---  subr-x.el.gz    36% L148    (Emacs-Lisp)
Next: Distrib,  Up: (dir)
(emacs)Top
```

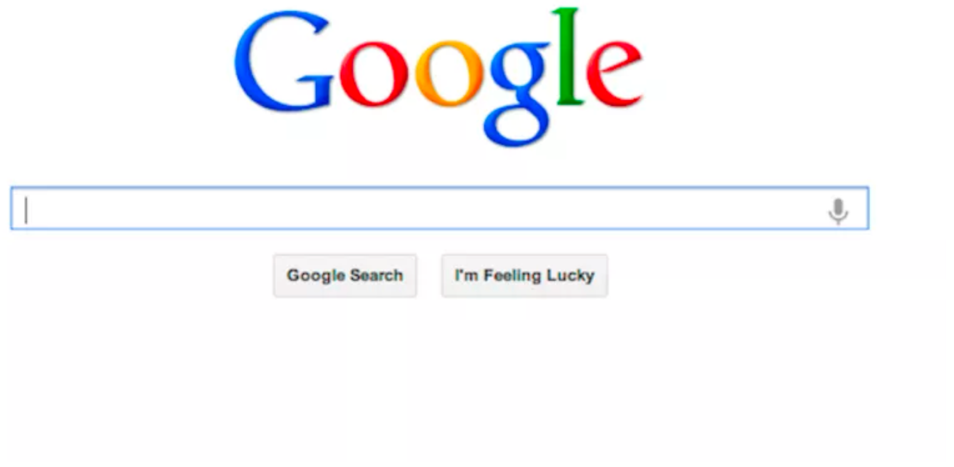
The Emacs Editor

```
Emacs is the extensible, customizable, self-documenting real-time
display editor.  This manual describes how to edit with Emacs and some
of the ways to customize it; it corresponds to GNU Emacs version
26.0.50.

   If you are reading this in Emacs, type ‘h’ to read a basic
introduction to the Info documentation system.
U:%%-  *info* (emacs) Top   Top L9     (Info Narrow)
```

8. Aesthetic and minimalist design

Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.



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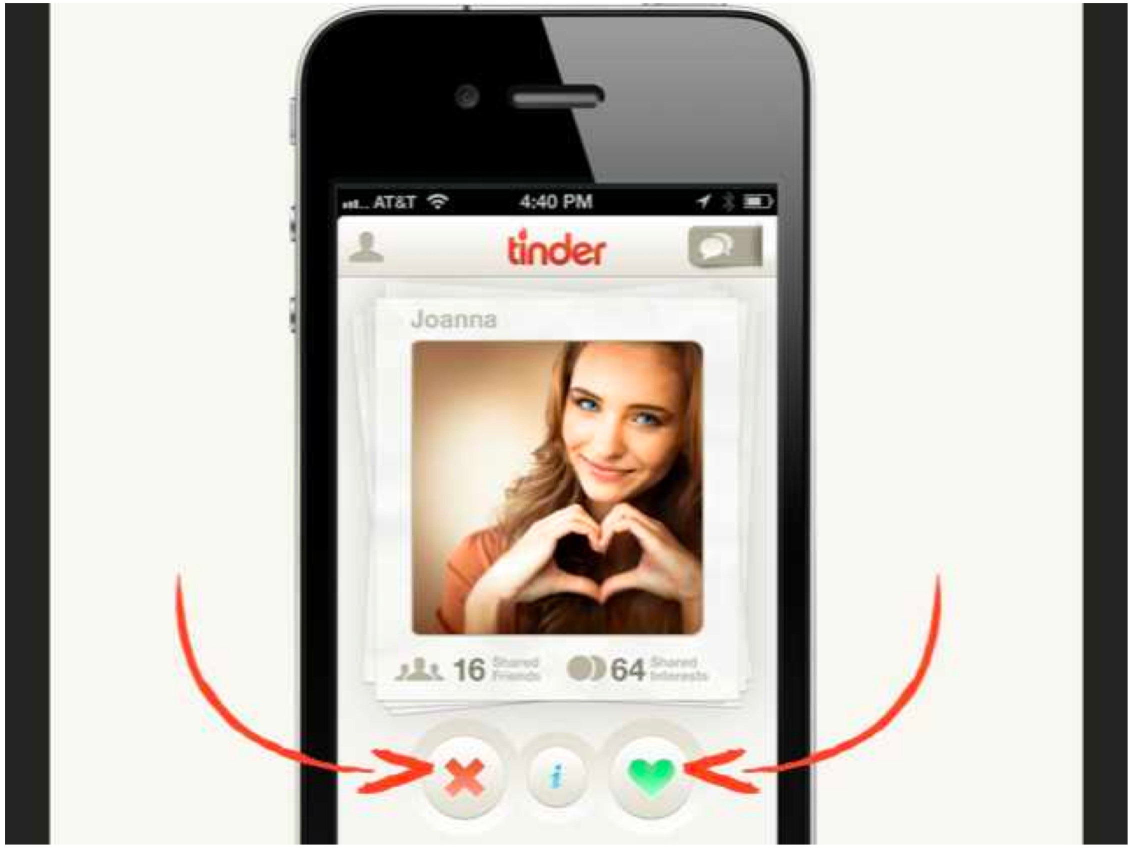
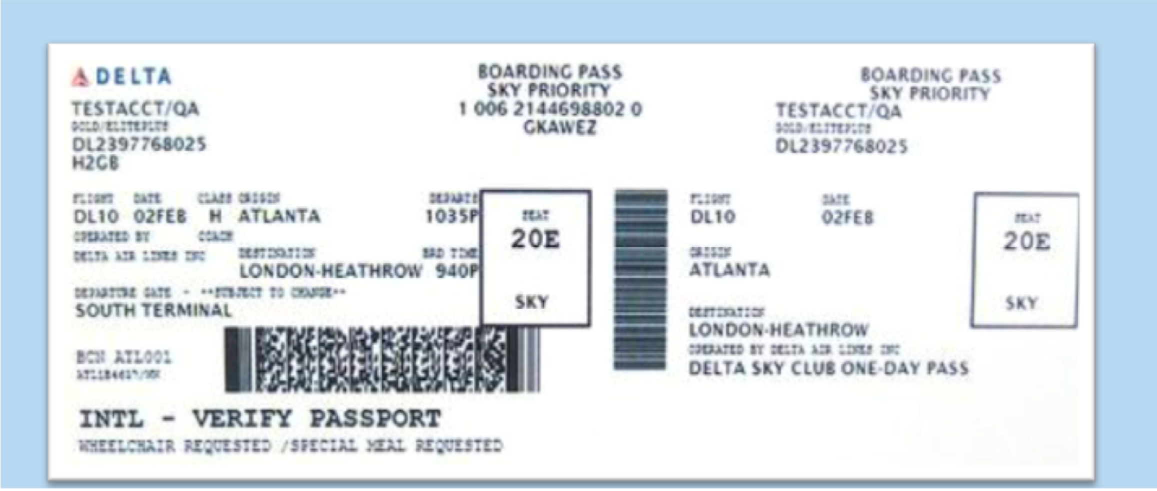


8. Violation: Aesthetic and minimalist design

Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.



DELTA

TESTACCT/QA
GOLD/ELITEPLUS
DL2397768025
H2GB

BOARDING PASS
SKY PRIORITY
1 006 2144698802 0
GKAWEZ

FLIGHT DATE CLASS ORIGIN DEPARTS
DL10 02FEB H ATLANTA 1035P
OPERATED BY COACH
DELTA AIR LINES INC DESTINATION BRD TIME
LONDON-HEATHROW 940P
DEPARTURE GATE - **SUBJECT TO CHANGE**
SOUTH TERMINAL

SEAT
20E
SKY

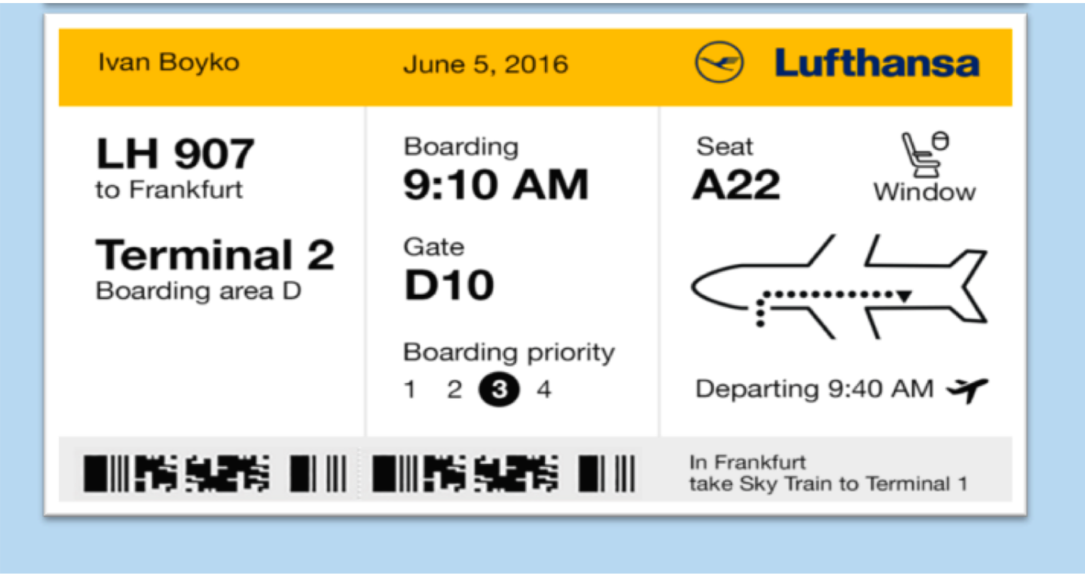
BCN ATL001

INTL - VERIFY PASSPORT
WHEELCHAIR REQUESTED /SPECIAL MEAL REQUESTED

BOARDING PASS
SKY PRIORITY
TESTACCT/QA
GOLD/ELITEPLUS
DL2397768025

FLIGHT DATE
DL10 02FEB
ORIGIN
ATLANTA
DESTINATION
LONDON-HEATHROW
OPERATED BY DELTA AIR LINES INC
DELTA SKY CLUB ONE-DAY PASS

SEAT
20E
SKY



Ivan Boyko June 5, 2016 Lufthansa

LH 907
to Frankfurt

Terminal 2
Boarding area D

Boarding
9:10 AM

Gate
D10

Boarding priority
1 2 ❸ 4

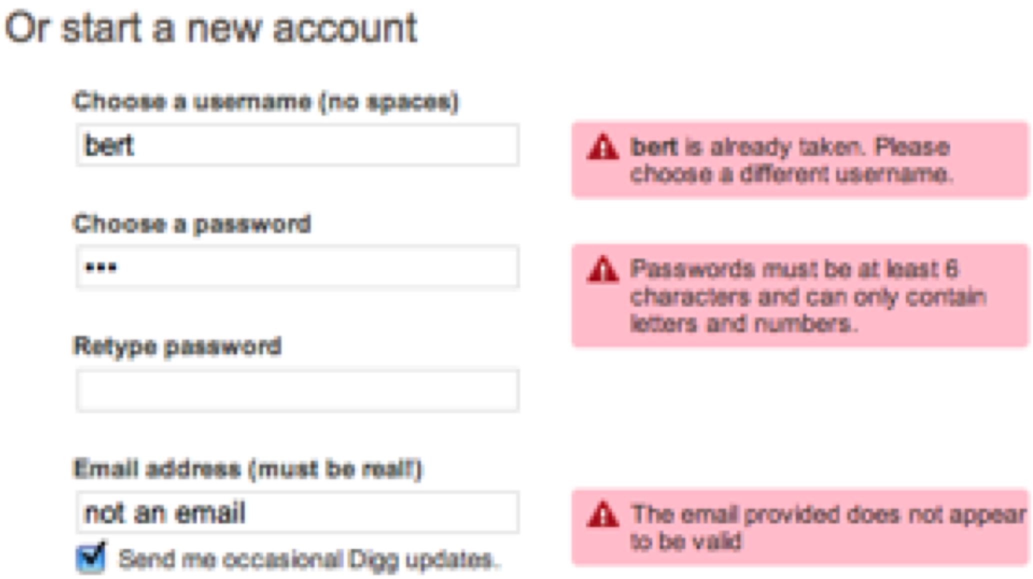
Seat
A22
Window

Departing 9:40 AM

In Frankfurt
take Sky Train to Terminal 1

9. Help users recognize, diagnose, and recover from errors

Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.



Or start a new account

Choose a username (no spaces)

bert

⚠ bert is already taken. Please choose a different username.

Choose a password

•••

⚠ Passwords must be at least 6 characters and can only contain letters and numbers.

Retype password

Email address (must be real!)

not an email

⚠ The email provided does not appear to be valid

☑ Send me occasional Digg updates.

9. Violation Help users recognize, diagnose, and recover from errors

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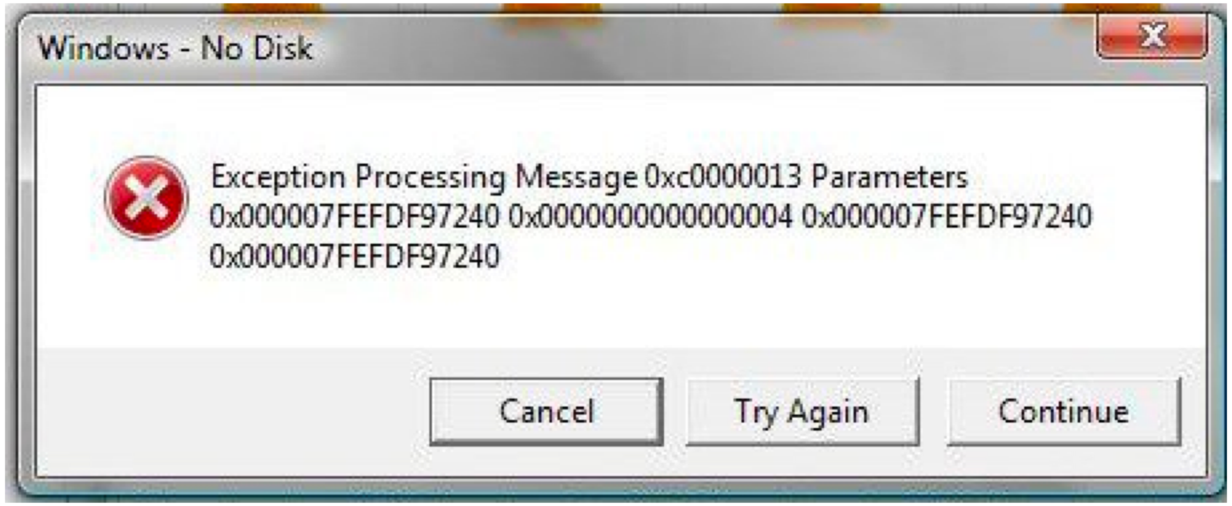
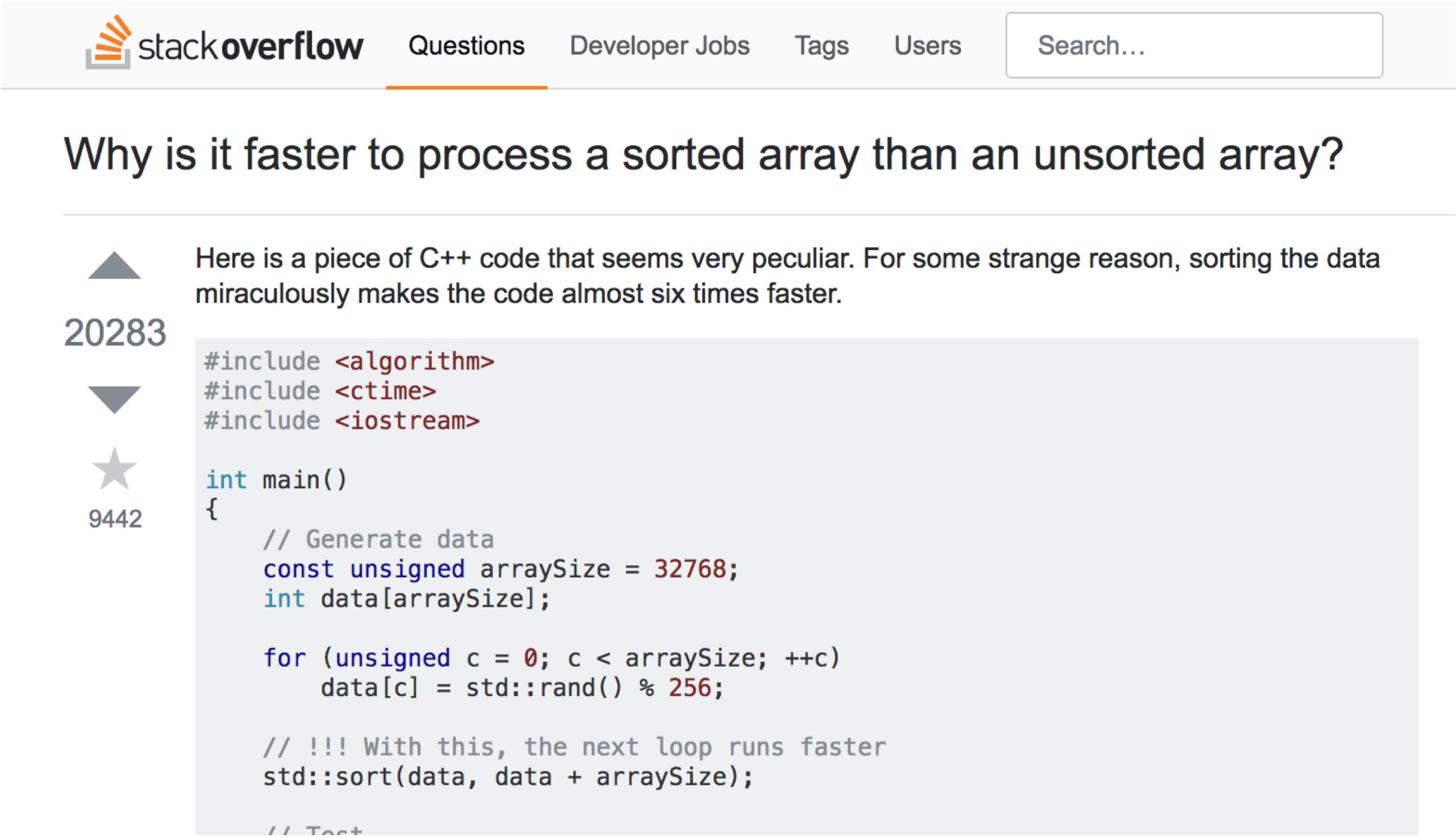


Windows - No Disk

Exception Processing Message 0xc0000013 Parameters 0x000007FEFDF97240 0x0000000000000004 0x000007FEFDF97240 0x000007FEFDF97240

10. Help and documentation

Documentation should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.



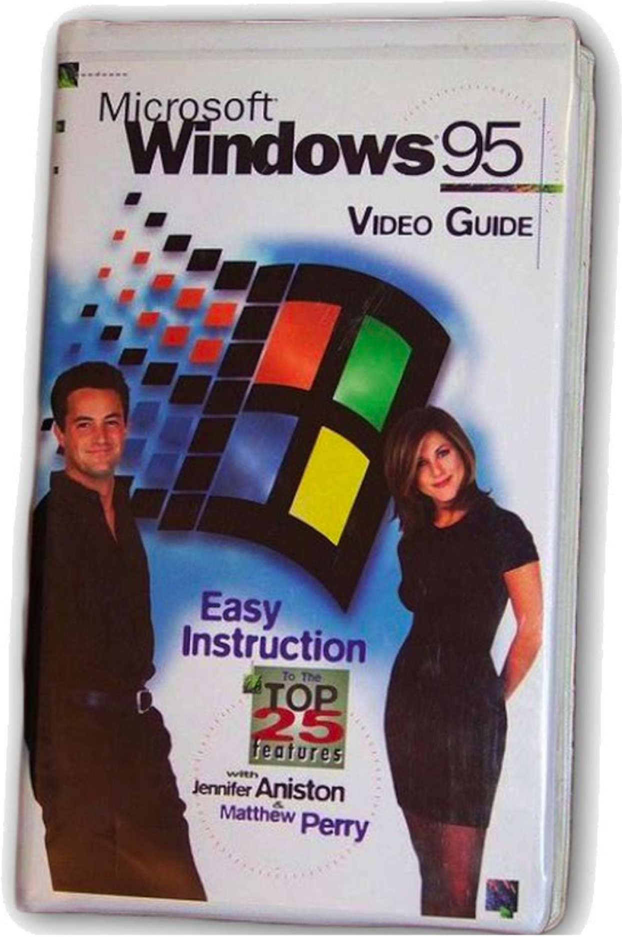
Why is it faster to process a sorted array than an unsorted array?

Here is a piece of C++ code that seems very peculiar. For some strange reason, sorting the data miraculously makes the code almost six times faster.

```
#include <algorithm>
#include <ctime>
#include <iostream>

int main()
{
    // Generate data
    const unsigned arraySize = 32768;
    int data[arraySize];

    for (unsigned c = 0; c < arraySize; ++c)
        data[c] = std::rand() % 256;

    // !!! With this, the next loop runs faster
    std::sort(data, data + arraySize);

    // Test
```

10. Violation: Help and documentation:

Documentation should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.

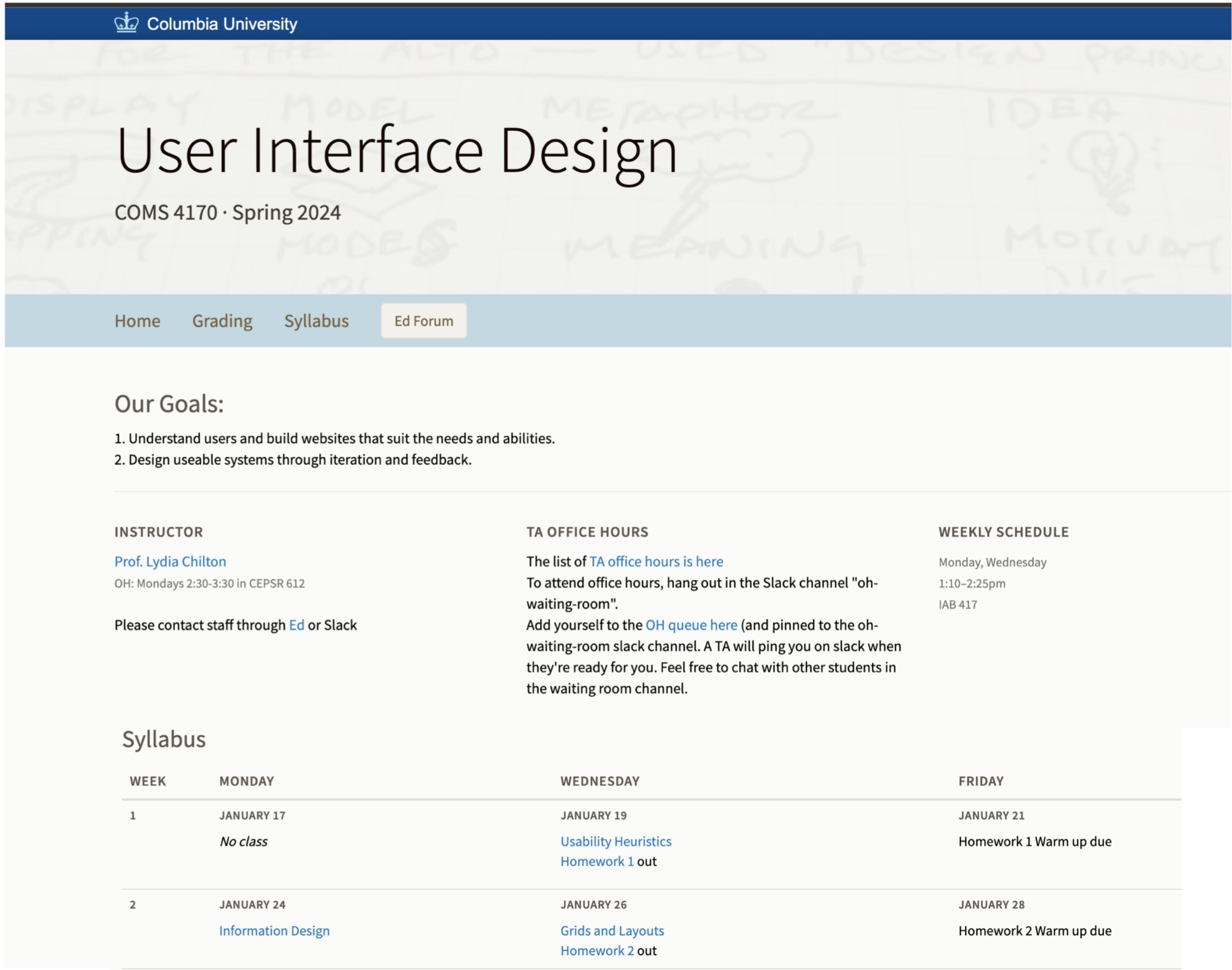


Nielsen’s 10 Usability Heuristics

1. Visibility of system status
2. Match the real world
3. User control and freedom
4. Consistency and Standards
5. Error prevention
6. Recognition rather than recall
7. Flexibility and efficiency of use
8. Aesthetic and minimalist design
9. Recover from Errors
10. Help and documentation

Homework 1

- Warm up due Friday 11:59pm
  - You can do this now!
- Main due Tuesday 11:59pm
  - You'll need Monday's lecture
- Homework is posted on the website:



Columbia University

User Interface Design

COMS 4170 · Spring 2024

Home Grading Syllabus Ed Forum

Our Goals:

1. Understand users and build websites that suit the needs and abilities.
2. Design useable systems through iteration and feedback.

INSTRUCTOR

Prof. Lydia Chilton

OH: Mondays 2:30-3:30 in CEPSR 612

Please contact staff through Ed or Slack

TA OFFICE HOURS

The list of TA office hours is here

To attend office hours, hang out in the Slack channel "oh-waiting-room".

Add yourself to the OH queue here (and pinned to the oh-waiting-room slack channel. A TA will ping you on slack when they're ready for you. Feel free to chat with other students in the waiting room channel.

WEEKLY SCHEDULE

Monday, Wednesday

1:10–2:25pm

IAB 417

Syllabus

WEEK	MONDAY	WEDNESDAY	FRIDAY
1	JANUARY 17 *No class*	JANUARY 19 Usability Heuristics Homework 1 out	JANUARY 21 Homework 1 Warm up due
2	JANUARY 24 Information Design	JANUARY 26 Grids and Layouts Homework 2 out	JANUARY 28 Homework 2 Warm up due

http://coms4170.cs.columbia.edu/2024-spring/