Models & Metaphors

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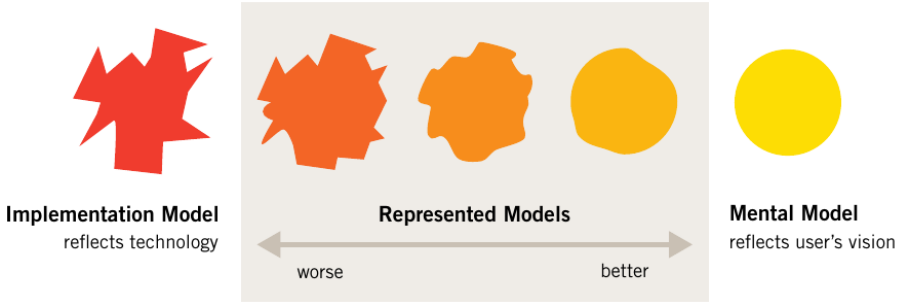
1 Introduction

Choice of Represented Model



A comparison of the implementation model, mental model, and represented model.
(Cooper et al., 2014)

Interaction Styles

- We look at the following Interaction Styles
  - Command language/command line
  - Menus & forms
  - Direct manipulation
    - Touch and Mouse
- Also interesting, but outside the scope today
  - Other forms of graphical interaction
  - 3D-Gestures
  - Natural Language Interfaces
  - Explicit *vs.* implicit interaction
  - Behavioural Interfaces

Command Line Interface

- User types in commands in an artificial language
  - Unix shell (`ls -l *.java`)
  - Search engine query language (`AND, OR`)
  - SQL (`SELECT FROM Book WHERE price > 100.`)

  - SPARQL (`SELECT ?name ?email WHERE {?person a foaf:Person. ?person foaf:name ?name. ?person foaf:mbox ?email.}`)
- Command syntax is important
- Powerful tool with a steep learning curve – find all .tex files that mention the word foo in a given subtree and replace those occurrences with bar
- When designing a command language, the key problem is the syntax
- Task analysis drives the choice of commands, the names you give them, the parameters they have, and the syntax for fitting them together

Menus & Forms

- User is prompted to choose from menus and fill in forms
  - web sites "before Web 2.0"
  - dialog boxes
- Navigation structure is important
  - Wizard: linear sequence of forms
- The navigation structure is the important design problem for menu/form interfaces
- Task analysis tells you what choices need to be available, where they should be placed in a menu tree, and what data types or possible responses need to be available in a form

Direct Manipulation

- User interacts with visual representation of data objects (based on Shneiderman and Plaisant (2005)):
  - Continuous visual representation
    - Verbal or iconic
  - Physical actions or labeled button presses
    - most direct kind of action, analog to real world interaction
    - not everything can be easily mapped – convert a text to bold – so "command actions" are allowed
  - Rapid, incremental, reversible, immediately visible effects
    - within 100ms (why?)
    - drag a bit, see the change
    - physical or logical

Direct Manipulation II

- Examples
  - Files and folders on a desktop
  - Scrollbar
  - Dragging to resize a rectangle
  - Selecting text
- Visual representation and physical interaction are important
- It is powerful since it exploits perceptual and motor skills of the human user
- Some say it depends less on linguistic skills than command or menu/form interfaces
  - Only partly true and for a limited understanding of language

Touch *vs.* Mouse

- While the underlying metaphor does still work, differences between mouse and touch need to be considered
- For touch-based devices, we need to look at
  - Size of elements
    - "Even bigger"
  - Interaction option
    - There is no mouseover
  - New "natural" (cultural?) patterns
    - Swipe, pinch to zoom
- We still have objects to interact with, what about
  - 3D-Gestures
  - Speech Interfaces
  - Implicit Interaction
- Direct Manipulation has served us well, but we need to move on

Comparison of Interaction Styles

- Knowledge in the head *vs.* world
  - CLI needs practice, training, references, manuals
  - M&F put much more information into the world
  - DM has information from affordances and constraints of metaphor
- Error messages regarding the interaction itself
  - DM rarely needs them – try to drag a scroll bar too far
- Efficiency
  - CLI good for experts
  - M&F demand good shortcuts
  - DM if appropriate for task, but mis-using can be labor intensive
- User experience
  - CLI best for experts
  - M&F, DM better for novices, infrequent users

Comparison of Interaction Styles II

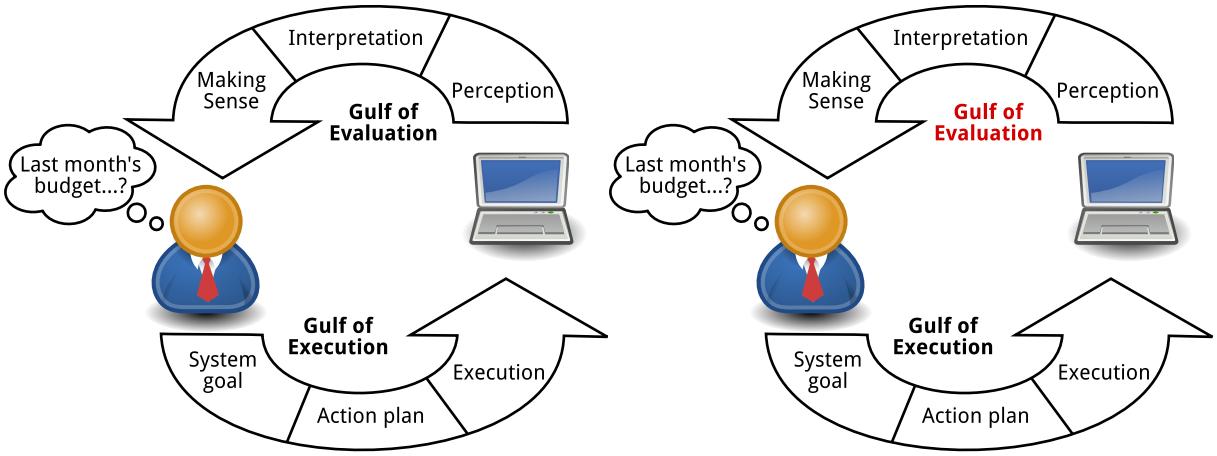
- Synchrony
  - CLI synchronous, M&F (user types, system does)
  - DM asynchronous, user can point anywhere, do anything
- Programming difficulty
  - CLI are easy, parsing rigid texts well understood
  - M&F, DM with substantial toolkit support
- Accessibility
  - CLI, M&F easier since both are text based
  - DM much harder

2 Norman's Gulfs

Stages of Interaction

- There are lots of places where interaction between human and machine can go wrong
  - Perception
  - Cognition
  - Action
- Stages of action proposed by Norman (1986)
- Two gaps
  - **Gulf of Evaluation:** the "cognitive distance" between what is displayed and the user's mental representation
  - **Gulf of Execution:** distance between the user's goals and the procedures and actions provided to pursue this goals

Gulf of Evaluation



Information-Design

- The **objects** and **actions** possible in a system are **represented** and **arranged** in a way that facilitates **perception** and **understanding**
- Includes the design of
  - Application screens
  - Web pages
  - Menus
  - Dialogs
  - Icons
- Other modalities
  - Sound
    - Speech synthesis
  - Tactile
    - Force feedback game controls
  - Visual
    - 3D-displays (geowall)
- Addresses the Gulf of Evaluation

Perception

- Guiding viewers to see the structure in an information display
- Gestalt principles
  - Similarity
  - Closure
  - Area
  - Symmetry
  - Continuity
  - Proximity
- Organization

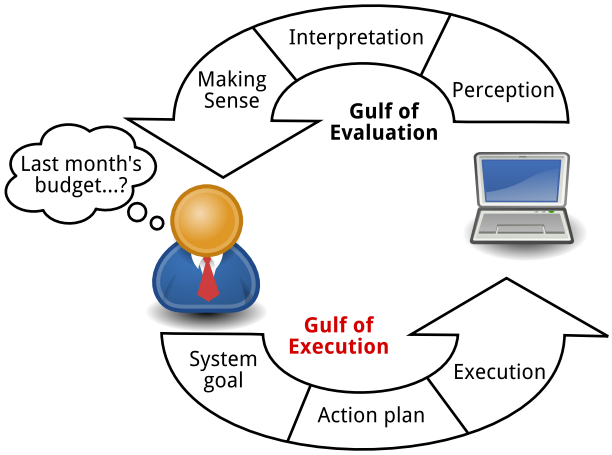
Interpretation

- During interpretation, the content is recognized as input fields for data, choices for presentation, etc.
- Key concepts:
  - Familiarity
    - Connect to existing knowledge
  - Realism and abstraction
    - Realistic – easy to recognize, but maybe too particular?
    - Abstract – harder to recognize, but maybe more general?
  - Recognizing Affordances
    - Show the user what can be done and where

Making Sense

- Relating the information to what they currently understand about their task
- Evaluating whether and how it addresses their active goals and interests
- Consistency
  - Visual design program: fonts, logo, colors
- Visual metaphors
  - Is it map? Does it work as a map?
- Information models
  - hierarchies, maps
- Dynamic display
  - redisplay or animation

Gulf of Execution



Interaction-Design

- Goal: specify the mechanisms for accessing and manipulating task information
- **Information design** focuses on determining which task objects and actions to show and how to represent them
- **Interaction design** tries to make sure that people can **do the right things at the right time**
- Broad scope:
  - Selecting and opening a spreadsheet
  - Pressing and holding a mouse button while dragging it
  - Specifying a range of cells
- Addresses the Gulf of Execution

Task & System Goal

- Task goal
  - the task the user really wants to achieve
- System goal
  - translate the real world goal into a system goal
  - UI-Models/Interaction style
  - opportunistic goals

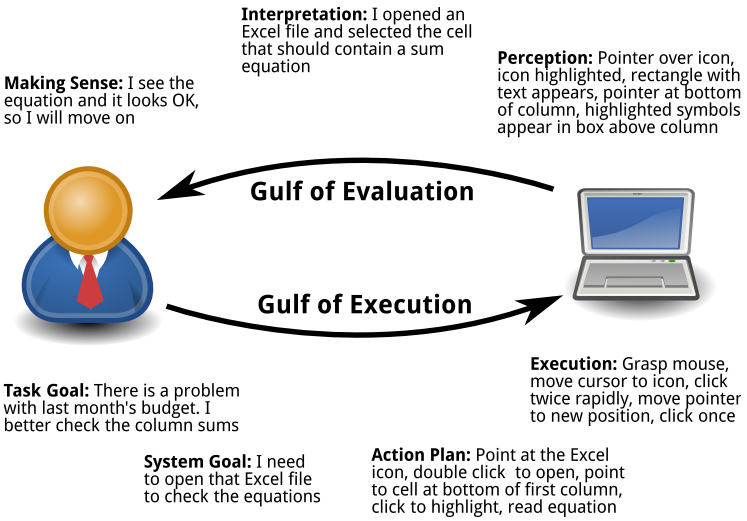
Action plan

- steps needed to achieve a system goal comprise an action plan
- task analysis $\rightarrow$ idealized action plan
- Other key concepts:
  - mental models
  - making actions obvious

Execution

- final phase: execution of plan steps
- articulatory directness: mapping of physical movement with a device to a task's input requirements
  - Mouse, keyboard, trackball, joystick
- Feedback and undo
- optimizing performance
  - efficient interaction
  - sane defaults

Gulf of Evaluation



3 Cues

Questions from the Action Cycle

1. What do I want to accomplish?
2. What are the alternative action sequences?
3. What action can I do now?
4. How do I do it?
5. What happened?
6. What does it mean?
7. Is this okay? Have I accomplished my goal?

(Norman, 2013)

Principles

1. Discoverability.
   - It is possible to determine what actions are possible and the current state?
2. Feedback.
   - Full and continuous information about the results of actions and the current state of the product or service.
3. Conceptual model.
   - Design projects all the information needed to create a good conceptual model.
4. Affordances.
   - The proper affordances exist to make the desired actions possible.
5. Signifiers.
   - Effective use of signifiers ensures discoverability and that the feedback is well communicated and intelligible.
6. Mappings.
   - The relationship between controls and their actions follows the principles of good mapping.
7. Constraints.
   - Constraints guide actions and eases interpretation.

Discoverability

Which Is the US One-Cent Coin, the Penny? Fewer than half of the American college students who were given this set of drawings and asked to select the correct image could do so (Norman, 2013).

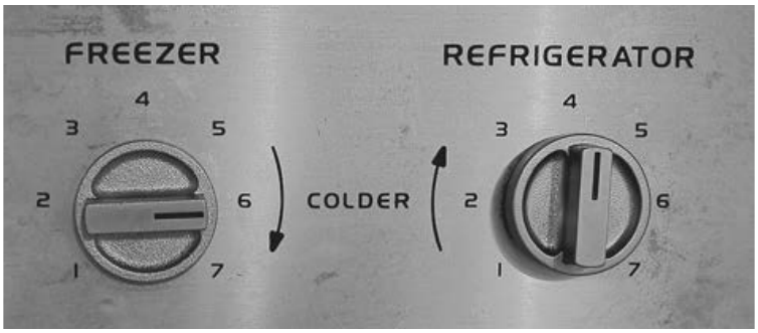
Discoverability by Visibility

- *Relevant parts* of system should be *visible*
- If the user cannot see an important control, they would have to
  - guess that it exists, and
  - guess where it is
- Not usually a problem in the real world
  - Look at a bike or a pair of scissors
  - Hiding often takes effort (hidden doors)
  - Design can come in the way
- But takes extra effort in computer interfaces
  - Mouse clicks can be interpreted in arbitrary ways

Feedback

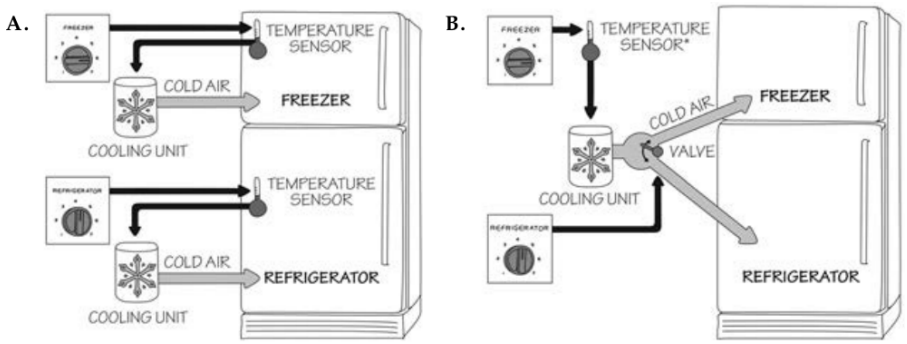
- *Feedback:* what the system does when you perform an action
- When the user successfully makes a part work, it should appear to respond
- Actions should have immediate, visible effects
  - Push buttons depress and release
  - Scrollbars move
  - Drag & drop following the cursor
- Kinds of feedback
  - Visual – see above
  - Audio – clicks made by keyboard (or, artificially, touch screens)
  - Haptic – vibrating touch screens, force feedback 3D-mouse

Conceptual Model



Two compartments — fresh food and freezer — and two controls (in the fresh food unit). Your task: Suppose the freezer is too cold, the fresh food section just right. How would you adjust the controls so as to make the freezer warmer and keep the fresh food the same? (Norman, 2013).

Conceptual Model



(Norman, 2013).

Affordances

- *Perceived* and *actual* properties of a thing that determine how the thing could be used
  - Chair is for sitting
  - Knob is for turning
  - Button is for pushing
  - Listbox is for selection
  - Scrollbar is for continuous scrolling or panning
- Perceived *vs.* actual
  - A paper-mache chair still has a perceived affordance for sitting
  - A pole has no perceived affordance for sitting, but you can sit on it (albeit uncomfortably)
- The DM UI should agree on perceived and actual affordances

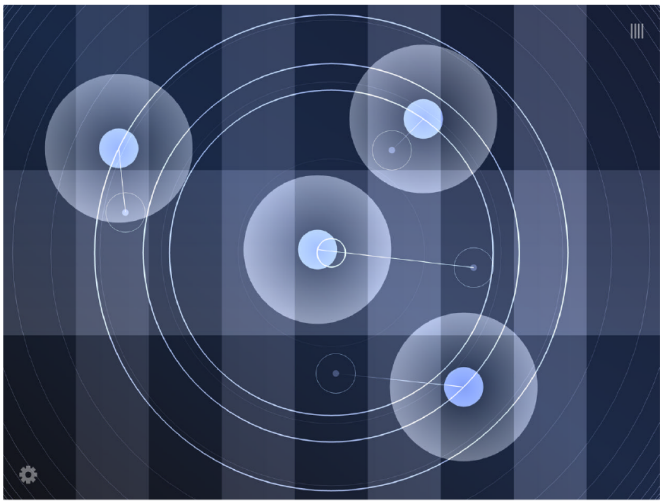
Signifiers

- Affordances exist even if they are not visible
- For designers, their visibility is critical: visible affordances provide strong clues to the operations of things
  - A flat plate mounted on a door affords pushing
  - Knobs afford turning, pushing, and pulling
- Perceived affordances help people figure out what actions are possible without the need for labels or instructions
- The signaling component of affordances is a signifier
  - Perceived affordances often act as signifiers, but they can be ambiguous
  - Signifiers signal things, in particular what actions are possible and how they should be done
- Signifiers must be perceivable, else they fail to function.

Affordances & Signifiers

(Cooper et al., 2014)

Affordances & Signifiers

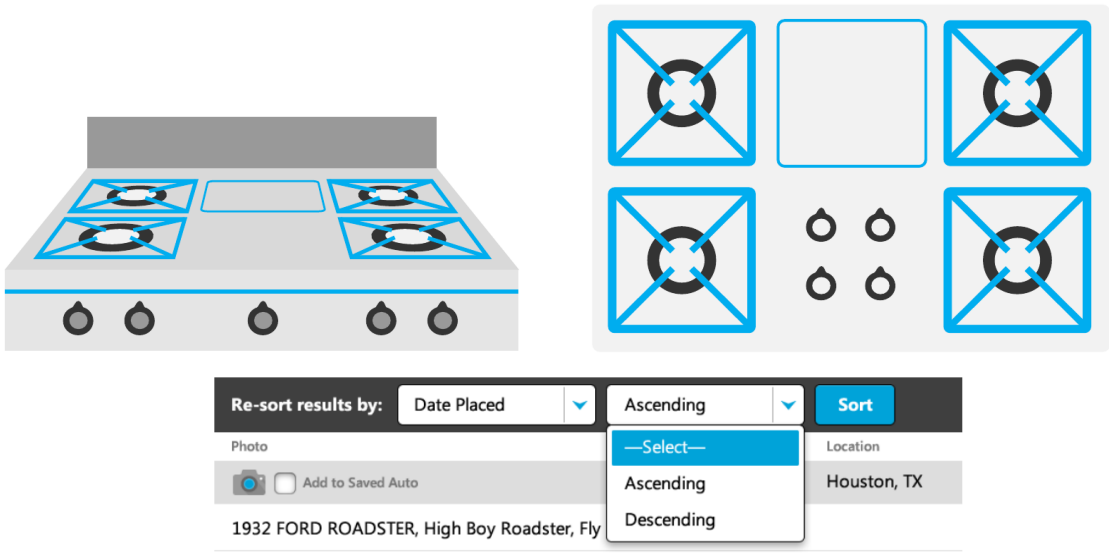


(Cooper et al., 2014)

Mapping

- *Physical arrangement* of controls should match *arrangement of function*
- Best mapping is direct, but natural mappings do not have to be direct
  - Light switches
    - If the switches are arranged in the same fashion as the lights, it is much easier to learn which switch controls which light
  - Stove burners
    - Most stoves have four plates in a square and four controls in a row
  - Car turn signals
    - Up and down instead of left and right, but synchronous to turning wheel
  - DJ audio mixer
    - between turntable
- What is a direct mapping anyway?
  - Rudder of a boat *vs.* steering wheel of a car

Mapping Example



(Cooper et al., 2014)

Constraints I

- Graphical screen layout relies greatly on conventional interpretations of the symbols and placement
- Different types of constraints:
  - *Physical* constraints are closely related to real affordances
    - it is not possible to move the cursor outside the screen
    - Restricting the cursor to exist only in screen locations where its position is meaningful
  - *Logical* constraints use reasoning to determine the alternatives
    - If we ask the user to click on five locations and only four are immediately visible, the person knows, logically, that there is one location off the screen
    - It is how the user knows to scroll down and see the rest of the page
    - Logical constraints go hand-in-hand with a good conceptual model.

Constraints II

- Different types of constraints (contd):
  - *Cultural* constraints are conventions shared by a cultural group
    - That the graphic on the right-hand side of a display is a "scroll bar" and that one should move the cursor to it, hold down a mouse button, and "drag" it downward in order to see objects located below the current visible set is a cultural, learned convention
    - The choice of action is arbitrary: there is nothing inherent in the devices or design that requires the system to act in this way
    - "Arbitrary" does not mean that any random depiction would do equally well: the current choice is an intelligent fit to human cognition, but there are alternative methods that work equally well.

Assignment 10.1: Affordances & Signifiers

- Explore the concepts of Affordances & Signifiers
  - In "real world"
  - In software you regularly use
- Form groups of 4-6 people
  - Individually search for examples
  - Discuss your examples in the group
  - Discuss the concepts within the context of the image on the next slide
- Present your findings in the course

Assignment 10.1: Affordances & Signifiers

Assignment 10.2: Discoverability & Mapping

- Explore the concepts of Discoverability & Mapping
  - In “real world”
  - In software you regularly use
- Form groups of 4-6 people
  - Individually search for examples
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Assignment 10.2: Discoverability & Mapping

(Norman, 2013)

4 Errors

Anticipating Errors

- Users will make errors
- It is important to take possible errors into account, when designing the system

- Usability guidelines
  - Nielsen: Usability Heuristics
    - Avoid errors
    - Constructive feedback
  - Shneiderman: Golden rules
    - Avoid errors
    - Easy undo
- There are different kind of errors
  - Knowing them makes it easier to recognize the problem

Modeling Human Error

- Description error
- Capture error
- Mode error

cc by-nc-sa freekz0r at flickr

Description Error

- Intended action is replaced by another action with many features in common
- The user intends to do one action, but accidentally substitutes the other
  - Pouring orange juice into your cereal
  - Putting the wrong lid on a bowl
  - Throwing shirt into waste paper instead of hamper
- *Mitigation:* Avoid actions with very similar descriptions
  - Long rows of identical switches
  - Adjacent menu items that look similar

Description Error Mitigation

☞ Cockpit Chronicles: Why I've fallen for the MD-80
7:09-7:55

Capture Error

- A sequence of actions is replaced by another sequence that starts the same way
- The user starts executing one sequence of actions, but then veers off into another (often more familiar) sequence
  - Leave your house and find yourself walking to school instead of where you meant to go
  - Vi `:wq` command
- Picture for this: you have developed a mental groove from executing the same sequence of actions repeatedly, and this groove tends to capture other sequences that start the same way
- *Mitigation:* Avoid habitual action sequences with common prefixes

Mode Error

- Modes: states in which actions have different meanings
  - Vi's insert mode *vs.* command mode
  - Caps lock
  - Drawing palette
- Mode errors occur when the user tries to invoke an action that doesn't have the desired effect in the current mode
- *Mitigation:* Avoid modes ☺

Avoiding Mode Errors

- Eliminate modes
- Visibility of mode
  - much harder problem for mode status than it is for affordances
  - the user isn't actively looking for the mode, like they might actively look for a control
  - mode status indicators must be visible in the user's locus of attention → caps lock light does not work well
- Spring-loaded mode
  - the user has to do something active to stay in the alternate mode, essentially eliminating the chance that they'll forget what mode they're in
  - Shift key, drag-and-drop

Avoiding Mode Errors II

- Temporary modes
  - in many graphics programs, when you select a drawing object like a rectangle or line from the palette, that drawing mode is active only for one mouse gesture
  - afterwards, the mode automatically reverts to ordinary pointer selection
- Disjoint action sets in different modes
  - mode errors may still occur, when the user invokes an action in the wrong mode, but the action can simply be ignored

5 Metaphors

Metaphors

- Another way to address the model problem
- Advantage: borrowing a conceptual model the user already has experience with.
- Can convey a lot of knowledge about the interface model all at once
- Examples
  - Desktop
  - Trashcan
- Each of these metaphors carries along with it a lot of knowledge about the parts
  - purposes
  - interactions
- The user can draw on these to make guesses about how the interface will work.

Levels

- Metaphors can be used on different levels
  - A metaphor for how the system works (Activity design in Scenario-Based Development)
    - A discussion forum like a lecture or like the kitchen at a party
  - A metaphor for how information is displayed (Information Design)
    - Free space left on hard disk as a partially full bar
  - A metaphor for the interaction offers (Interaction Design)
    - Dragging a file into the waste paper basket

Dangers of Metaphors I

- Hard to find
  - Particularly with real-world objects
  - Basic rule for metaphors is: use it if you have one, but don't stretch for one if you don't
- Deceptive
  - Leading users to infer behavior that your interface doesn't provide
  - Looks like a book, but can I write in the margins?
- Constraining
  - Strict adherence to the desktop metaphor wouldn't scale, because documents would always be full-size like they are in the real world.

Dangers of Metaphors II

- Breaking the metaphor
  - Your interface is presumably more capable than the real-world object, so at some point you have to break the metaphor
  - Nobody would use a word processor if really behaved like a typewriter
  - Features like automatic word-wrapping break the typewriter metaphor, by creating a distinction between hard carriage returns and soft returns
- Use of a metaphor doesn't excuse bad communication of the model
  - If it looks like a book, but you don't show how to open it, the metaphor does not help

6 Tutorial

Helpdesk

☞ Medieval Helpdesk

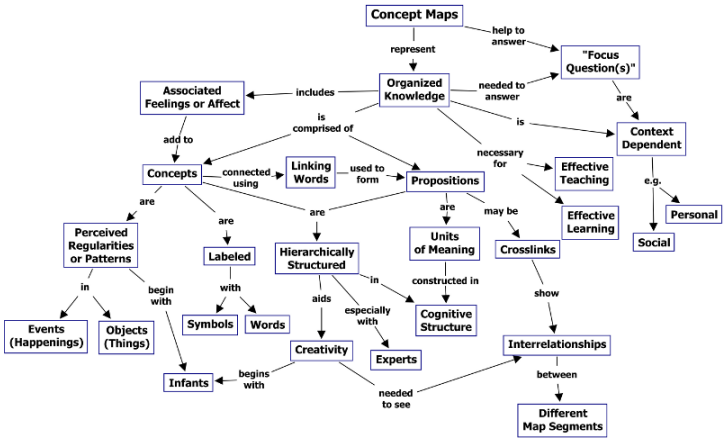
Assignment 10.3

- Bilden Sie Gruppen von 3-6 Personen
- Diskutieren Sie Stärken und Schwächen dieser Veranstaltung
- Leiten Sie daraus Anforderungen an eine Veranstaltung ab, die Inhalte der Mensch-Computer Interaktion praxisnah und zeitgemäß abdecken sollte
- Stellen Sie die Ergebnisse Ihrer Arbeit im Plenum vor
- Benutzen Sie dabei nach Wunsch verschiedene Präsentationstechniken

Assignment 10.4

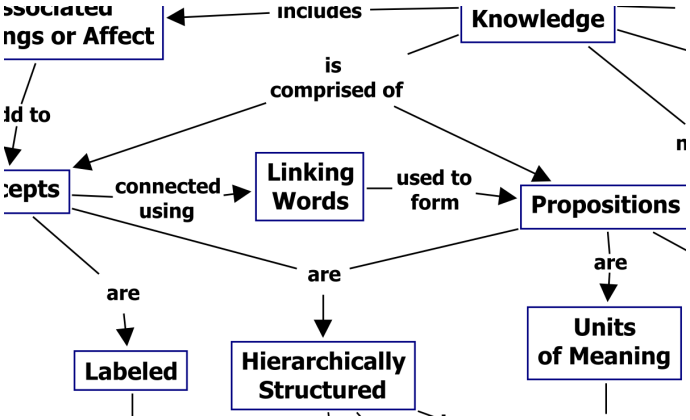
- Bilden Sie Gruppen von 3-6 Personen
- Modellieren Sie Ihr Verständnis der Inhalte dieser Vorlesung
- Benutzen Sie dafür z.B.:
  - Mindmaps
  - Semantic Nets
  - Concept Maps
- Stellen Sie Ihr Ergebnis vor
- Gelingt es uns, eine gemeinsame Modellierung zu finden?

Assignment 10.4



☞ Novak & Cañas: IHMC CmapTools

Assignment 10.4



☞ Novak & Cañas: IHMC CmapTools

Assignment 10.5

- Bilden Sie Gruppen von 3-6 Personen
- Überlegen Sie sich mögliche Fragen für eine Prüfung in Medieninformatik II
- Begründen Sie Ihre Auswahl an Fragen

References

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