User-Centered Design
Software development

Requirements analysis

Design

Implementation

Testing

waterfall model (1970s)
Software development

- Requirements analysis
- Design
- Implementation
- Testing

waterfall model (1970s)
Software development

Spiral model (Boehm, 1998)
User-centered design

Requirement analysis & specification

Design

Evaluation

Prototyping

Users
User-centered design

Requirements analysis & specification
- field studies, interviews & questionnaires
- « personas »
- scenarios
- task analysis
- requirements specification

Evaluation
- usability testing
- heuristic evaluation
- focus group
- laboratory experiments
- observatory studies

Design
- brainstorming
- participatory design
- conceptual models
- metaphors
- interaction styles
- scenarios
- storyboards
- interaction models
- visual design

Prototyping
- paper prototypes
- low- or hi-fidelity prototypes
- physical models
- alpha/beta-system
Importance of user-centered design

Development cost
  Cost of user interfaces: ~50% of total cost

Cost of maintenance
  20%: « bugs »
  80%: unpredictable user needs

Cost of problem corrections
  $1 during the design stage
  = $10 during the development
  = $100 after the delivery
Methods

<table>
<thead>
<tr>
<th>Comprendre l’utilisateur</th>
<th>Analyser l’utilisateur</th>
<th>Inventer les idées</th>
<th>Prototyper le système</th>
<th>Évaluer le système</th>
<th>reconcevoir le système</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Fly-on-the-wall observation&quot;</td>
<td>Interactive Thread</td>
<td>Oral brainstorming</td>
<td>Paper prototyping</td>
<td>Focus group</td>
<td>Generative Walkthrough</td>
</tr>
<tr>
<td>Ethnography</td>
<td>HCI</td>
<td>Psychology</td>
<td>Participatory Design</td>
<td>Marketing</td>
<td>HCI</td>
</tr>
<tr>
<td>Critical incident interview</td>
<td>Contextual Inquiry</td>
<td>Design space</td>
<td>Video prototyping</td>
<td>Usability study</td>
<td>Technology probe</td>
</tr>
<tr>
<td>Human Factors</td>
<td>Anthropology</td>
<td>Design</td>
<td>Participatory Design</td>
<td>Human Factors</td>
<td>Design/Arts</td>
</tr>
<tr>
<td>Questionnaire</td>
<td>Task analysis</td>
<td>Sketching</td>
<td>Wizard of Oz</td>
<td>Heuristics</td>
<td>Design Rationale</td>
</tr>
<tr>
<td>Sociology</td>
<td>Human Factors</td>
<td>Design/Arts</td>
<td>Human Factors</td>
<td>HCI</td>
<td>HCI</td>
</tr>
<tr>
<td>Cultural probe</td>
<td>Scenario analysis</td>
<td>Video brainstorming</td>
<td>Software simulation</td>
<td>Design walkthrough</td>
<td>Design/Arts</td>
</tr>
<tr>
<td>Design/Arts</td>
<td>Activity Theory</td>
<td>Participatory Design</td>
<td>Computer science</td>
<td>Psychology</td>
<td>Design/Arts</td>
</tr>
<tr>
<td>Grounded Theory</td>
<td>Protocol analysis</td>
<td>Design room</td>
<td>Design scenario</td>
<td>Design Critique (Crit)</td>
<td></td>
</tr>
<tr>
<td>Cognitive Psychology</td>
<td>Cognitive Psychology</td>
<td>Design/Arts</td>
<td>HCI</td>
<td>Design/Arts</td>
<td></td>
</tr>
</tbody>
</table>

Image by W. Mackay & M. Beaudouin-Lafon
1: Understanding the users and analyzing their needs
1. Data collection
2. Data analysis: interpretation, modeling & specification of user needs, requirements
Identify the users

Who are they?
  eg. kids, elderly people, students, professionals, artists

What are their problems, needs, preferences & experiences?

What are their capacities (perception, cognition, motor skills), their knowledge and expertise?
  Experts, novices, handicaps, etc.

Cultural diversity
  Language, symbols, communication protocols

Economic context
  How much are they willing to pay for a new product?
Example: « one laptop per child »

Which are the special needs and constraints for the development of such a product?
Recherch methods

Qualitative or quantitative

*Can be subjective:* we cannot completely remove the bias of the observer

Techniques:
- Documentation, reading previous studies
- Observation
- Interviews
- Questionnaires
- Focus group
Direct observation

Observe the users as they make use of the current system

In the field:
Every observer is biased
Effect of the observation on the observed
Ethical questions: what do we register?

Artists use sketchbooks to register their observations at any time
Direct observation: registering

Field notebook
  Few details, subjective, incomplete

Audio
  Not always useful, hard to analyze

Video
  Detailed but intrusive, hard to analyze, retrospective analysis

Logs: mouse or keyboard events, etc.
  When we observe actions on a computerized system
Direct observation: coding

Systematic procedure for compressing the data into smaller entities, easier to analyze

Define categories & classifications
  nominal, ordinal, interval & ratio variables
Direct observation: coding

Systematic procedure for compressing the data into smaller entities, easier to analyze

Define categories & classifications
nominal, ordinal, interval & ratio variables

Example (coding of videos: observing how several people work on simple math problems)

- Sex (nominal)
  - Male
  - Female

- Age (ordinal)
  - 18-25
  - 26-33
  - 34-41

- Expertise (interval)
  - [0 – 5]

- Paper use (ordinal)
  - rare
  - medium
  - frequent

- Success of the task (ratio)
  - 0 – 100 %
Direct observation: coding

The same data could be coded by several people (more reliable)

Can the researcher participate or not? Which approach is less biased?
Questionnaires

Quick collection of responses from many people
Questionnaires

Guides:

1. Clear and concrete questions
2. Clear instructions
3. Prefer closed questions with a range of choices
4. Consider including an option « no opinion » for the questions that ask for opinions
5. Structure the questions carefully
   - the order is important
   - grouping into logical sections
5. Avoid multiple-choice questions that are too complex
6. Use well-thought and coherent scales
7. Avoid the jargon
Likert scale

In general, it contains 5 or 7 choices

Please circle the number that represents how you feel about the computer software you have been using

I am satisfied with it
Strongly Disagree —-1—-2—-3—-4—-5—-6—-7— Strongly Agree

It is simple to use
Strongly Disagree —-1—-2—-3—-4—-5—-6—-7— Strongly Agree

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Undecided</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>The cashier was courteous.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>The cashier was professional in appearance</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I was given a receipt at the end of my transaction</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
### Semantic Differential

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Probable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Improbable</td>
</tr>
<tr>
<td>Practical</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>Impractical</td>
</tr>
<tr>
<td>Safe</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>Risky</td>
</tr>
<tr>
<td>Stable</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>Volatile</td>
</tr>
<tr>
<td>Affordable</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>Expensive</td>
</tr>
<tr>
<td>Efficient</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>Inefficient</td>
</tr>
</tbody>
</table>
Semantic differential


Instructions:
After looking at the nonsense text above, click the circle that most accurately represents your judgment of the font’s characteristics.

<table>
<thead>
<tr>
<th>Passive</th>
<th>Cool</th>
<th>Active</th>
<th>Happy</th>
<th>Sad</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warm</td>
<td>Weak</td>
<td>Good</td>
<td>Delicate</td>
<td>Rugged</td>
</tr>
<tr>
<td>Strong</td>
<td>Good</td>
<td>Weak</td>
<td>Calm</td>
<td>Exciting</td>
</tr>
<tr>
<td>Bad</td>
<td>Good</td>
<td>Weak</td>
<td>Feminine</td>
<td>Masculine</td>
</tr>
<tr>
<td>Loud</td>
<td>Quiet</td>
<td>Good</td>
<td>Hard</td>
<td>Soft</td>
</tr>
<tr>
<td>Old</td>
<td>Quiet</td>
<td>Weak</td>
<td>Fast</td>
<td>Slow</td>
</tr>
<tr>
<td>Cheap</td>
<td>Quiet</td>
<td>Young</td>
<td>Relaxed</td>
<td>Stiff</td>
</tr>
<tr>
<td>Beautiful</td>
<td>Quiet</td>
<td>Expensive</td>
<td>This typeface is legible. Agree</td>
<td>Disagree</td>
</tr>
</tbody>
</table>
Interviews

Understand the tasks of users, identify their needs, know their opinions

Limited number of participants

Richer data but more qualitative

Structured vs. semi-structured interviews
Structuring an interview

From specific to general

From guided to open
design an interview

**Goal:**
Facts or opinions?
Details or generalities?
Real stories or abstractions?

**Guides:**
Go from specific to general
Go from directed to open
Go from facts to opinions
Focus group

Sessions with several people
Interaction between participants & discussion
Interpret the data

Who are the users?
   **Personas** (user profiles)

Which are the tasks?
   **Task analysis**

What are the representative **scenarios** of use?
Persona

A hypothetical archetype of a user used throughout the design characteristics, activities, interests motivations, needs, goals
Persona

Sherry

Working Mom, age 38

“Help me find appropriate toys and games for my family.”

Sherry is a 38-year-old working mom. She works as a caterer from her home planning menus and creative ways to add flair to her client’s events. She has two sons and one daughter who all need a full time mom. Between carpool, after school activities and work, Sherry has little time to socialize or browse the malls. Shopping is a necessity, not a pleasure. To unwind she enjoys dining out with friends, the occasional yoga class and needlepoint.

<table>
<thead>
<tr>
<th>Web &amp; Technology</th>
<th>Interests</th>
<th>Favourite Irwin Brands</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-speed on an iMac.</td>
<td><em>Activities</em>: Dining out, reading,</td>
<td>All brands; specifically Sailor Moon, Caillou,</td>
</tr>
<tr>
<td><em>Purchases</em>: Toys,</td>
<td>needlepoint, yoga, doing crafts</td>
<td>BKC, GirlZone, Reboot and kids/ adults board</td>
</tr>
<tr>
<td>videos, board games</td>
<td>with her children</td>
<td>games</td>
</tr>
<tr>
<td><em>Favourite Sites</em>:</td>
<td><em>General Interests</em>: Decorating,</td>
<td></td>
</tr>
<tr>
<td>marthastewart.com</td>
<td>cooking and baking, children’s</td>
<td></td>
</tr>
<tr>
<td>and</td>
<td>educational issues</td>
<td></td>
</tr>
<tr>
<td>epicurious.com</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Motivations</th>
<th>Goals</th>
<th>Needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>My child wants a certain toy or game.</td>
<td>To purchase a toy or game my child/family will enjoy.</td>
<td>I want to know what I’m getting: show me pictures; give me some information on size, batteries, etc.</td>
</tr>
<tr>
<td>My child’s birthday is coming.</td>
<td>I want to keep my child/family happy and entertained.</td>
<td>I want to see toy categories: age, gender, television show, and brand.</td>
</tr>
<tr>
<td>My child enjoys a certain children’s television show.</td>
<td>“Give me quick access to information I can understand.”</td>
<td>I want to know which toys/games are new.</td>
</tr>
<tr>
<td>My family needs to spend more time together.</td>
<td></td>
<td>I need quick access to relevant information.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I want to keep my child and family entertained.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I want to know about Irwin Toy events.</td>
</tr>
</tbody>
</table>
Scenarios

Informal narrative description
How the users reach their goals
Artifacts, environment & context

Use of the users’ vocabulary

Generally textual
But also as video or *storyboard*
Scenarios

Used at different phases of the development process

(Rosson and Carroll, 2002)
Task analysis

Investigate the current user tasks

What are the goals of the users and how do they accomplish them?
Hierarchical task analysis

Tasks & subtasks

*Plans* to describe alternative sequences

0. make tea
   1. boil water
      1.1 fill kettle
      1.2 light stove
      1.3 put kettle on stove
      1.4 wait
      1.5 turn off stove
   2. empty pot
   3. put leaves in pot
   4. pour water
   5. wait
   6. pour tea

Plan 0: do 1.
   if pot is full,
      then do 2 at the same time
   do 3-4-5
   when tea is brewed, do 6

Plan 1: do 1.1-1.2-1.3-1.4
   when water is boiling, do 1.5
Hierarchical task analysis

0 make tea

plan 0
do 1
at the same time, if pot is full, do 2
3–4–5
after four or five minutes do 6

1 boil water
2 empty pot
3 put tea in pot
4 pour water
5 wait
6 pour tea

plan 1
1.1–1.2–1.3–1.4
when kettle boils 1.5

1.1 fill kettle
1.2 light stove
1.3 put kettle on stove
1.4 wait
1.5 turn off gas
Requirements specification

Functional
What? (functions)

Non-functional
How? (constraints)

utility

usability
2: Designing an interactive system
Design

Requirements analysis & specification
- field studies, interviews & questionnaires
- « personas »
- scenarios
- task analysis
- requirements specification

Evaluation
- usability testing
- heuristic evaluation
- focus group
- laboratory experiments
- observatory studies

Design
- brainstorming
- participatory design
- conceptual models
- metaphors
- interaction styles
- scenarios
- storyboards
- interaction models
- visual design

Prototyping
- paper prototypes
- low- or hi-fidelity prototypes
- physical models
- alpha/beta-system
The design of everyday things (Norman, 1990)

The ordinary objects reflect the problems of user interface design

- Door handles
- Washing machines
- Telephones
- etc.

Introduces the notion of affordance, metaphores, and conceptual models

Provides design rules
Mental model

What is it? How does it work?
Mental model

Operational mental representation of the reality
  e.g., directions about how to go back home

Provides a structure that allows for associating causes with effects
  What did I do to produce this result?

Allows for predictions
  What will it happen if I press this?
conceptual model vs. mental model

- conceptual model
  - formal
  - structured
  - logical

- mental model
  - informal
  - incomplete
  - sometimes erroneous

image of the system

designer

user
Conceptual modeling

Conceptual model
- How the designer wants the user to see the system
- Needs to hide the technical aspects
- Needs to anticipate what the user wants to do with the system

Image of the system
- How the user sees the system (including its documentation)
- Used by the user to build the mental model

Mental model of the user
- Created from the image of the system, from its use, by reading the documentation, etc.
Conceptual modeling

Correspondance between the conceptual and the mental model
- Improved by a good use of *metaphors*
- Improved by making use of *affordances*
- Improved by following *design recommendations*

Bad correspondance
- Errors
- Frustration
- Poor productivity
Metaphor

Transfer of a relationship between a set of objects to another set of objects in a different domain

office/desktop

folders

electronic desktop
Metaphor

Transferring the properties of objects
Open a folder, move to the trash, etc.
Metaphor

Goals:
- Save in learning a new interface
- Take advantage of existing knowledge
- Make use of properties found in the real world

The goal is not to simulate a real desktop but take advantage of our knowledge from the real desktop
Metaphors and negative transfers

Metaphors and negative transfers

The calculator
Design

**Requirements analysis & specification**
- field studies, interviews & questionnaires
- « personas »
- scenarios
- task analysis
- requirements specification

**Evaluation**
- usability testing
- heuristic evaluation
- focus group
- laboratory experiments
- observatory studies

**Design**
- brainstorming
- participatory design
- conceptual models
- metaphors
- interaction styles
- scenarios
- storyboards
- interaction models
- visual design

**Prototyping**
- paper prototypes
- low- or hi-fidelity prototypes
- physical models
- alpha/beta-system
Steps in the design process

Conceptual design
The concept: *conceptuel model, metaphors, interaction styles*

Physical design & detailed design
Concrete decisions on the user interaction, the interfaces, the « look-and-feel » (visual design), the structure of menus, etc.
How to start?

Synthesize the results of observations
   Personas, scenarios, etc.

Invent ideas
   Generate multiple alternative solutions

Create a *design space*
   Not simply a list of functionalities

Choose the concept
   Concentrate on the interaction between the user and the system
Brainstorming

Goal: Generate as many creative ideas as possible
**Brainstorming: procedure**

- Form a small team with different roles and expertise
- Fix the time (e.g., 1 hour maximum)
- Describe a specific design problem
- Generate as many ideas as possible
  - Never criticise the ideas!
- Write down the ideas on a whiteboard or a transparency
- At the end, each participant votes for the best three ideas
Brainstorming video

Simulate the interaction between the user and the system

The ideas have to be brief

Use transparencies, post-its, scissors, etc.
Other design methods

Scenarios and storyboards
  capture and communicate the interaction with the new system

Rapid prototyping
  physical models, sketches, paper prototypes
  receive user feedback early enough in the design process
Scenarios

Whenever the DIR beeps, it indicates that a match is identified. In this case, a buyer is found. It also shows the buyer's location and their actual relative distance.

Joe introduces himself.

Joyce asks Joe about the price for the book.

At the same time, the buyer's DIR is behaving the same way. They can then easily locate each other.

Joe does not believe his eyes, because Joyce is exactly the same type of girl he always dreams of!!

Joe is totally defeated under Joyce's beauty.

He takes out the DIR from his pocket.

The DIR shows a sparkling indicator on the screen. This shows Joyce's location at this moment.

Joe decides to follow the map of the DIR to meet Joyce.

On the friends list, Joyce's name is highlighted indicating that she is near him. Joe selects her name to view her location.

He goes downstairs.

student project on the design of a new communication device
Storyboards

Describe the interaction in easy-to-read segments
Define the key elements in a coherent order
Decide which details to show
note how each scene in this storyboard is annotated
Storyboards

Alfred Hitchcock’s storyboards (Musée des Lettres et manuscrits, Paris)
Possible storyboard structure

this type focuses on a complete interaction

Possible storyboard structure

this type focuses on detailed interaction sequences

from the book “Sketching User Experiences: The Workbook”
Possible storyboard structure

(we can show more interaction details with video prototyping)

From Wendy Mackay
Participatory design

Active participation of users in the design

Brainstorming, scenarios, analysis of tasks, simulations, paper & video prototypes
Participatory design
Detailed design

Define the interaction, e.g., with navigation diagrams and state machines

Define the « look-and-feel »
Prototypes

Prototype is used to ...
- Explore different design alternatives
- Ensure its usability under different conditions
- Aid users to imagine the interface
- Focus on problematic aspects of the interface

Why prototype?
- If you start implementing code too early, you risk spending too much time to create a system that does not work for your users

Prototyping is a fast way to ...
- Explore details of your concept before implementation
- Communicate the concept to users, your managers, etc
- Justify your design choices
What is a prototype?

Concrete representation of an IS

Characteristics :
- Representation: form of the prototype
- Simulation
- Precision: level of detail
- Interactivity: interaction
- Evolution: life cycle of prototype

Dimensions :
- Off-line ... on-line,
- Informal ... well defined
- Look ... interact
- Throw away ... iterative

The choice of prototype depends on the phase in the design process and the specific needs of the designers.
Prototype: representation

Off-line Prototypes
Easy and quick to create, can be thrown away
Usually used at the beginning of the design process
e.g.: storyboard of a screen sequence, ‘mockup’ or video showing a complex interaction

On-line Prototypes
Use the computer, longer to create,
Usually used later in the design process
e.g.: animations, interface builders
Prototype: precision

Low-fidelity (not detailed) prototypes
Good for exploring ideas quickly
  e.g.: sketches, systems like “Silk”

High-fidelity (very detailed) prototypes
Good for communicating a specific aspect
  e.g.: detailed dialog box with the size and text of buttons

Note: A detailed representation is not always precise
  we can leave open aspects that are not yet decided
  but can fool users to believe it is final (later)
Designing with office supplies
  multiple layers of sticky notes and plastic overlays
  different sized post-it’s represent icons, menus, windows etc.

interaction demonstrated by manipulating notes
  new interfaces built on the fly

sessions videotaped for later analysis
  usually end up with mess of paper and plastic!
Paper prototypes

concrete representation of an IS (that does not exist)
Paper prototypes

concrete representation of an IS (that does not exist)

From Design for the Wild, Bill Buxton
Prototype: interactivity

Non-interactive prototypes
No interaction, but can show predefined interaction
  e.g.: a video clip illustrating an interaction, but the user does nothing

Closed-interactive prototypes (predefined sequences)
Permits to test some interaction alternatives
  e.g.: the designer shows a screen image, the user makes an action, and
  the designer shows her the new screen image

Interactive (open) prototypes
The user can interact with the system
Prototype: Wizard of Oz

The «wizard» interprets the user input and controls the system behavior.

The user feels as if she interacts with the real system.

The system can be:
- Inexistent
- Partially implemented
- Fully functional

Better adapted for some forms of interaction...
Prototype: strategies

Horizontal: complete layer of the system, no detailed function at other layers
  e.g.: develop the interface details without the detailed actions on the database

Vertical: complete functionality for a small part of the system
  e.g.: develop the entire spelling correction interface and functionality

Task: functionality needed to complete a specific task
  e.g.: develop the interface for moving an image

Scenario: functionality needed to run a scenario
  e.g.: develop the functionality need for a realistic scenario under a specific context, such as how to search, add and correct data in a database and then print the new database

Prototyping & design evolution

**Early design**
- Brainstorm different representations
  - Choose a representation
  - Rough out interface style
- Task centered walkthrough and redesign
- Fine tune interface, screen design
- Heuristic evaluation and redesign
  - Usability testing and redesign
- Limited field testing

**Late design**
- Sketches & low fidelity paper prototypes
- Medium fidelity prototypes
- High fidelity prototypes
- Working systems
- Alpha/Beta tests
- Working systems
From sketches to prototypes

From Sketching the User Experience, Bill Buxton