



Universidade de Aveiro  
Departamento de Electrónica,  
Telecomunicações e Informática

# Usability Principles and Paradigms



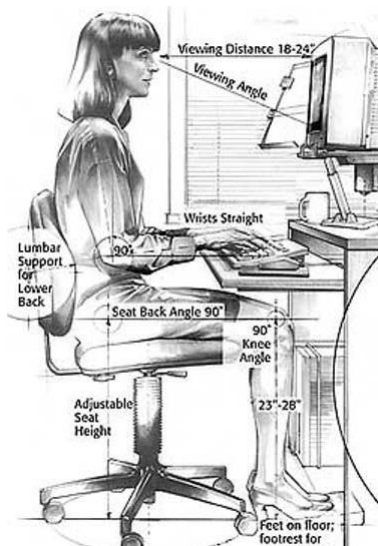
(Donald Norman, Design of everyday things)

- Introduction
- History
- Usability and standards
- Principles
- Paradigms

- During and after the World War II the following disciplines emerged:

**Ergonomics** – more focused on physical aspects      **Human factors** – also cognitive aspects

*Factores Humanos*



Ergonomics- The science of fitting workplace conditions and job demands to the capabilities of the working population

<https://www.cdc.gov/niosh/topics/ergonomics/ergoprimer/default.html>

# Ergonomics and Human Factors



- Interaction emerged as new independent field within Computing in the 80s, mainly due to:
  - Lower price of technology
  - Technology migration
  - Need to increase users' productivity

**Man-Machine Interaction**



**Human-Computer Interaction**

- It expanded rapidly
- It is currently an interdisciplinary field
- Human-Centered Computing is an ACM scientific area within Computing (also at the University of Aveiro)

# Interactive systems design

- Interactive systems include a “part” which we don’t control:

The user, who:

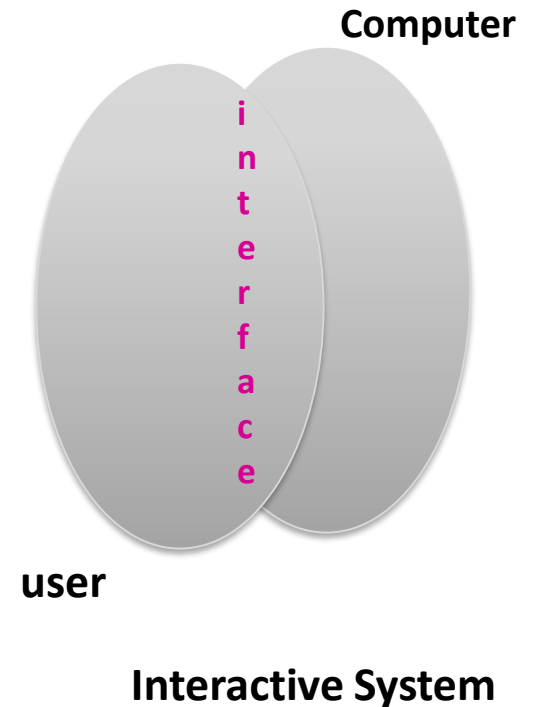
- is very complex
- not well known
- we cannot control



(and users may be very different)

This makes design difficult

- User Interface (UI) is the means by which the user and a computer system interact
- To the user **“the interface is the system”**
- The user interface design involves a considerable effort



# Interactive system design – Human-Centered design


- Involves knowing:

**Methods** • Human Centered Design *→ forte do conhecimento dos utilizadores*

**Usability principles** (independent from technology)

**Usability paradigms** (more technology dependent)

*exemplos ...*

- We must know the success examples (usability paradigms) *→ Paradigmas são os exemplos de sucesso!!*
- Understand why they work (usability principles) *→ Os princípios mostram o porque?*
- Use the adequate methodology (user-centered approach) and methods *Metodologia*
- And **test**, re-design,   
test, redesign

...

**until we attain the usability goals**

- **Usability** is, according to **ISO 9241-11:**

Temos de ter a noção  
dos standards e  
que têm efeito



“the extent to which a product can be used by **specified users** to achieve specified goals with **effectiveness, efficiency and satisfaction** in a **specified context of use**”

Eficácia + Eficiência + Satisfação

- Effectiveness + efficiency -> **ease of use**  
→ Depend on context of use ! //
- **Satisfaction** is also very important



Standards evolve:

*Institution Organization  
for standardization*

- ISO 9241-11's three factors of usability have become five by **ISO 25010's quality in use** factors:
- Effectiveness
- Efficiency *→ Vamos acrescentando ...*
- Satisfaction
- Freedom from risk
- Context coverage

→ Mais abrangente que as Usabilidades  
→ Questões emocionais...

- **User Experience (UX)** is:

“ person's perceptions and responses resulting from the use and/or anticipated use of a product, system or service”

Percepções e respostas

- UX includes all the users' emotions, preferences, perceptions, physical and psychological responses, ... that occur before, during and after use

▽

- UX is broader than usability, it includes other aspects...

↳ Vai para além da usabilidade

MAIOR que a Usabilidade

- Usability criteria can be used to assess aspects of user experience.

<https://www.iso.org/obp/ui/#iso:std:iso:9241:-210:ed-1:v1:en>

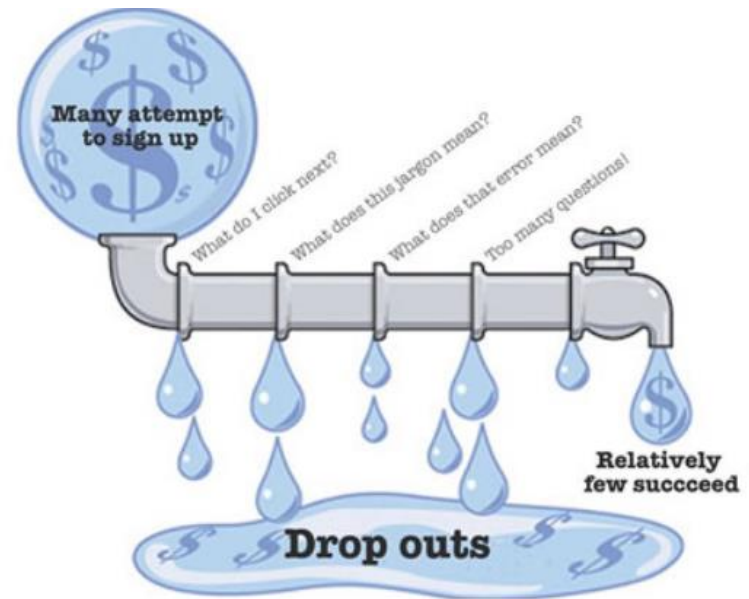
# Usability

- Is directly related to the system capacity to allow users **attaining their goals through its usage**
- Fundamental aspects:
  - **easy to use** (fast and with few errors) (efficiency, efficacy-> performance)
  - **satisfaction**

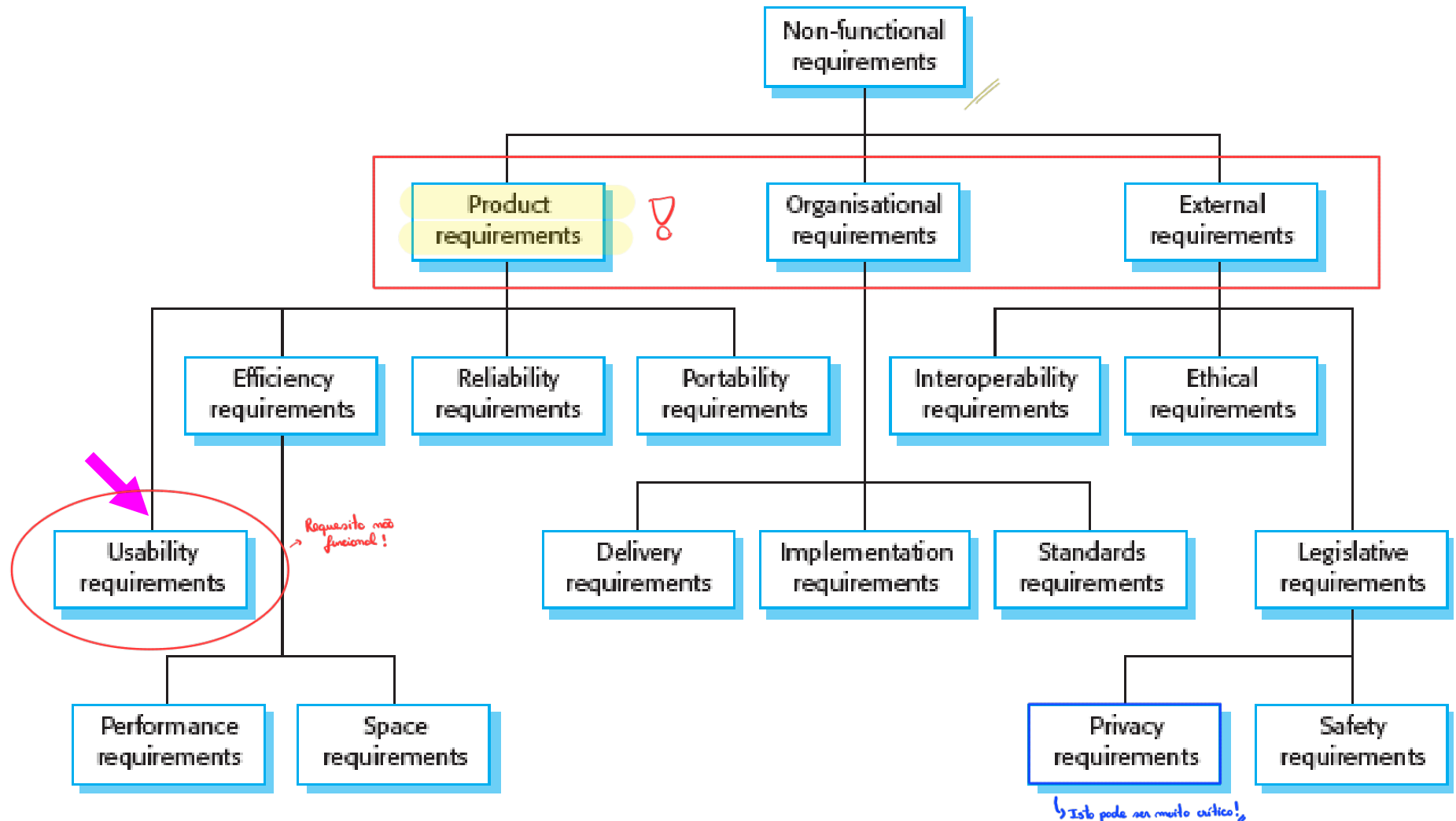
Is defined in a **context of use**: is a system property of allowing specific users to perform specific tasks efficiently with efficacy and satisfaction

- Easy to learn and remember (learnability, memorability) is a related aspect

- Main usability benefits:
  - Higher user performance and satisfaction
  - Lower development costs
  - Lower support costs ...
- **Higher profits for everyone!**



# Usability is a non-functional requirement





- ISO 13407 -> ISO 9241-210 (2010) addresses:
- ... Four Principles of **Human-Centered Design**: *→ regulamentar metodologias de desenvolvimento*
  - active involvement of users ~
  - appropriate allocation of function to system and to user
  - iteration of design solutions
  - multi-disciplinary design
- ... and **Four Human-Centered Design Activities**:
  - understand and specify the context of use
  - specify user and organizational requirements
  - produce more than one candidate design solution
  - evaluate designs against requirements



- **ISO 9241-112:2017**
- **Ergonomics of human-system interaction — Part 112:**
- **Principles for the presentation of information**
- ... establishes ergonomic design principles for interactive systems related to the software-controlled presentation of information by user interfaces.
- It applies to the three main modalities  
visual, auditory, tactile/haptic
- These principles apply to the perception and understanding of presented information
- are applicable in analysis, design, and evaluation of interactive systems
- ...

<https://www.iso.org/standard/64840.html>

# Paradigms

=> Bons exemplos de formas de utilizar a tecnologia por utilizadores!,,

- Examples of creative insight that enhanced interaction along the history of computing
- Inspirations for a conceptual model
- General approach adopted by a community for carrying out research
  - Shared assumptions, concepts, values, and practices
  - For example, desktop, ubiquitous computing, in the wild



# Some usability paradigms (along the history of computing)

*Alon Kay - "The best way to predict the future is to invent it"  
( premio Turing  
800)*

*Examples...*



(VDUs)

**Video Display Unites (VDUs) (1950s)**

**Time sharing (1960s)**

**WIMP (Windows, Icons, Menus, Pointers) (1980s)**

**Direct manipulation (1980s)**

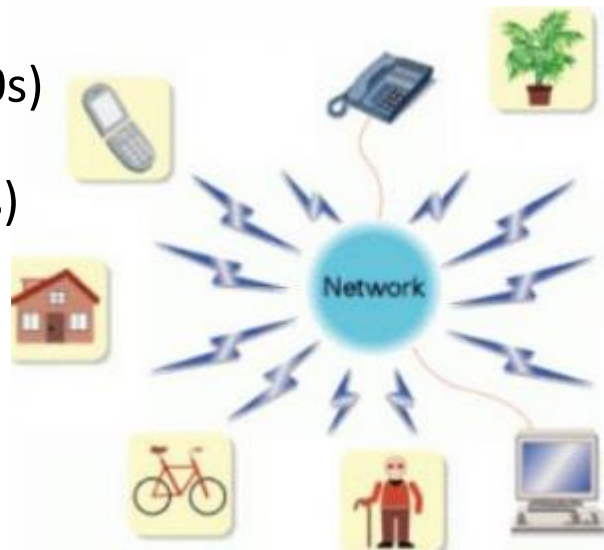
**WWW (1990s)**

**Ubiquitous computing (1990s)**

**Wearable Computing (1990s)**



(WIMP)



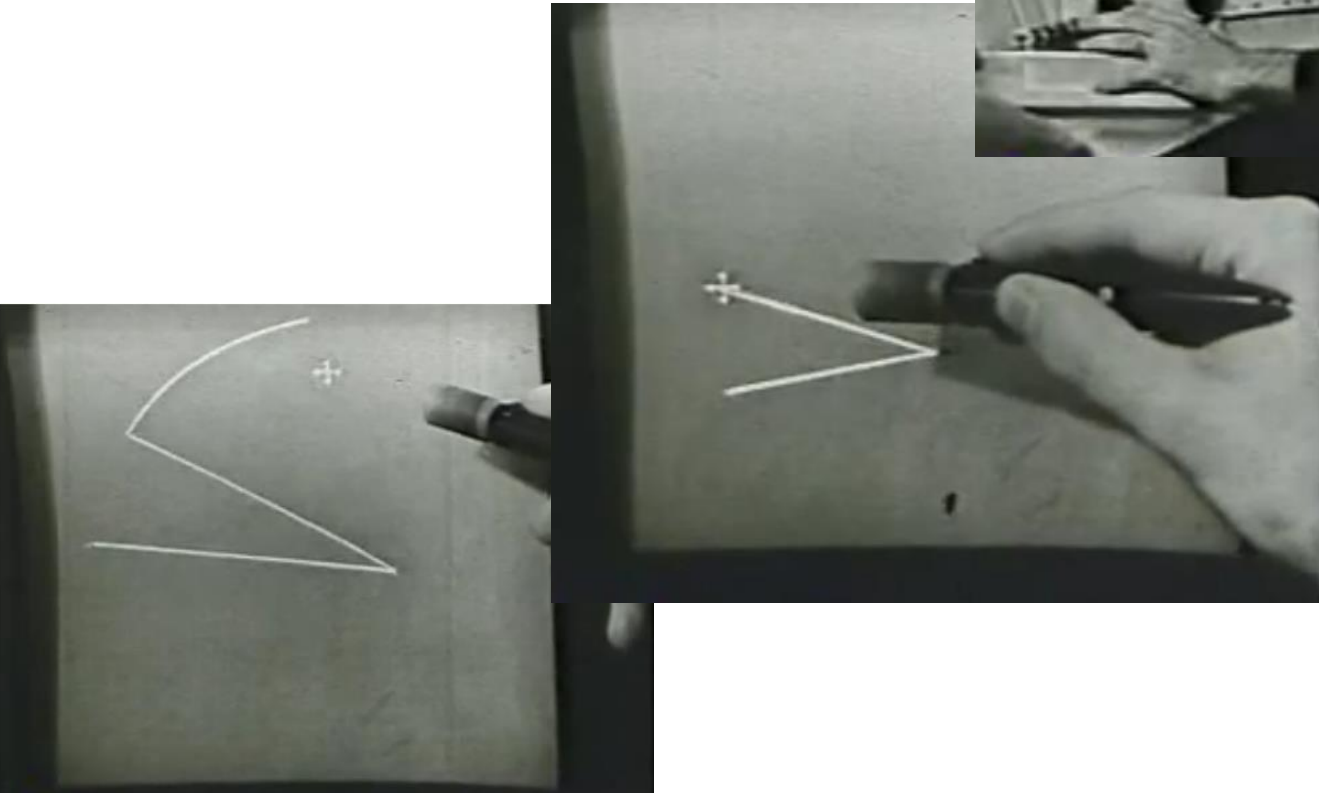
(anytime, anywhere...)

(networking everything ...)

# Sketchpad (Ivan Sutherland, 1963)

*Premio Turing*

→ Inventor dos primeiros AR



## Alto and Macintosh



^

Apple Macintosh 512KB, 1984

< Xerox PARC, 1973

"Compute anywhere and everywhere"

## Ubiquitous computing (Ubicomp)

↑ dentro da nossa vida...

Mark Weiser, "The Computer for the 21st Century", Scientific American, Sept 1991, pp. 94-104

<https://www.ics.uci.edu/~corps/phaseii/Weiser-Computer21stCentury-SciAm.pdf>

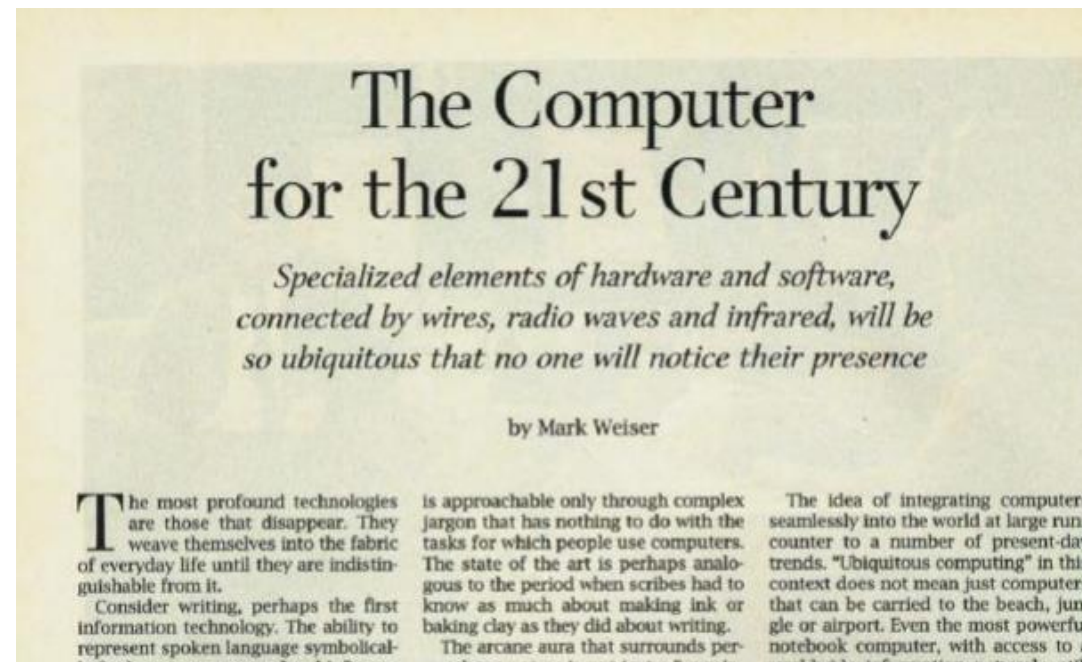
<https://dl.acm.org/doi/10.1145/329124.329126>

- Computing everywhere and anywhere

- Related concepts:

- Pervasive computing
- Ambient intelligence
- Cyber-physical computing
- Internet of things

- Haptic computing ⇒ proporcionar uma experiência diferente  
Força / Tato



- Ubiquitous computing involves:
  - small, inexpensive, robust networked processing devices
  - distributed at all scales throughout everyday life
- Examples:
  - refrigerators "aware" of their suitably tagged contents
  - domestic control illumination and heating, continuously and imperceptibly considering the occupants
- Ubiquitous computing presents challenges across computer science:
  - in systems design and engineering, in systems modelling , in user interfaces

<https://www.youtube.com/watch?v=TrfflHzupTY>



# Wearable computing



Steve Mann's 'GlassEye™' (aka EyeTap)

“the study or practice of inventing, designing, building, or using miniature body-borne computational and sensory devices. Wearable computers may be worn under, over, or in clothing, or may also be themselves clothes, i.e. "Smart Clothing" (Mann, 1996a).

Other terms: "Body-Borne Computing" or "Bearable Computing"

<https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/wearable-computing>

## Usability principles (a possible list)

User compatibility

Task compatibility

Work-flow compatibility

Product compatibility

Feedback

Coherence

Familiarity

Simplicity

Flexibility

Control

Technology invisibility

Robustness

Error protection

## Usability goals:

Easy to learn and memorise

Easy to use

Satisfaction

Freedom from risk

# Principles should be used in interactive computing systems...

## More conventional ...





other devices ...



less conventional interactive computing systems...



and critical interactive computing systems...

Muito Importante ☺



- E.g. medical devices:

<https://criticalsoftware.com/multimedia/critical/de/KNrWVSj87-UxD-Pocket-Guide.pdf>

*From the cockpit displays in planes to the dashboard layouts in cars, design can literally be a matter of life and death.*

⇒ Muito Crítico!!

- or avionics:

<https://rightware.com/blog/modernizing-aircraft-cockpits-with-automotive-ui-design-knowhow/>



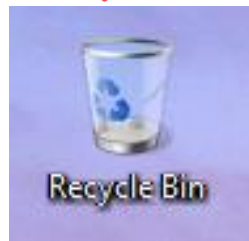
**Everything you  
wanted to know  
about UxD for  
critical systems**

...but were afraid to ask

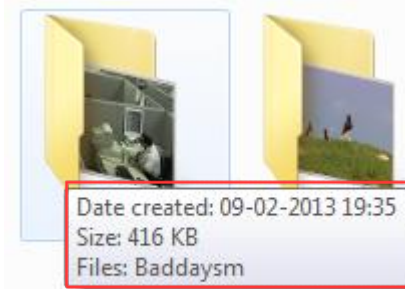
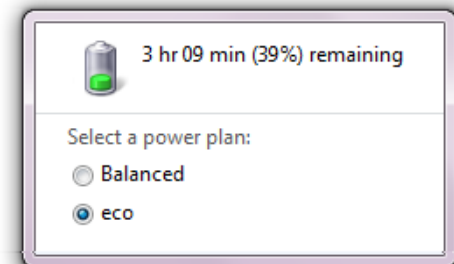
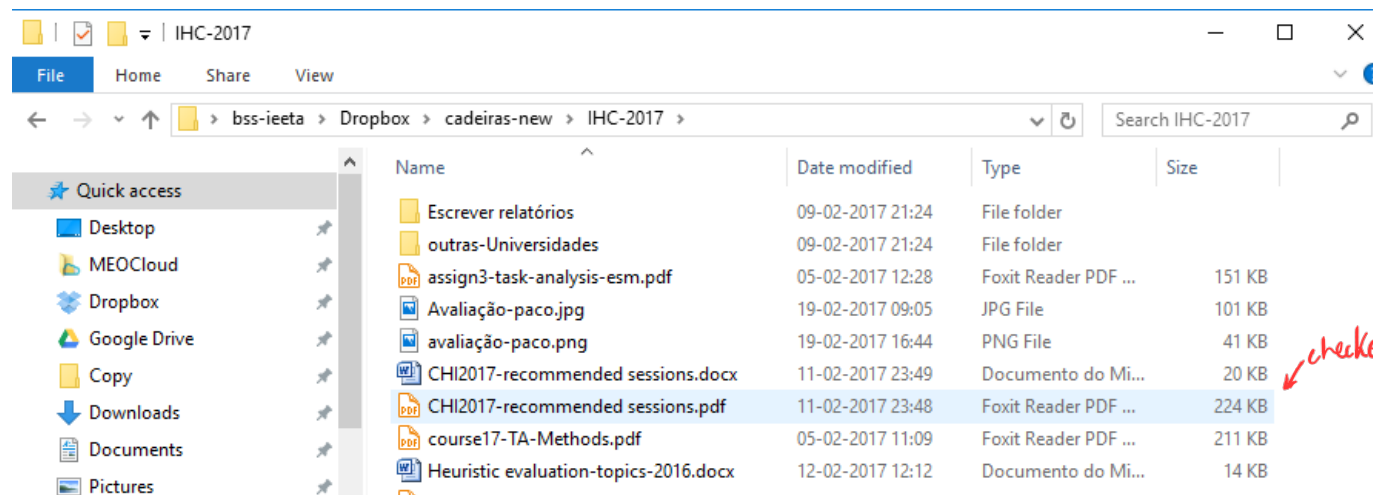
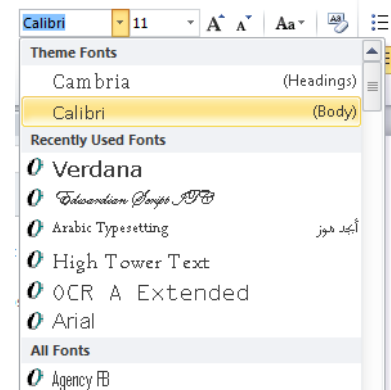
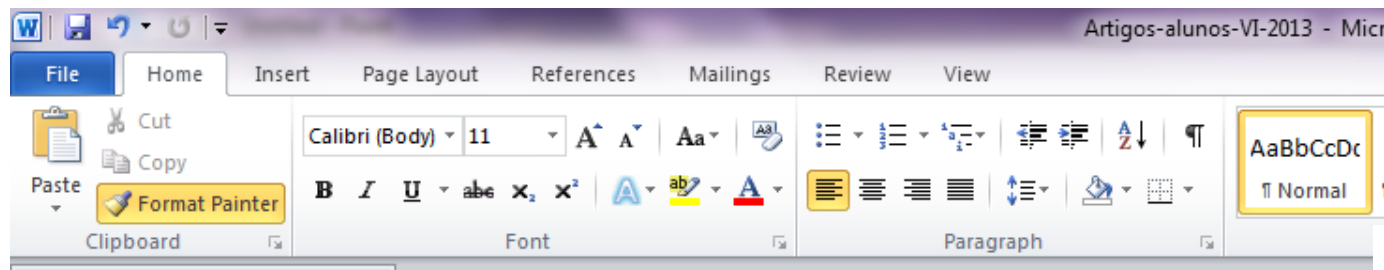
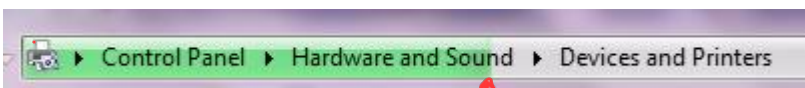
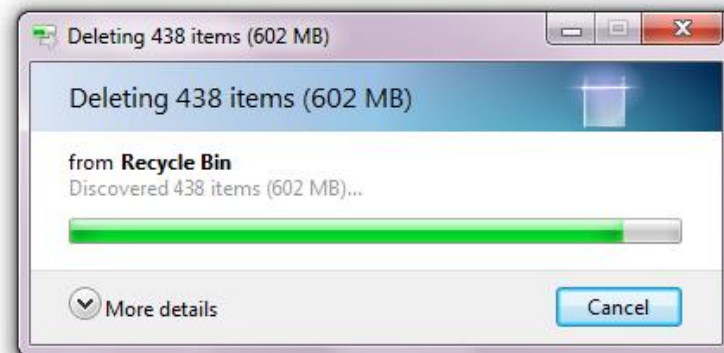




# Visibility of the system status, Feedback (in more conventional platforms)



Utilização @ Satizfeto!!

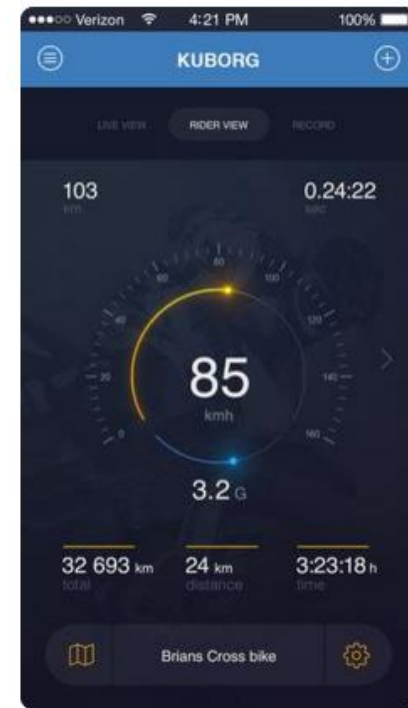
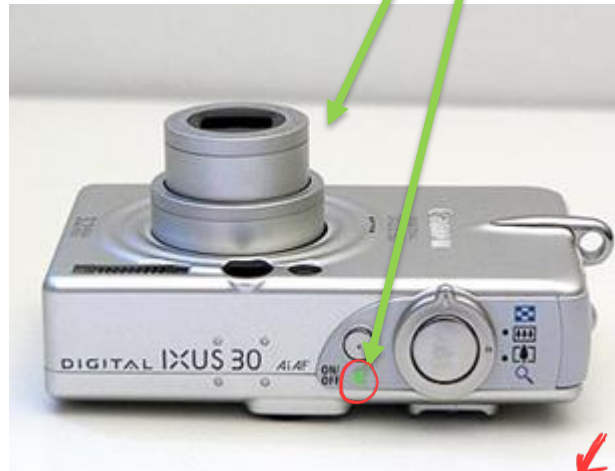


# Feedback

## Visibility of the system status



TV off



ON

TV on



# Feedback

## Visibility of the system status

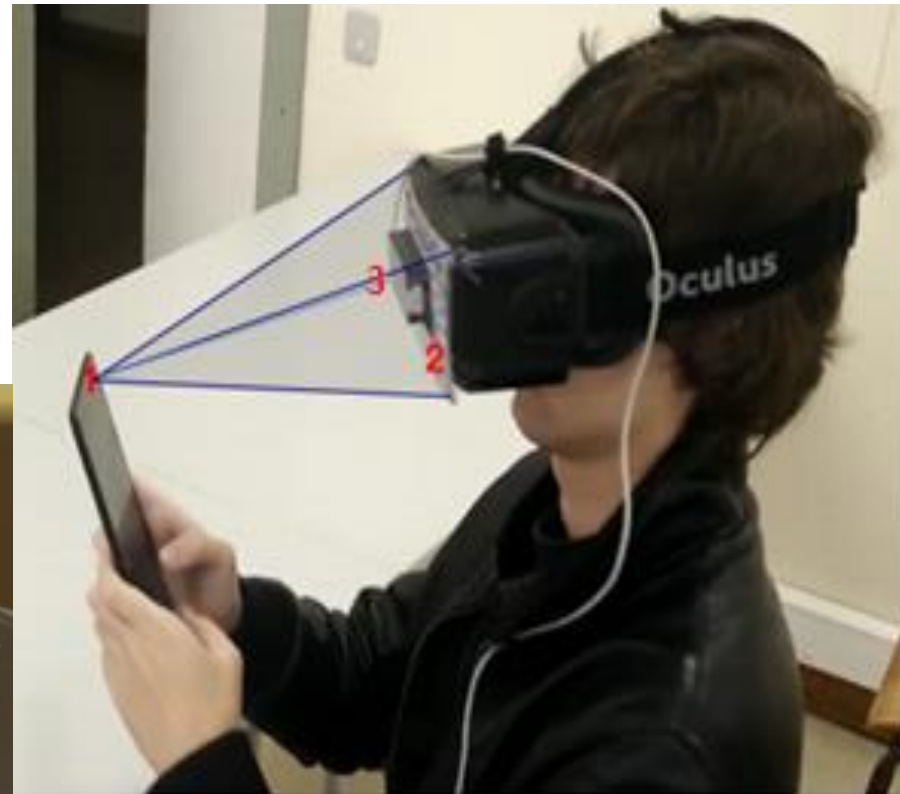
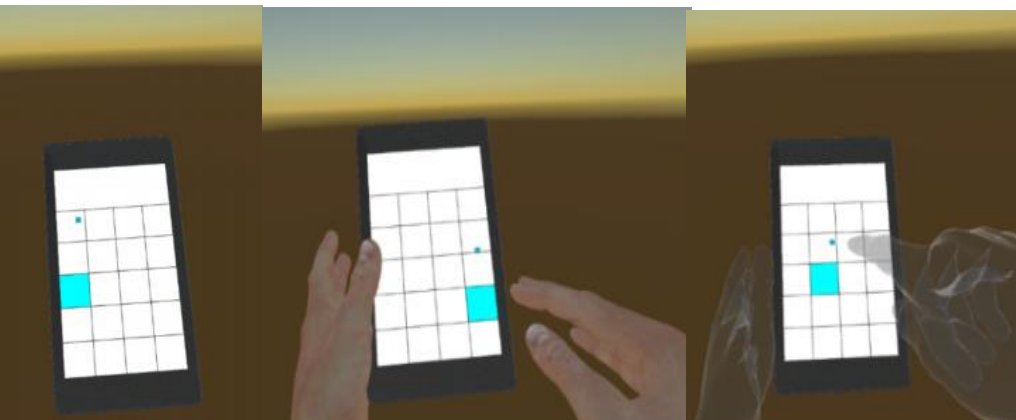
In a virtual reality system it is important to have:

- Feedback in tasks (navigation, manipulation, selection ...)
- Visibility concerning body position (avatar)
- ...

No avatar

Realistic avatar

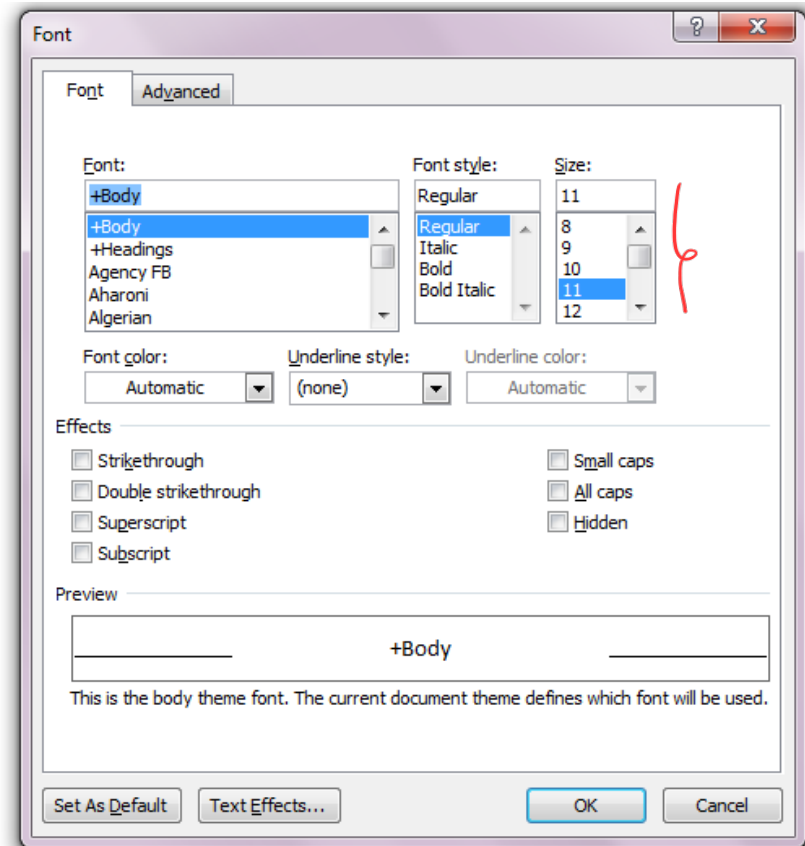
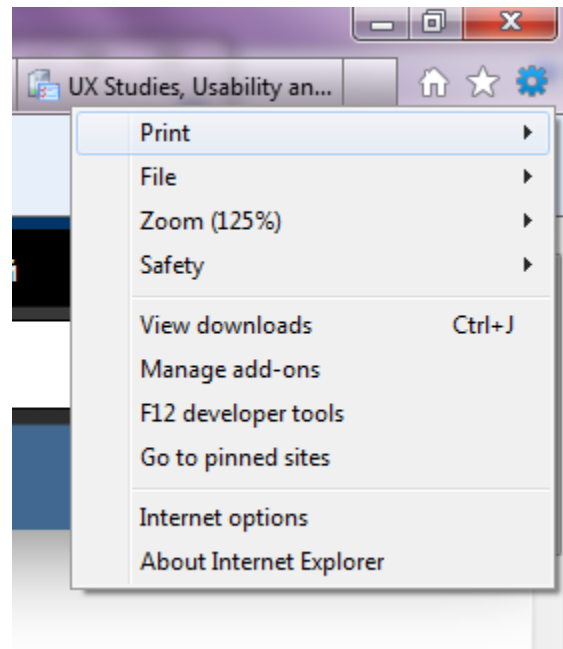
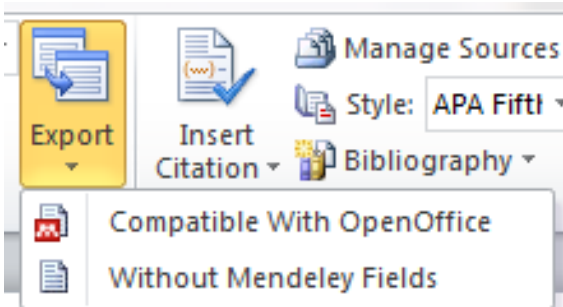
Translucent avatar



# Simplicity (hide complexity)

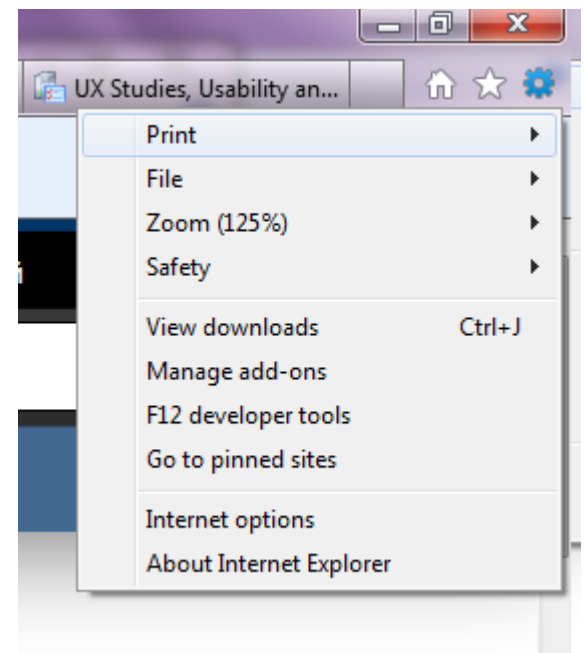
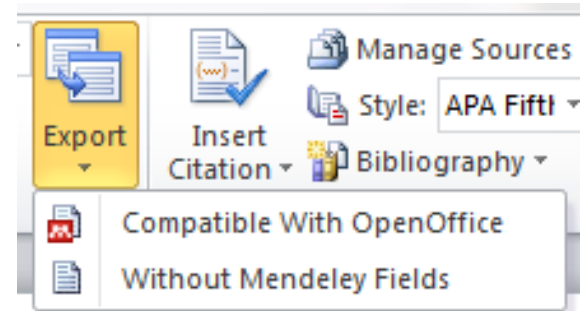
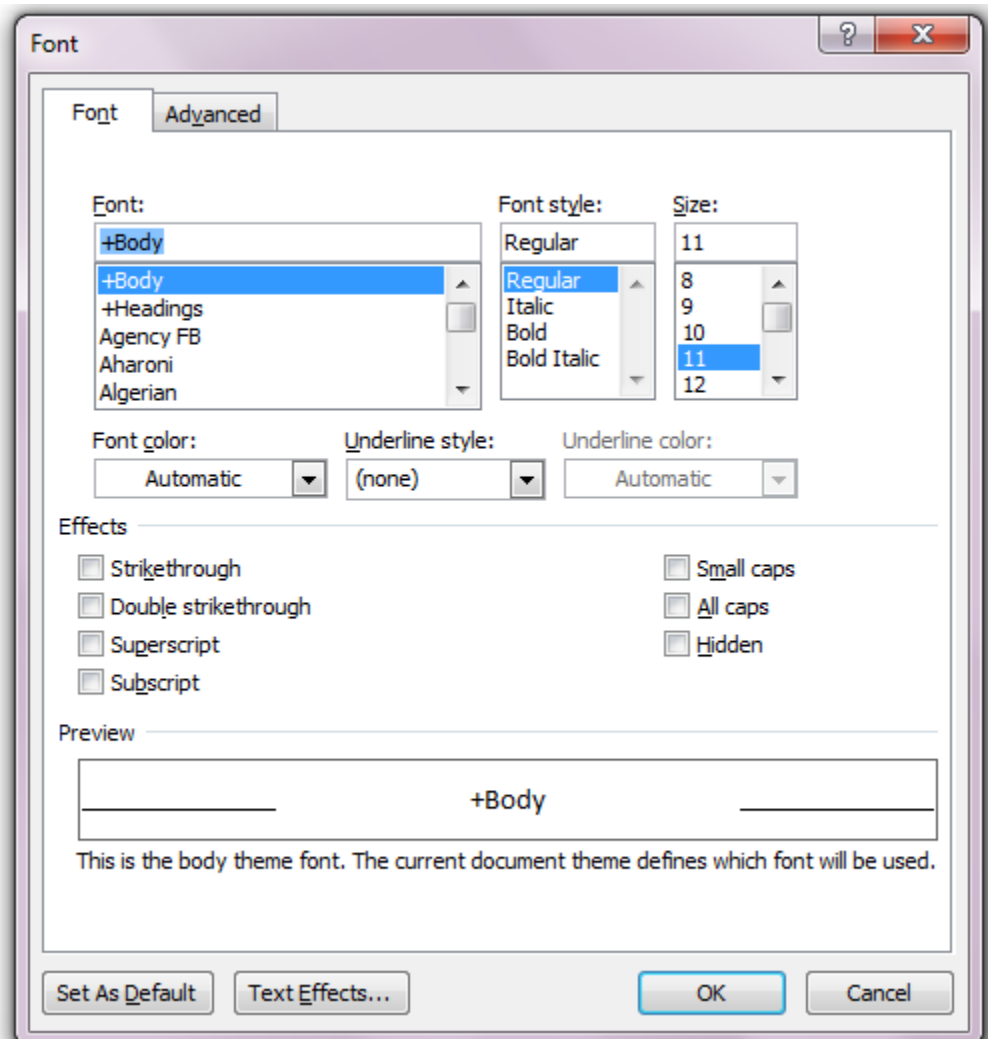
Avoid providing a large number of choices and try solving problems using the simplest solutions possible

*Quito importante  
(Por o 2º Projeto)*



# Simplicity

(defaults hide complexity)





# Familiarity

(profit from the user's experience)

→ Movimento fora do Mundo Digital...



User Documents



Private Folder  
Closed

Private Folder  
Open



Calendar



Contacts



Dashboard



Recycle Bin

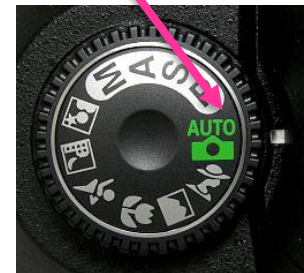


CutePDF Writer



# Familiarity

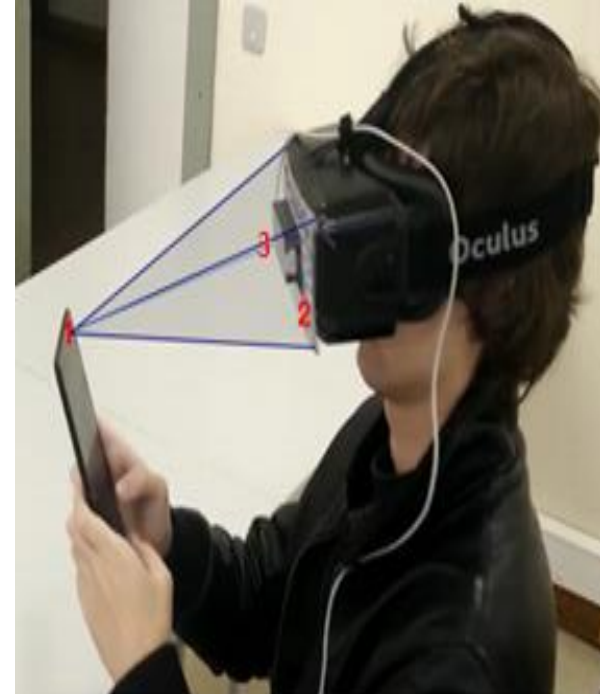
Familiar Icons



# Familiarity

In less conventional interactive systems it is important to have:

- Familiar gestures to perform tasks (navigation, manipulation, selection ...)



Selection method



Manipulation method

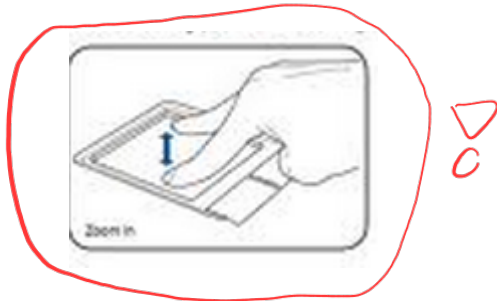
Bike navigation method





# Flexibility

(let the user choose)



## Taskbar and Start Menu

Customize the Start menu | Customize icons on the taskbar |  
Change the picture on the Start menu



## Ease of Access Center

Accommodate low vision | Use screen reader |  
Turn on easy access keys | Turn High Contrast on or off



## Folder Options

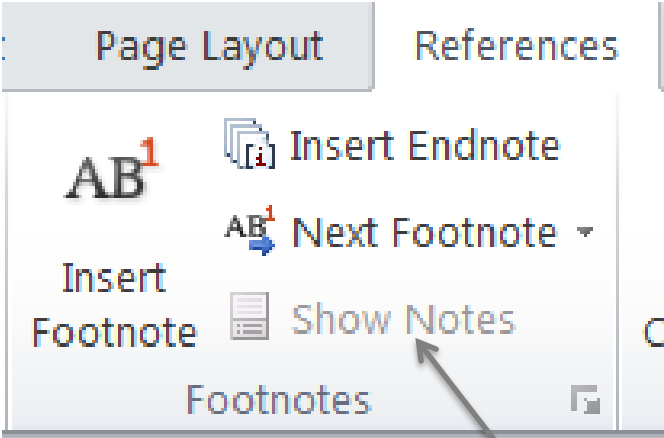
Specify single- or double-click to open |  
Show hidden files and folders



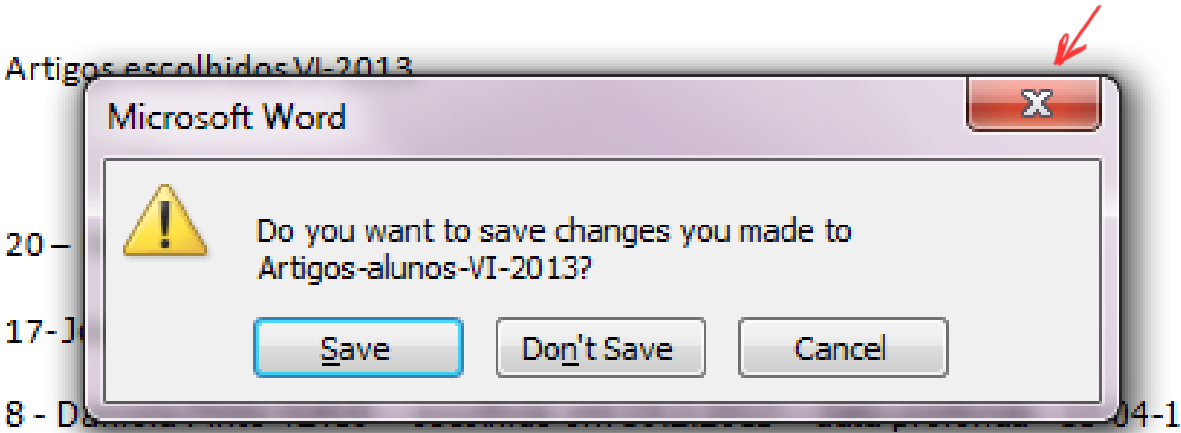
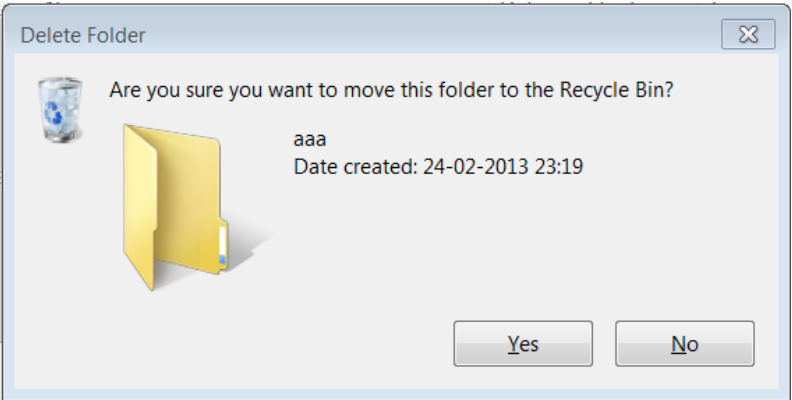
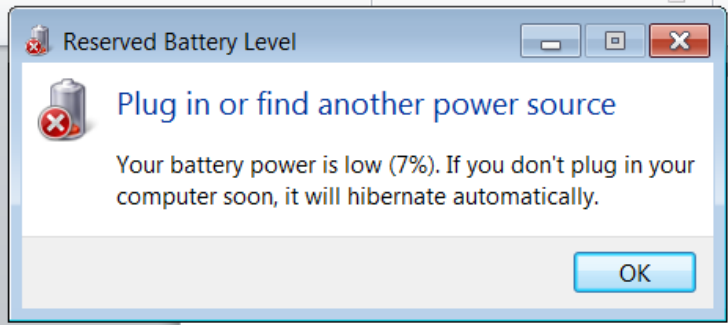
Let the user use different devices,  
Or select the volume ...



# Robustness and error prevention



Not accessible (in grey)



## Old usability problems @ DETI (already solved!)

Solved : lights control @ room 4.1.02



# Usability problems @ home



How does it open?



Wrong affordance!

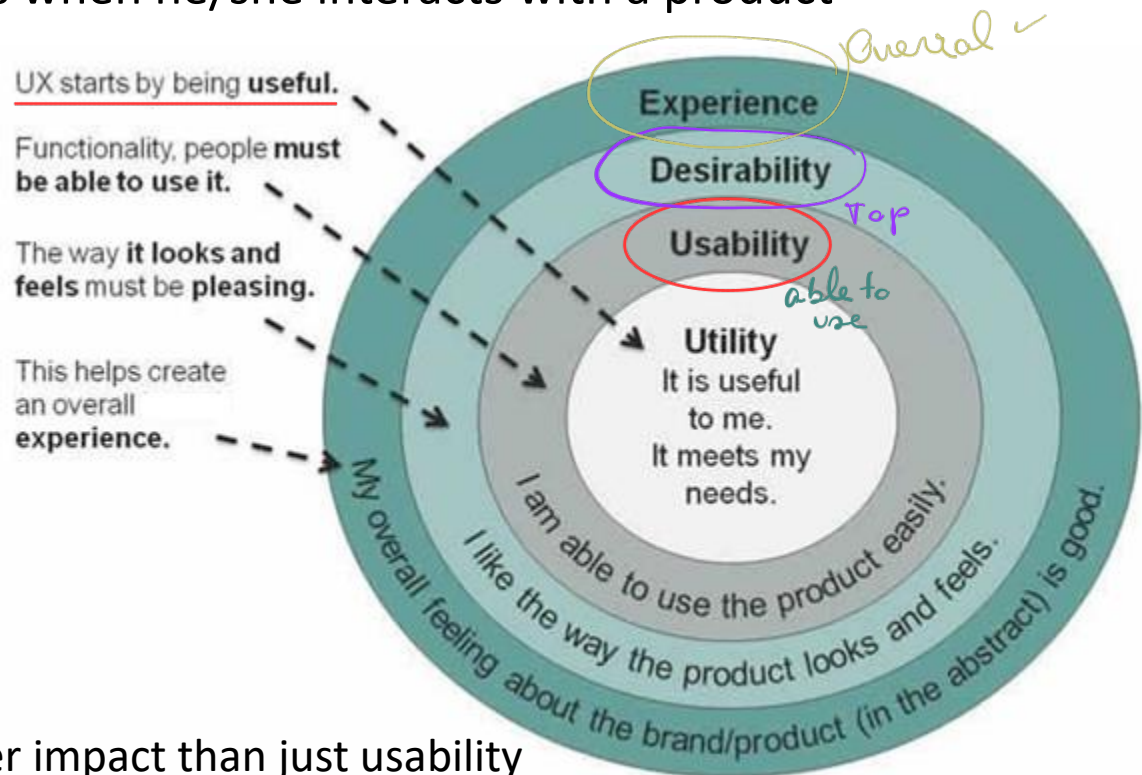


# User Experience (UX)



- The ease in which people interact with a system to achieve specific goals
- The experience a person has when he/she interacts with a product (encompasses all aspects)

Usability -> function



A positive UX has a much greater impact than just usability

<https://www.nngroup.com/articles/ux-research-cheat-sheet/>



- **Usability** is concerned with the “effectiveness, efficiency and satisfaction with which specified **users** achieve specified goals in particular environments”
- **User experience** is concerned with “all aspects of the user's experience when interacting with the product, service”
- User experience (UX) involves a person's:
  - behaviors,
  - attitudes,
  - and emotions about using a particular product, system or service
- It includes the practical, experiential, affective, meaningful and valuable aspects of human-computer interaction and product ownership
- and also a person's perceptions of system aspects such as utility, ease of use and efficiency
- may be considered subjective and is dynamic as it is constantly modified over time

## Main bibliography

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- Dix, A., J. Finley, G. Abowd, B. Russell, *Human Computer Interaction*, 3rd ed., Prentice Hall, 2004
- Shneiderman, B., Plaisant, C., Cohen, M., and Jacobs, S., *Designing the User Interface: Strategies for Effective Human-Computer Interaction* , 5th ed., Addison-Wesley, 2009
- The Encyclopedia of Human Computer Interaction, 2<sup>nd</sup> ed., Interaction Design Foundation. <https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed>