

Augmented & Virtual Reality

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Industrie et robotique – Santé Biotech
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SUMMARY

- 1. Human-Machine Interface**
 - 1. Digital revolution**
 - 2. Ergonomics**
 - 3. Evaluation**
- 2. Extended realities**
 - 1. Augmented reality**
 - 2. Virtual Reality**
 - 3. Mixed Reality**
- 3. 3D modeling & scanning**

01. Human-Machine Interface

- 01. Digital revolution
- 02. Ergonomics
- 03. Evaluation

Digital revolution

Dream of flying like the birds

Abbas ibn Firnas

- Born 810
- Andalusian Scientist and inventor



Statue of Ibn Firnas
Baghdad International Airport



Stained glass window showing
Eilmer, installed in Malmesbury
Abbey in 1920

Eilmer of Malmesbury

- Born about 984
- English Benedictine monk

Jet MAN

- December 2006 by Yves Rossy



[Jetman takeoff](#)

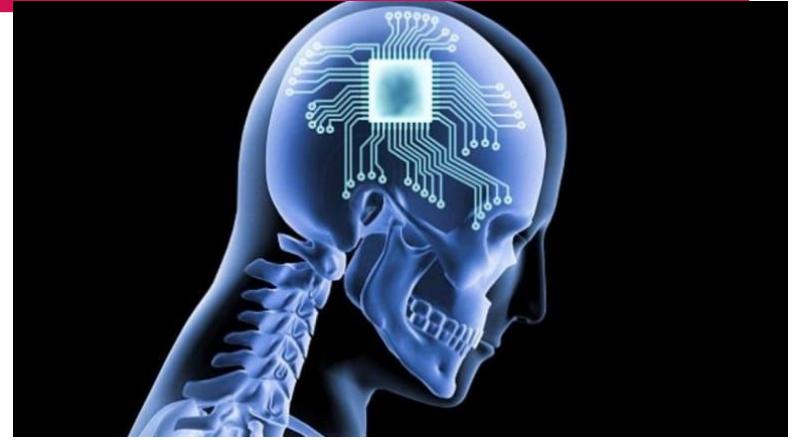


[Jetman & Airbus A380](#)

Augmented mind : Directly connect machine to mind

- Neuralink

- An American neurotechnology company founded by **Elon Musk**
- Developing implantable brain-machine interfaces (BMIs).



- CRTL Lab :

- A start-up acquired by facebook **SEP 24 2019**
- The deal was between \$500 million and \$1 billion
- Controlling a Machine with Your Intentions
- <https://www.youtube.com/watch?v=V7B3Z28LHB8>



Augmented body : Dream of becoming stronger



Giant exoskeleton!

Augmented body : Dream of overcoming disability

- **Mind-controlled exoskeleton (Imperial College London)**

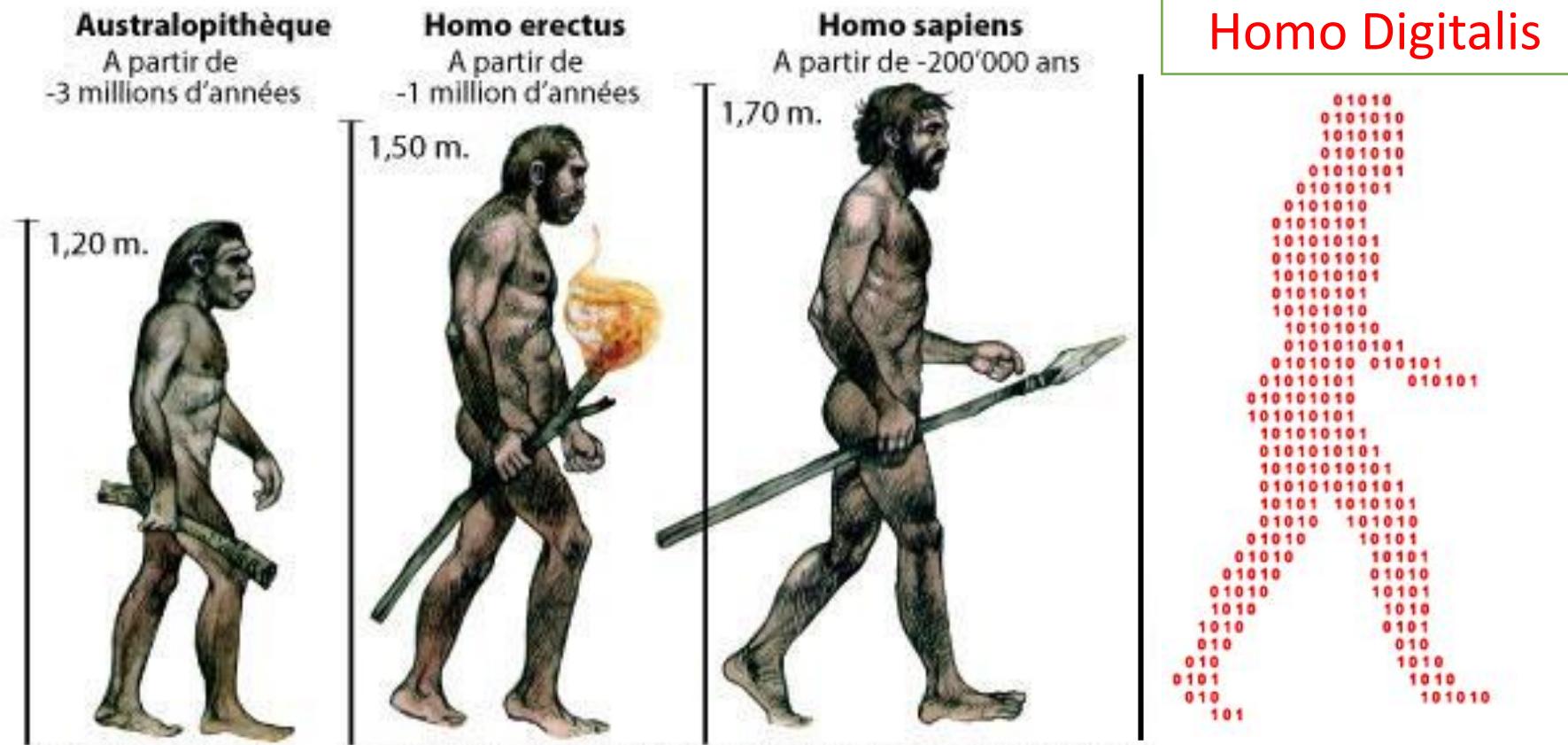
- October 3rd 2019
- Enhance physical power of men
- helped a man with paralysis walk again
- https://www.youtube.com/watch?v=1GyJBBB8O_M

- Suit X Bionic Exoskeletons

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



Towards Homo Digitalis ...!?



Digital revolution

- Digitalization
 - Digital revolution, the most important phenomenon of our time.
 - In most everyday objects, and in their design or manufacture

Sycamore
(October 2019)

Quantum processor
(53 qubits)

Quantum Supremacy
 10^9 x faster than summit supercomputer

Google's Artificial Intelligence division



Metaverse
(October 2021)

Parallel universe based on VR & AR

Meta



ENIAC (1945),
World's first computer
5,000 operations/second

University of Pensilvany



Sophia
(Avril 2015)
Most advanced humanoid robot,
Artificial Intelligence, facial expression,..

Hanson Robotics, Hong Kong



Frontier Supercomputer (June 2022)

Most powerful supercomputer
 $1.685 \times$ petaFlops

(petaflop = 10^{15} operation/sec)

Oak Ridge National Laboratory & U.S. Department of Energy

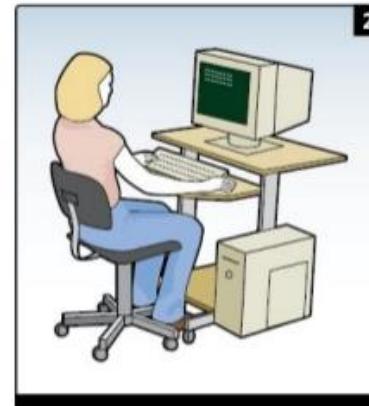
Eras of computing

1960: Mainframe Era



One computer for
many users

1980: Personal
Computer Era



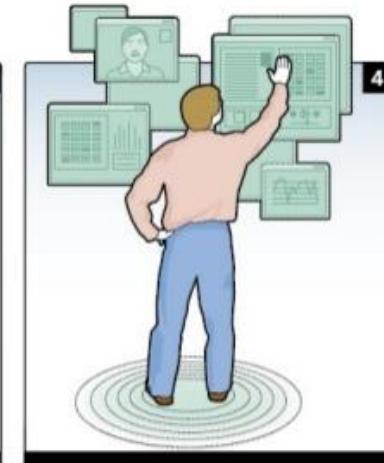
One computer for
each user

2000: Mobility Era



Many computers for
each user

2020+: Ubiquity Era



Thousands
computers for each
user

Source: Abigail Sellen, Yvonne Rogers, Richard Harper, Tom Rodden: *Reflecting human values in the digital age*. Commun. ACM 52(3): 58-66 (2009)

The breakthrough that ENIAC represents

- comparative table of calculation speeds

Moyens employés	Vitesses de multiplication de nombres de 10 chiffres	Temps de calcul d'une trajectoire d'une table de tir
Homme à la main, ou machine de Babbage	5 min	2,6 j
Homme avec calculateur de bureau	10 à 15 s	12 h
Harvard Mark I (électromécanique)	3 s	2 h
Model 5 (électromécanique)	2 s	40 min
Analyseur différentiel (analogique)	1 s	20 min
Harvard Mark II (électromécanique)	0,4 s	15 min
ENIAC (électronique)	0,001 s	3 s

Quantum computer... the digital grail

- David Deutsch (quantum computing specialist):
 - a topological quantum computer of +300 Qbits will be faster than a classical computer of the size of the observable universe.
- D-Wave 2X conventional quantum computer (1097 Qb)
 - Purchased by Google and Nasa in 2015
 - 100 million times faster than a conventional computer.
- In 2017 IBM
 - makes a quantum processor with 50 Qbits topology.
- In May 2018, Todd Holmdahl of Quantum Microsoft:
 - In 5 years we will have created a topological quantum computer

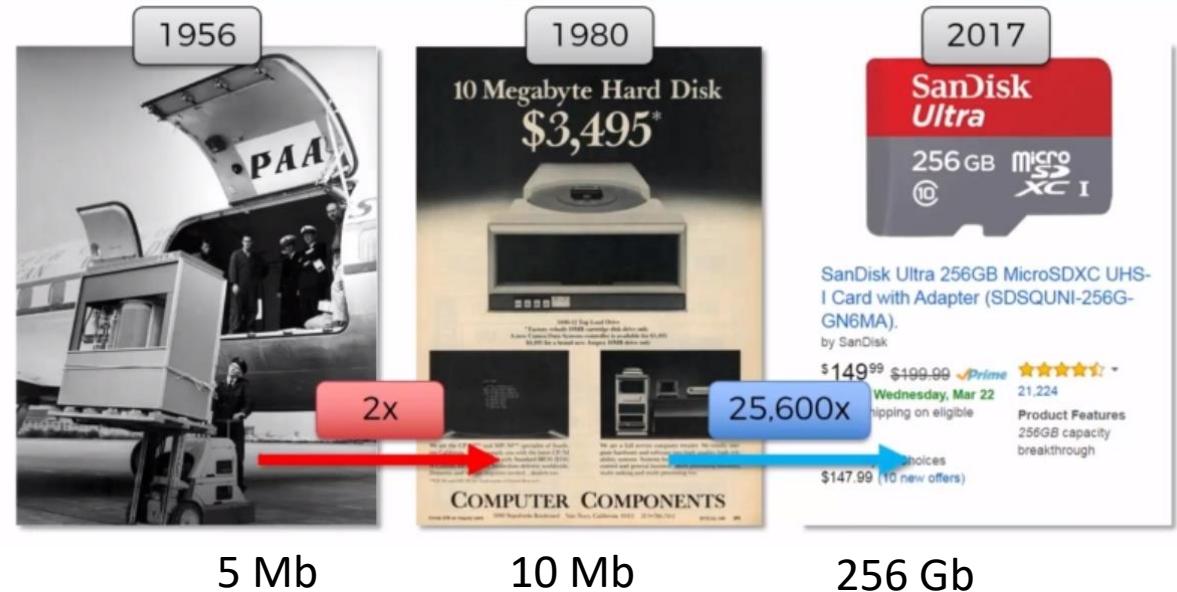
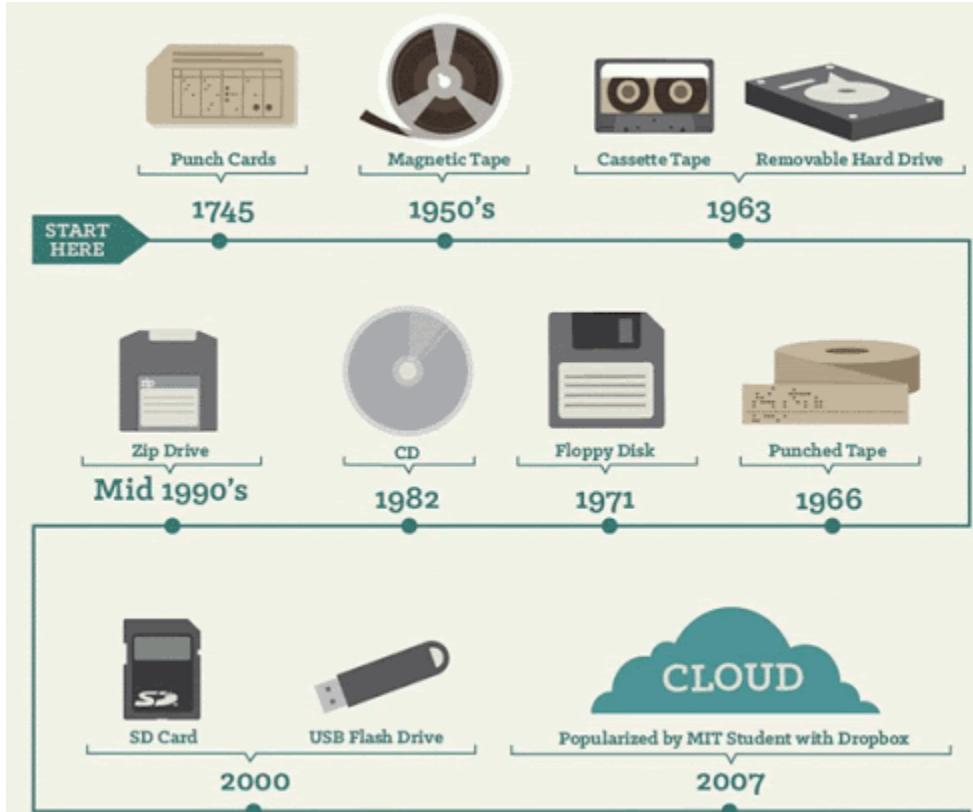


Quantum Processor... the supremacy

- Quantum Supremacy:
 - Computing speed that exceeds the computing capacity of supercomputers
- October 2019,
 - a publication in the journal Nature establishes the validity of a major step in quantum computing by google and NASA
(<https://www.nature.com/articles/s41586-019-1666-5>)
 - Google engineers, aided by NASA and Oak Ridge National Laboratory, claim to have succeeded in creating a processor capable of performing a calculation in 200 seconds when the most advanced computer today would take 10,000 years
 - IBM disputes the result...

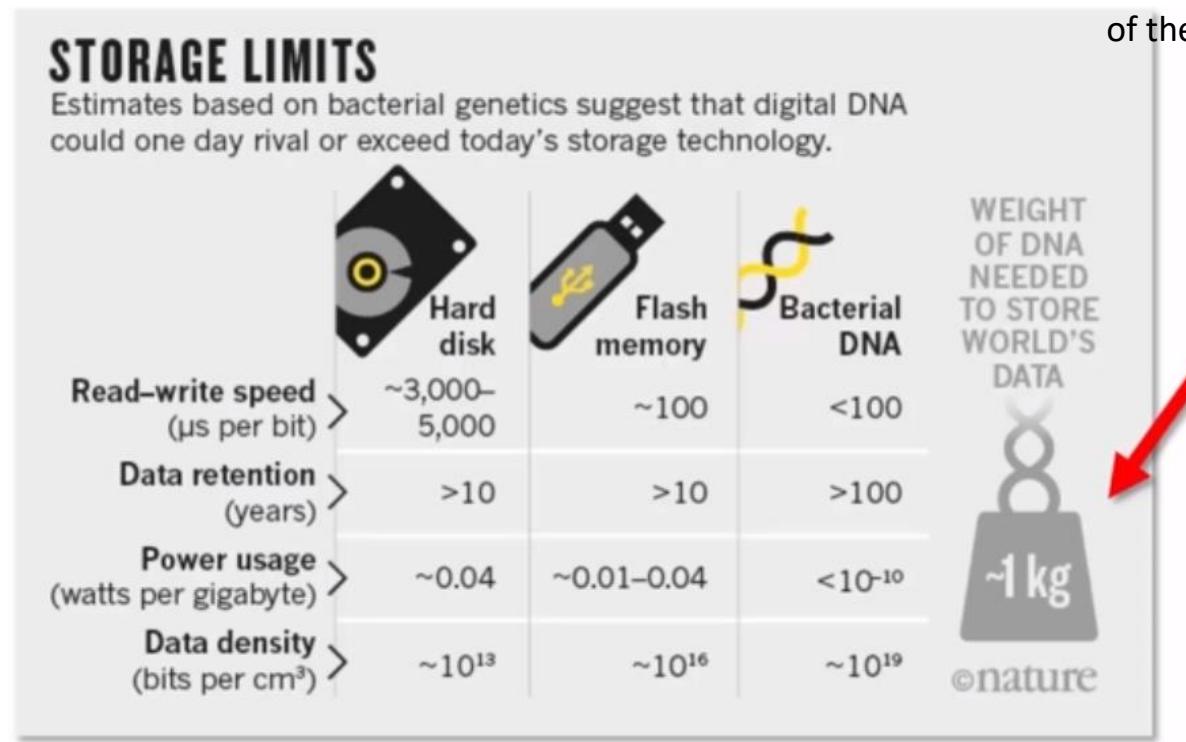


Evolution of technology is exponential



Evolution of technology is exponential

- DNA-based data storage

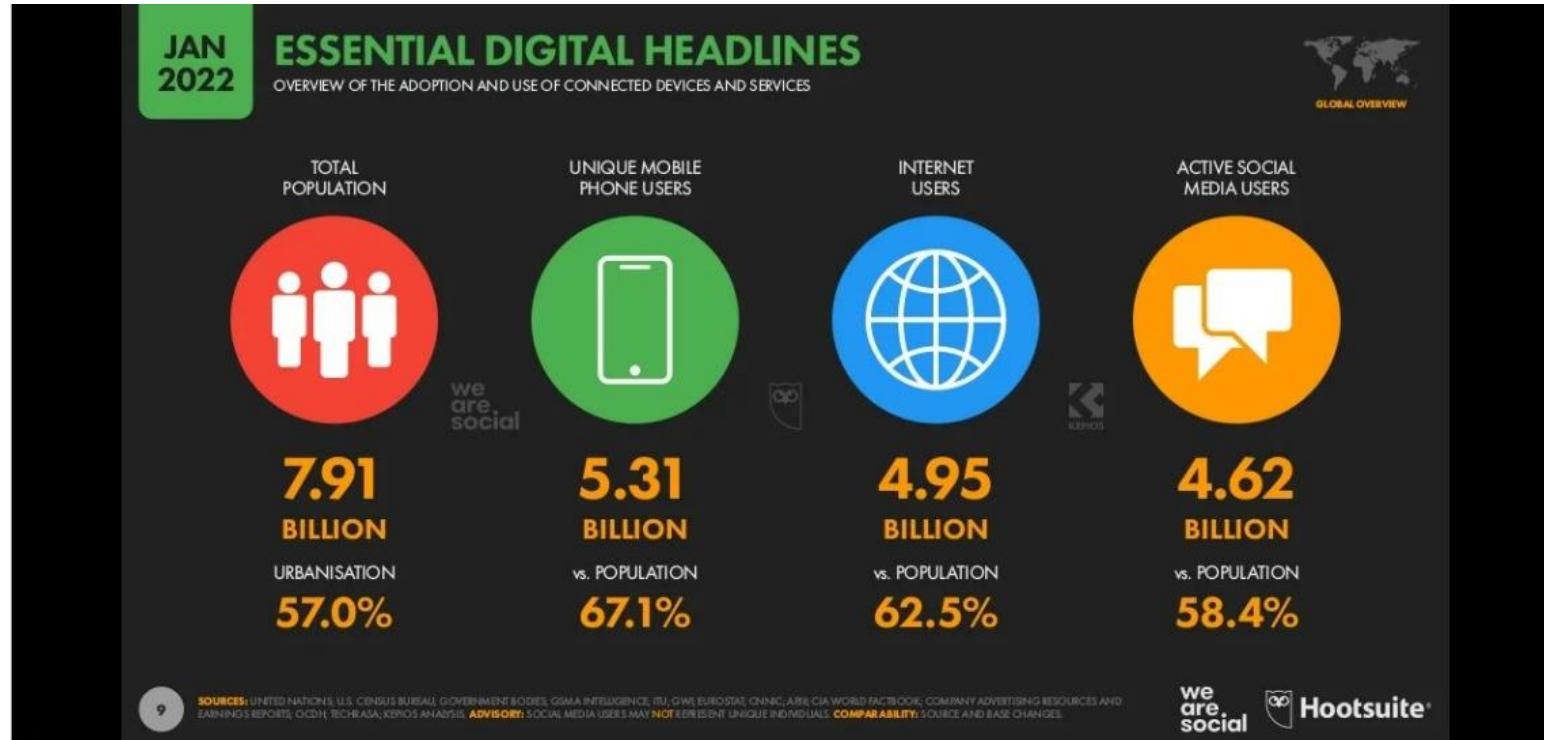


Escherichia coli bacteria can convert electrical pulses into bits of DNA stored in their genome

Source: nature.com

Digital usage in the world

- Out of 7.91 billion people in the world, there are :
 - 5.31 billion phone users (67%)
 - 4.95 billion Internet users (62%)
 - 4.62 billion active social network users (58%)



Mobile Internet usage

- 96% of the world's population uses a cell phone.



Computerization records

- In 2022, on YouTube
 - +2.2 billion users worldwide.
 - 25-35 age group is the majority of the audience.
 - The average time per visit : 30 mn 56 sec.
 - Most popular YouTube channel : 202 million subscribers.
 - 450 French YouTube channels have more than one million subscribers.
 - Most watched video on YouTube : +9.8 billion views.
 - 5 billion videos are watched on YouTube each day.
 - 500 Hours of Video Uploaded to YouTube Every Minute



Underestimation of computer progress

- "**I think there's a global market for something like five computers.**"
 - Thomas Watson, IBM president, 1943, In 2013 79.2 million PCs were shipped worldwide.
- "**There is no reason for a private individual to have a computer in their home.**"
 - Ken Olsen, president of DEC (Digital Equipment Corporation) 1977.
- "**\$500 for a phone? It's the most expensive phone in the world. Worse, it's not even suitable for business because it doesn't have a keyboard and therefore makes it a pain to send emails.**"
 - Steve Ballmer, CEO of Microsoft, in 2007
- "**There just aren't many videos I want to see.**"
 - Steve Chen, the co-founder of Youtube. 2005, Youtube has more than a thousand billion views.
- "**640 kb should be enough for everyone**".
 - Bill Gates in 1981, on the occasion of the PC announcement.
- "**The guys at Google want to be billionaires and rock stars and go to conferences etc. We'll see if they're still running their company in two years.**"
 - Bill Gates in 2003, he was not very optimistic about the future of Google

<http://www.atlantico.fr/decryptage/bill-gates-steve-jobs-et-autres-liste-predictions-faites-ces-grands-patrons-qui-se-sont-revelees-fausses-708153.html>

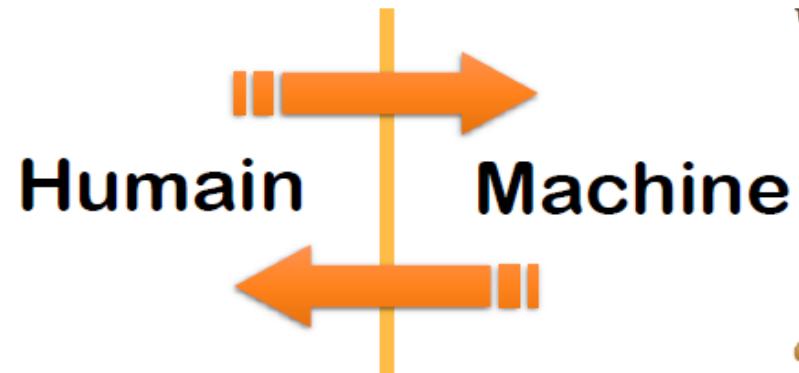
IHM Definition

What is HMI?

- HMI
 - Human-Machine Interface
 - Human-Machine Interactions
- But also
 - Human-Machine Communication
 - Human-Machine Dialogue
 - Person-machine interaction

What is HMI?

- **Human - Machine Interface**
 - all hardware and software devices that allow a human user to use a machine
- **Human - Machine Interaction**
 - all actions allowing communication between an interactive system and its human user



HMI approaches

- **Techno-centric** approach
 - focused on the machine and its possibilities
 - the user must adapt to the machine
 - **designer's** point of view



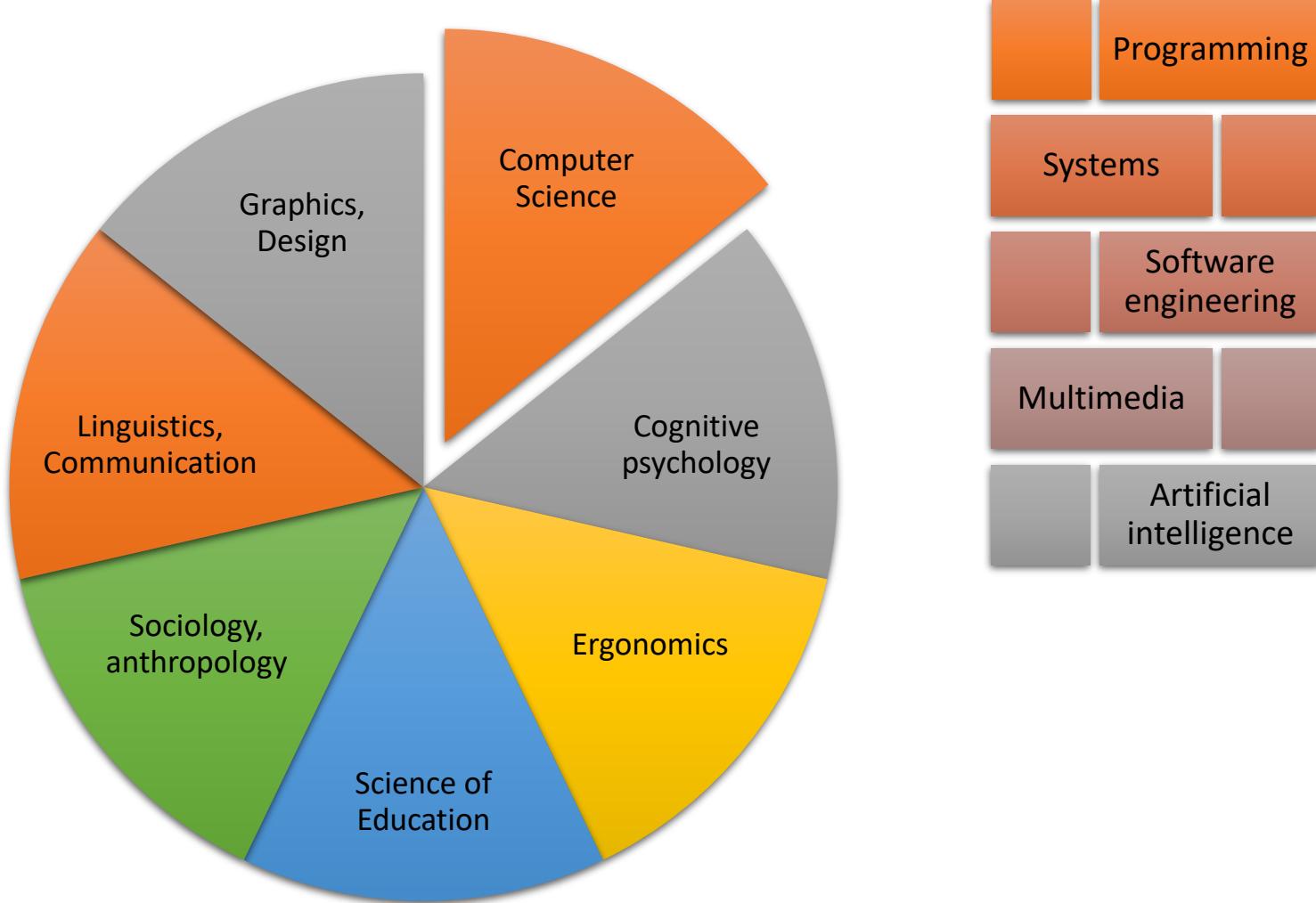
- **Anthropo-centric** approach

- focused on people and their needs
- the machine must adapt to the user
- **user perspective**

Misconceptions about HMI

- *It's easy*
 - Tools make it easy to create, but a good GUI is long and expensive
- *It is an aesthetic operation of the screen*
 - requires an early, methodical, iterative, experimental approach
- *It's only a matter of taste*
 - rules to respect, which have scientific sources
- *There is a miracle method*
 - no turnkey solution
 - theoretical and experimental points of reference, know-how, questioning
 - balances to be found, compromises to be made

HMI, a multidisciplinary field



The HMI must adapt

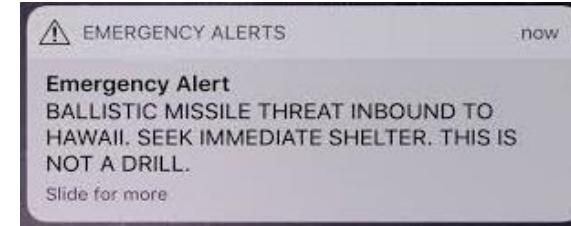
- To the user's characteristics
 - physical differences (age, disability)
 - knowledge and experience (novice, expert, professional)
 - in the field of the task
 - in computer science, on the software
 - psychological characteristics
 - visual/auditory, logical/intuitive, analytical/synthetic...
 - socio-cultural characteristics
 - date format 05.10.2000
 - writing direction
 - meaning of icons, colors



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The HMI must adapt

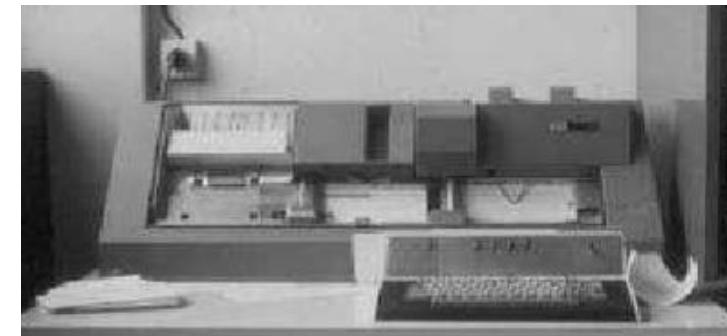
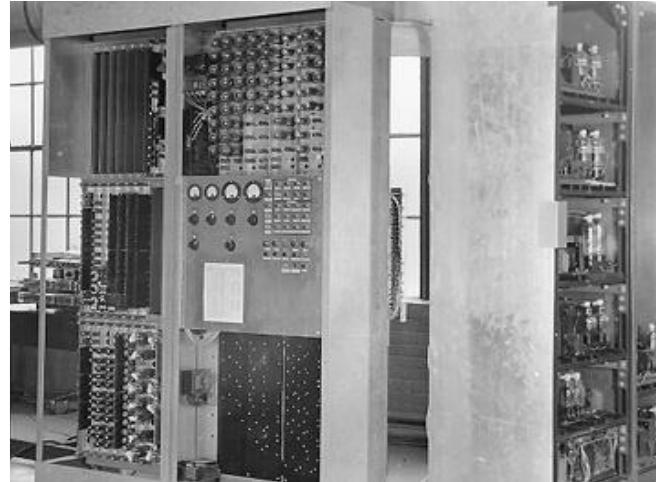
- To the context
 - general public (offer immediate access)
 - leisure (make the product attractive)
 - industry (increase productivity)
 - critical systems (ensure zero risk)
- Characteristics of the task
 - occasional, regular, daily use, repetitive task
 - sensitive to environmental changes, risky, time constrained...
- Technical constraints
 - platform
 - memory, bandwidth
 - display, sensors, effectors
 - reuse of old code



IHM devices' History

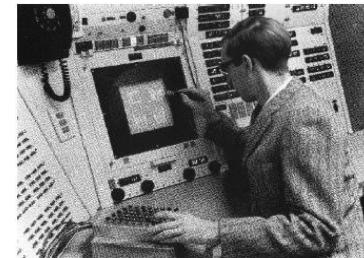
History

- 1945-1970: the premises
 - Limited input/output devices
 - card punches/readers
 - dashboards (lights)
 - printers
 - Command languages



History

- 1970s: "modern" computers
 - "New" input/output devices
 - 1963 : graphic screen and optical pen
 - 1968 : first mouse
 - 1980: consumer applications
 - direct handling
 - remain our reference



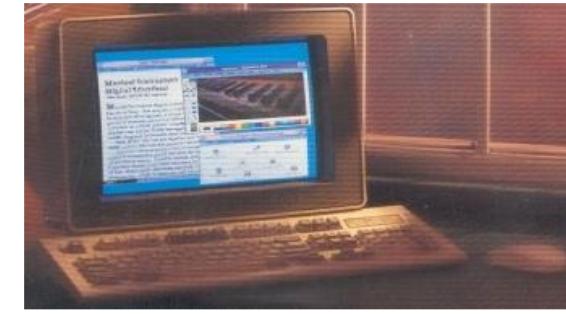
Xerox 8010 Star - 1981



Apple Lisa - 1982



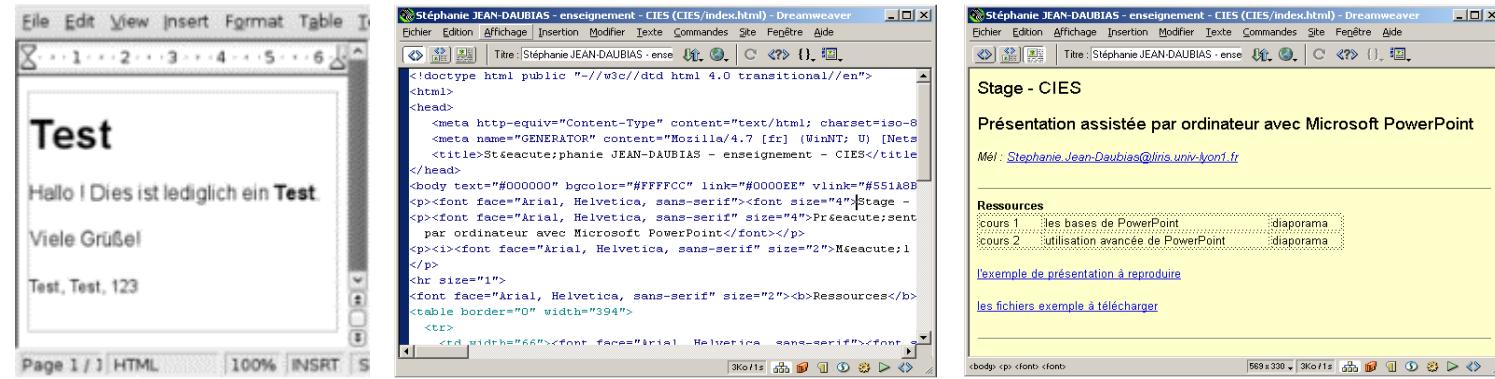
Macintosh - 1984



Windows 3.0 - 1990

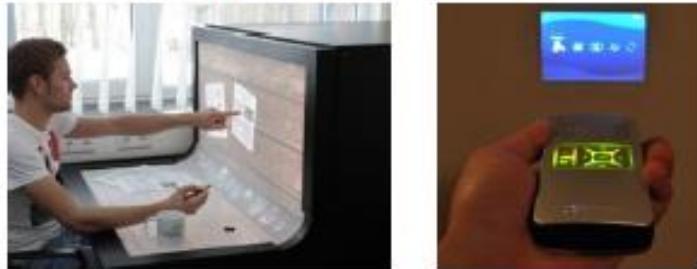
Evolution of interfaces

- More user-friendly systems, easy to understand and use
- Graphic interfaces
 - direct handling
 - direct action on the objects represented on the screen
- WYSIWYG
 - What You See Is What You Get:
 - Interface that allows you to visually compose the desired result,
 - Page layout software, a word or image processor.
 - Intuitive" interface: the user sees directly on the screen what the final result will look like.



Output devices

- Screens



- 3D printers



- Haptic force feedback



- Sound



- Speech synthesis

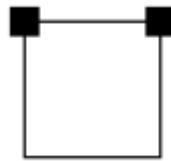
- Stereo Sound

- Two channels (left and right)



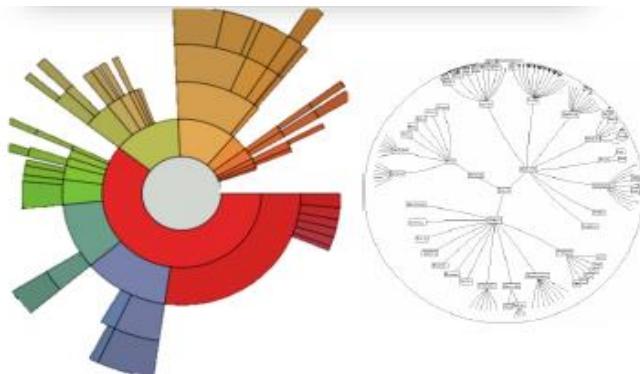
- 3D binaural sound

- All directions

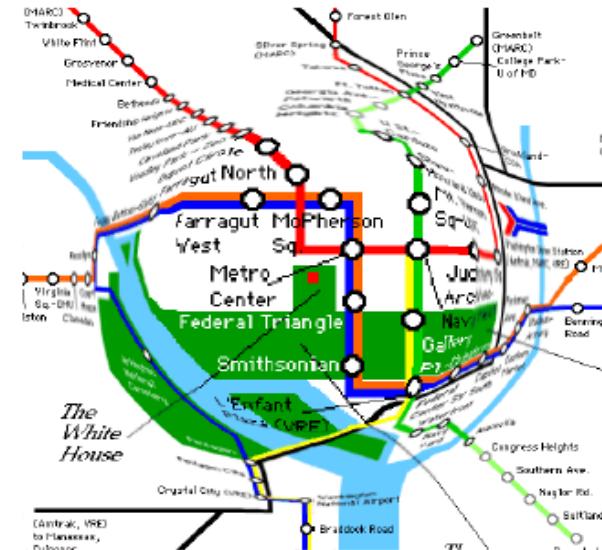


Output: 2D information display

- File representation

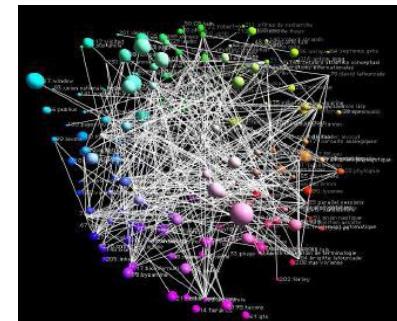
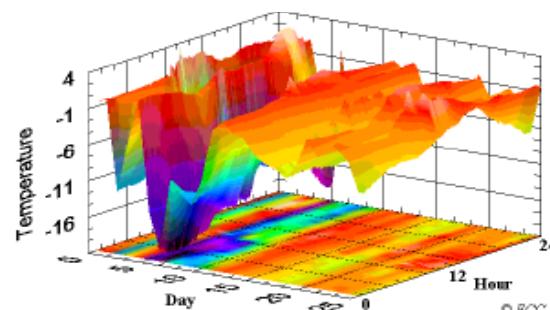


- Fisheye: focus + context



Output: 2.5D information display

- Between 2D and 3D
 - richer than 2D
 - less power hungry than 3D



Output: visualization of 3D information



Input devices

- Keyboards
 - azerty/qwerty...
 - "ergonomic" : Dvorak, bepo...



- Pointing devices
 - mouse, trackball, joystick, touchpad
 - touch input



- Sound
 - voice recognition (of speech)
 - sound/music recognition

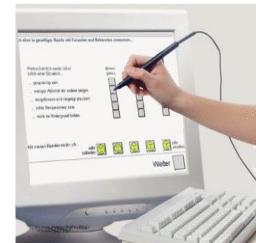


2D visual input devices

- 2D barcodes: text, web, mail, wifi, business card...
- Plot recognition, handwriting recognition



- Touchscreen



- Optical pencils

3D visual input devices

- Position, direction and speed sensors



Other input devices: sensors (connected objects)

- Temperature, hygrometry, air composition, light...



- Orientation, proximity, movement, altitude, direction, acceleration, rotation, magnetic field...



- Pressure, heart rate, fingerprint reader, sound level, barometer, smells...

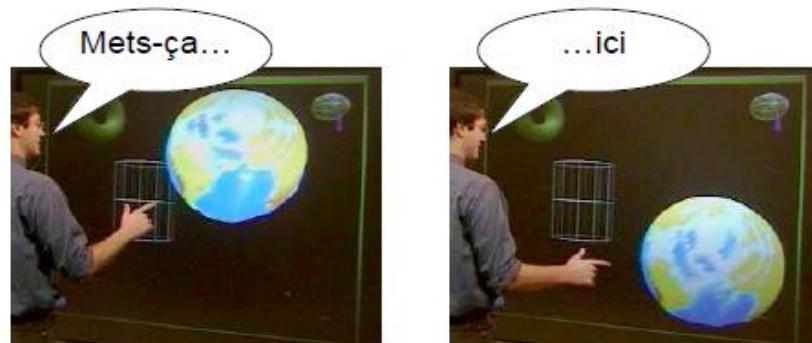


Multi-modality

- Combination of many input means of different types to interact with the machine
 - two-handed interaction



- "put it here": voice + gesture



Wearable computing

- Embedded computing
 - in clothing
 - in the accessories



Mobile computing, nomadic

- Mobile devices
 - small, powerful, connected



- Compatibility problem between the different devices
 - platform
 - technical constraints
 - bandwidth
 - memory
 - storage space
 - **screen size**
 - plasticity of interfaces



Intelligent objects, web of things (iot)

- Computing in everyday objects
 - Reduces the distance between computing and non-computing



Intelligent objects, web of things (iot)

- Pervasive environment: diffuse computing
 - communicating objects (computers, smartphones, objects)
 - recognize each other
 - are located
 - interact with each other (information transfer, data synchronization)
 - without user action
 - at any time
- Ubiquitous environment
 - pervasive
 - mobile



Interactive collaborative system, Groupware

- together in one place
 - interactive whiteboard
 - multitouch table
- remotely
 - shared editors
 - integrating means of communication



Ergonomics of IHM

8 Ergonomic criteria

1. Guiding
 2. Workload
 3. Explicit control
 4. Adaptability
 5. Error management
 6. Consistency / coherence
 7. Significance of codes and names
 8. Compatibility
-
- Based on the work of Bastien & Scapin 1993 (Inria)

Definition of : Ergonomics

- A bridge
 - Computer science : the machine
 - Cognitive science : the human
 - Ergonomics : the interaction between the two
- Definition that applies to any workstation
 - All studies and research on the methodical organization of work and the management of equipment according to the possibilities of man
 - Aims at an optimal performance of the work without damage or premature wear for the human being through working conditions as comfortable as possible
- Definition of software ergonomics
 - Set of techniques, methods and tools to improve the interaction between the user and the computer system

1/8 Ergonomic criteria : Guidance

- Definition
 - Means implemented to advise, orientate, inform and lead the user during his interactions with the computer (messages, alarms, labs,...)
- 4 sub criteria
 - Incentive
 - Grouping Items
 - Immediate feedback
 - readability

1/8 Ergonomic criteria : Guidance -> Incentive

- To Do :



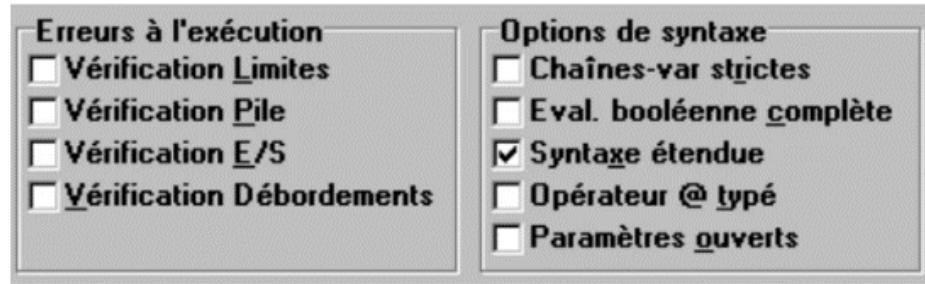
- Not to do :

- Some adventure games with no indications



1/8 Ergonomic criteria : Guidance -> Grouping Items

- To do :



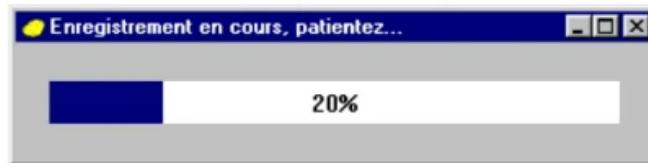
- Not to do



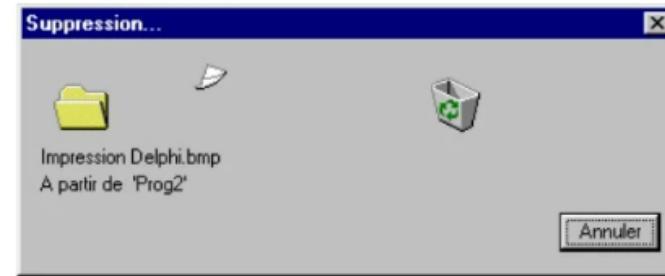
1/8 Ergonomic criteria : Guidance -> immediate feedback

- To do:

- Change appearance of a selected object
- hourglass of short spots
- Indicating task progression



- Not to do



1/8 Ergonomic criteria : Guidance -> readability

- To do

Guidance are the Means implemented to advise, orientate, inform and lead the user during his interactions with the computer (messages, alarms, labs,...)

- Not to do

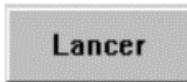
Guidance are the Means implemented to advise, orientate, inform and lead the user during his interactions with the computer (messages, alarms, labs,...)

2/8 Ergonomic criteria : Workload

- Definition :
 - Reduction of the perceptual load of the users
 - Increase of the dialogue efficiency
- 2 sub criteria
 - Brevity
 - Conciseness
 - Minimal actions
 - Information density

2/8 Ergonomic criteria : Workload -> Conciseness

- To do :



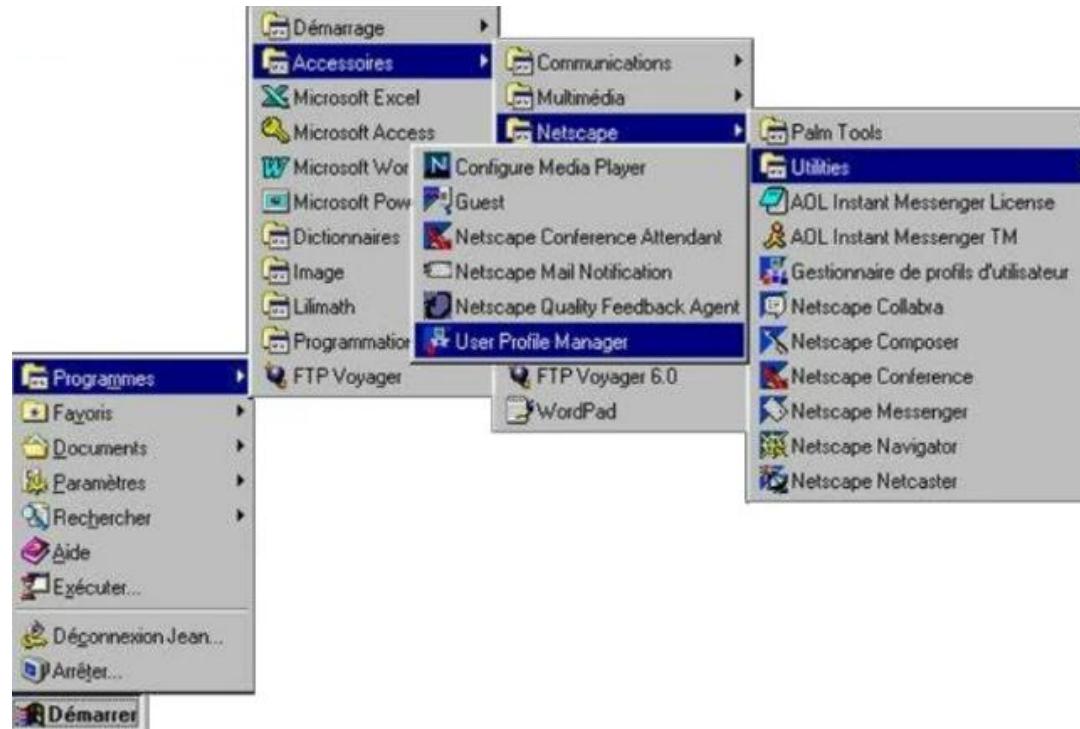
- Not to do:

Lancement de l'application de gestion des notes

Tapez ici le numéro d'identification de l'étudiant dont vous voulez saisir les notes

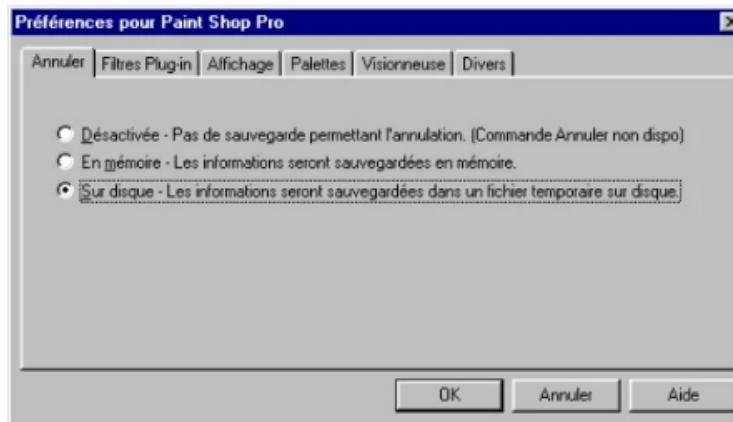
2/8 Ergonomic criteria : Workload -> Minimal actions

- Not to do



2/8 Ergonomic criteria : Workload -> Information density

- TO do:
- Not to do:



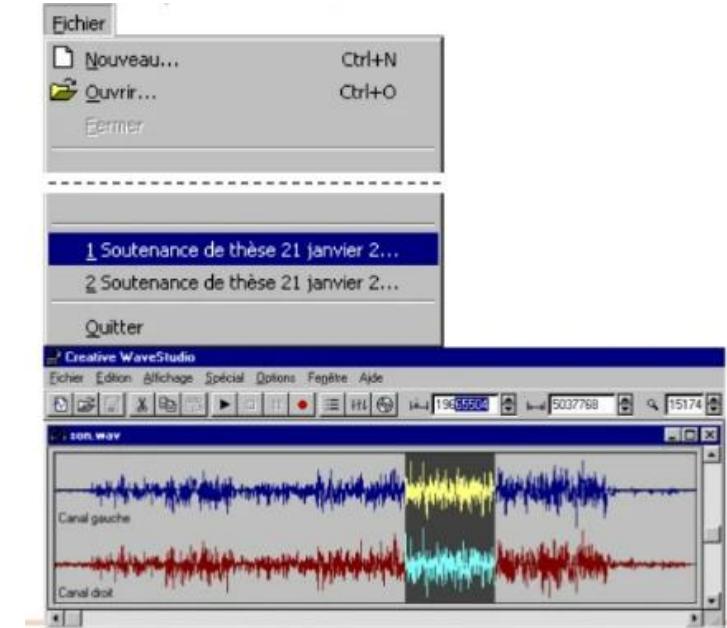
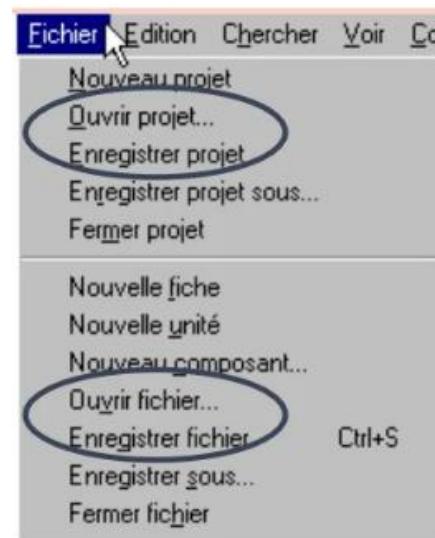
3/8 Ergonomic criteria : Explicit control

- Definition
 - A criteria that regroups two aspects
 - The taking into account by the system of the users' actions
 - The control of the users on the treatment of their actions
- 2 sub criteria
 - Explicit actions
 - User control

3/8 Ergonomic criteria : Explicit control-> explicit actions

- To do
 - Clear and complete text describing actions

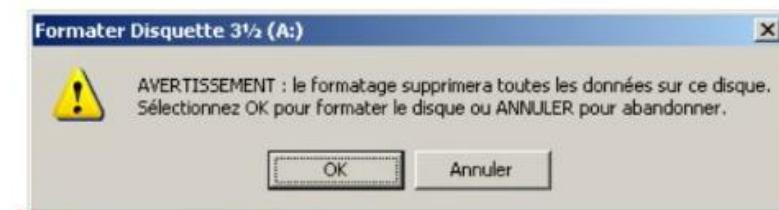
- Not to do
 - confusing text
 - lacking information



3/8 Ergonomic criteria : Explicit control->user control

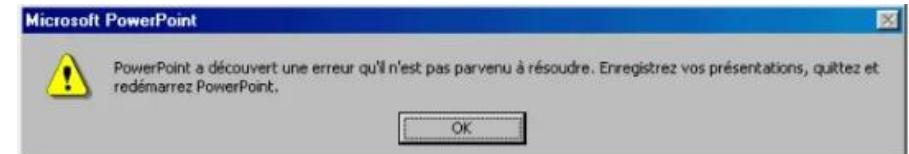
- To do:

- Leave the initiative to the user
- Let the user
 - Switch from one activity to another
 - Stop an activity



- Not to do:

- Actions imposes sans alternatives



4/8 Ergonomic criteria : adaptability

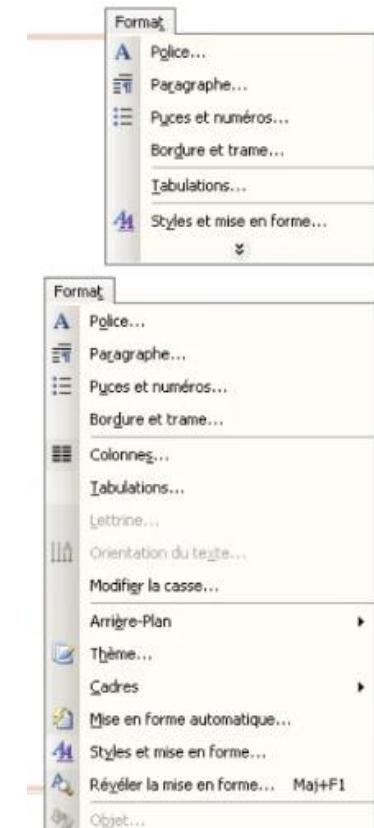
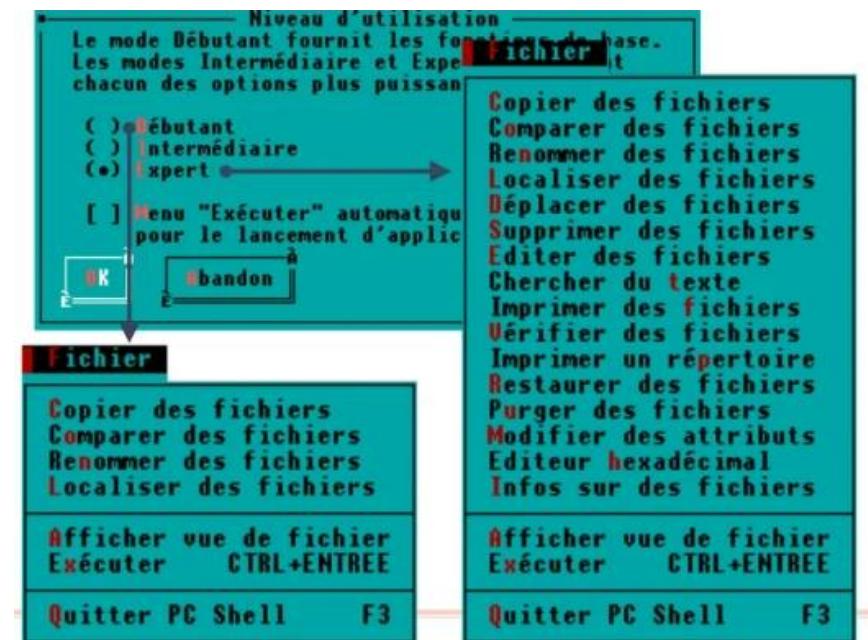
- Definition
 - Ability of the system to react according to the context, and according to the needs and preferences of the users
- 2 sub criteria
 - Flexibility : several ways to perform the same action
 - Taking into account the user's experience

4/8 Ergonomic criteria : adaptability-> flexibility

- Example:
 - Copying a file
 - Drag & drop
 - Edition menu
 - Send to...
 - CTRL+c, CTRL+x, CTRL+v
 - ...

4/8 Ergonomic criteria : adaptability-> user experience

- Change the interface according to the system
- Change the interface according to the user



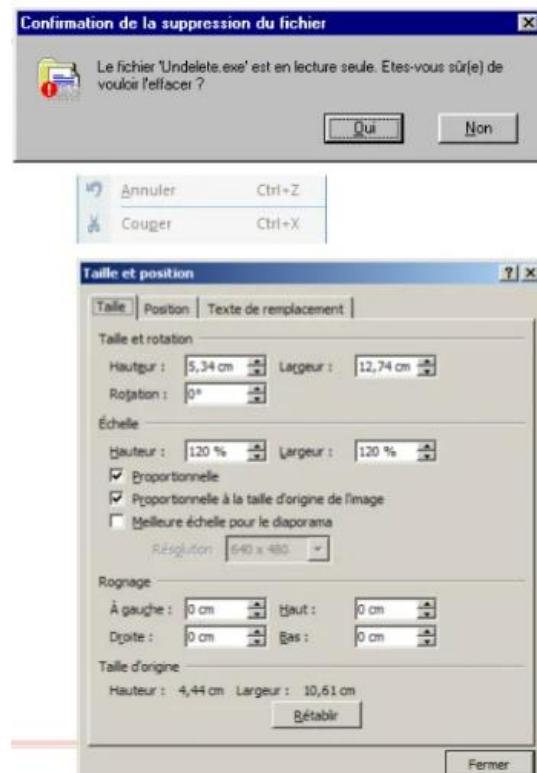
5/8 Ergonomic criteria : Error management

- Definition :
 - This criterion includes all the means to
 - Avoid or reduce errors
 - Correct errors when they occur
- 3 sub criteria
 - protection against errors
 - Quality of error messages
 - Error correction

5/8 Ergonomic criteria : Error management -> protection against errors

- To do:

- Protect sensitive actions
- Grey out unavailable commands
- Provide expected values



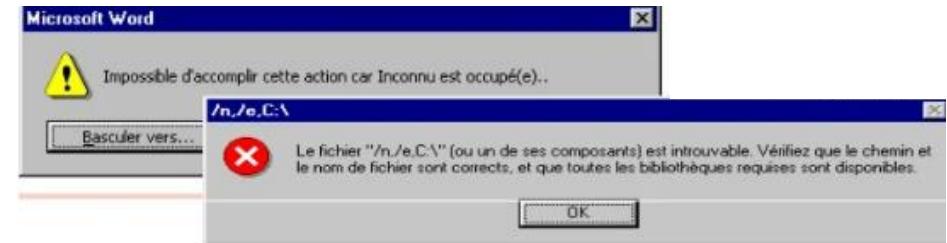
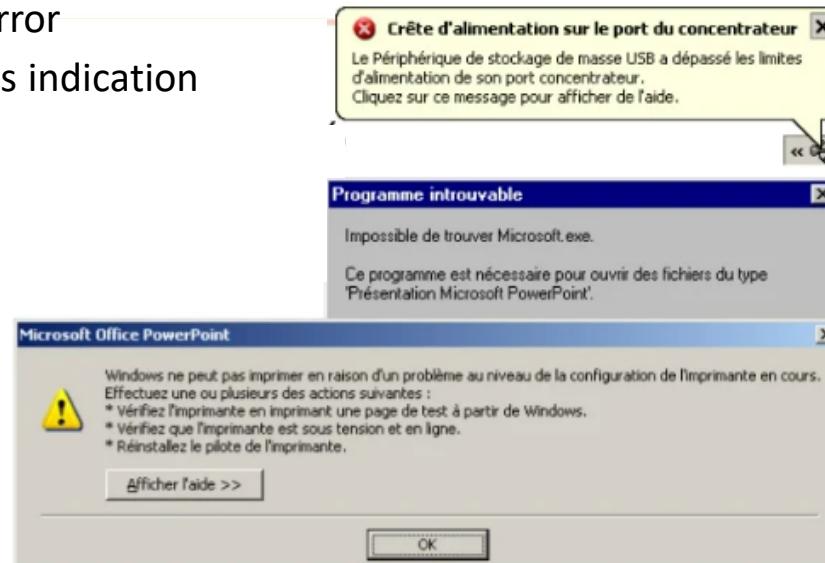
- Not to do:



5/8 Ergonomic criteria : Error management -> error messages

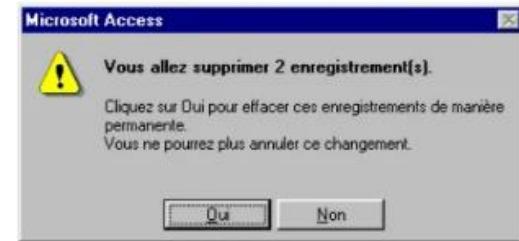
- To do:
- Not to do

- Informative messages, constructive, friendly, showing the cause and the cure, never computer language
- 4 types of messages
 - Information
 - Warning
 - Bulky error
 - Progress indication



5/8 Ergonomic criteria : Error management -> error correction

- To do:



- Not to do:

6/8 Ergonomic criteria : homogeneity/coherence

- Definition
 - How the interface design choices are kept the same for identical contexts and are different for different contexts

6/8 Ergonomic criteria : Consistency / coherence

- In the same software
- To do :
 - Consistency of appearance, position of graphic chart, colors, behavior of different elements (buttons, menus, lists ...)
- Not to do:

énoncé de l'exercice 1
Calculer l'aire d'un rectangle de 7 largeur et 3 mètres de longueurs.

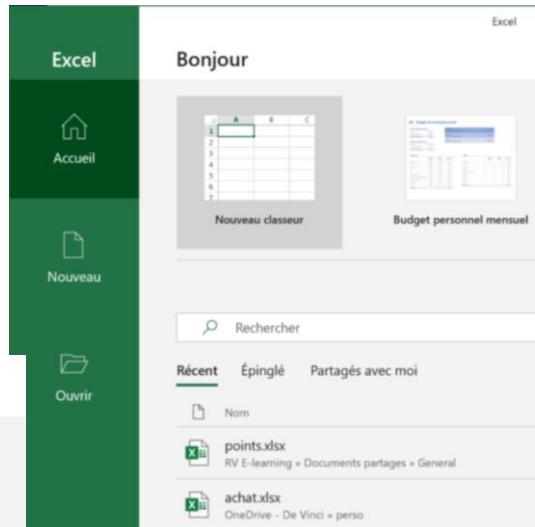
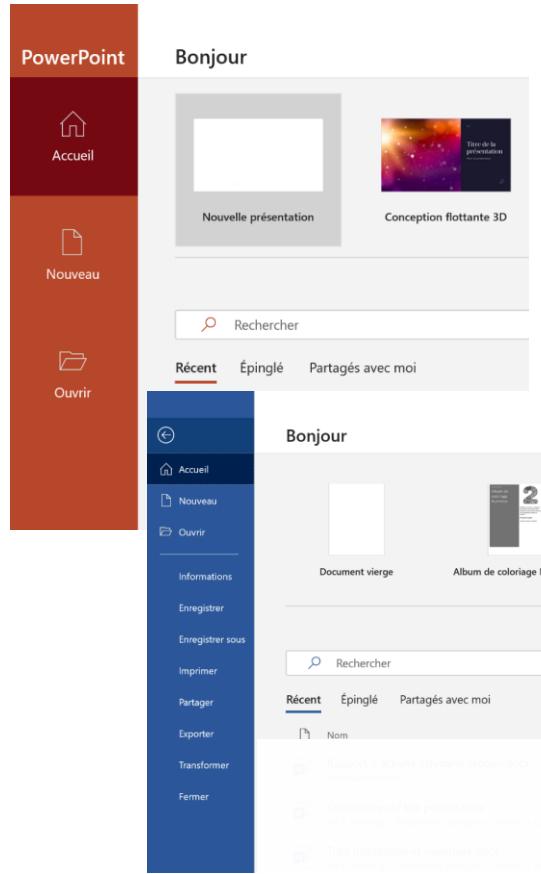
réponse

Exercice 2 : énoncé :
Calculer l'aire d'un carré de 7 mètres de côté.

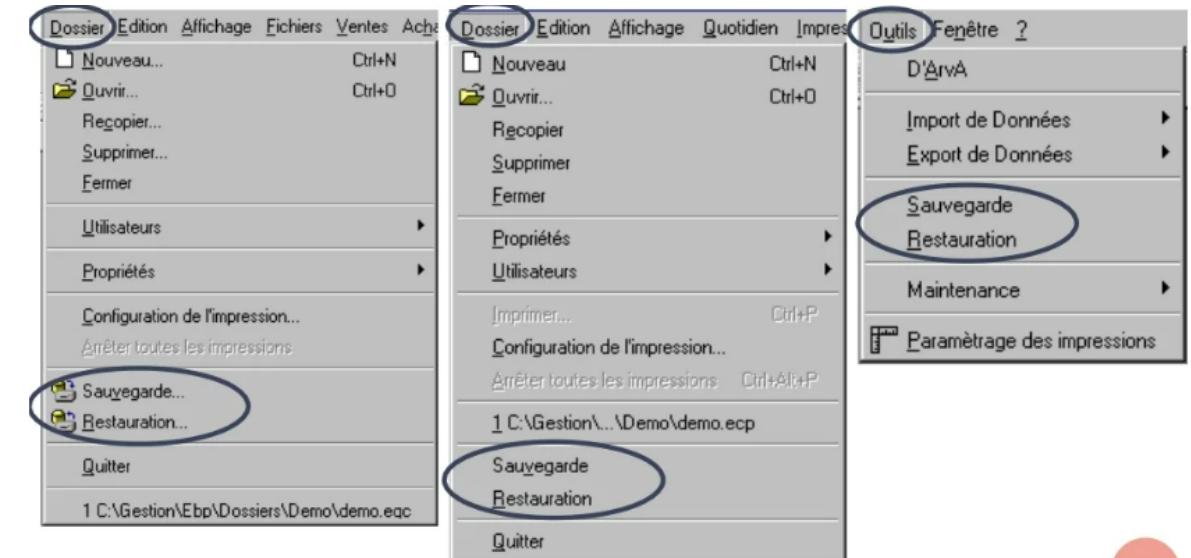
Réponse à l'exercice 2 :

6/8 Ergonomic criteria : Consistency / coherence

- between the software of the same suite
- To do :

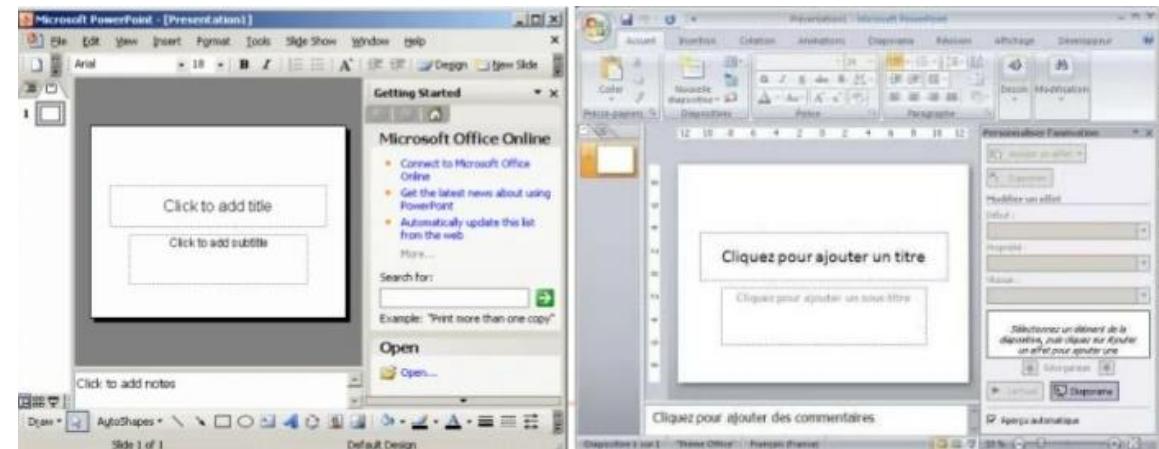


- Not to do:



6/8 Ergonomic criteria : Consistency / coherence

- Between different releases
- To do :
 - Keep the main commands at the same place in the menu
- Not to do:
 - Changing the position of main command without real need



7/8 Ergonomic criteria : Significance of codes and names

- Definition
 - Suitability between
 - The object or information displayed or entered
 - And its referent

7/8 Ergonomic criteria : Significance of codes and names

- To do:
 - Use standard icons and names

- Not to do



8/8 Ergonomic criteria : compatibility

- Definition
 - compatibility with the users:
 - The criterion of compatibility refers to the agreement that can exist between
 - The characteristics of the users (memories, perceptions, habits, skills, age, expectations, cultures,...)
 - ...and the organization of the outputs of the inputs and dialogues of a given application
 - compatibility with the environment
 - Compatibility also concerns the degree of similarity between various environments or applications

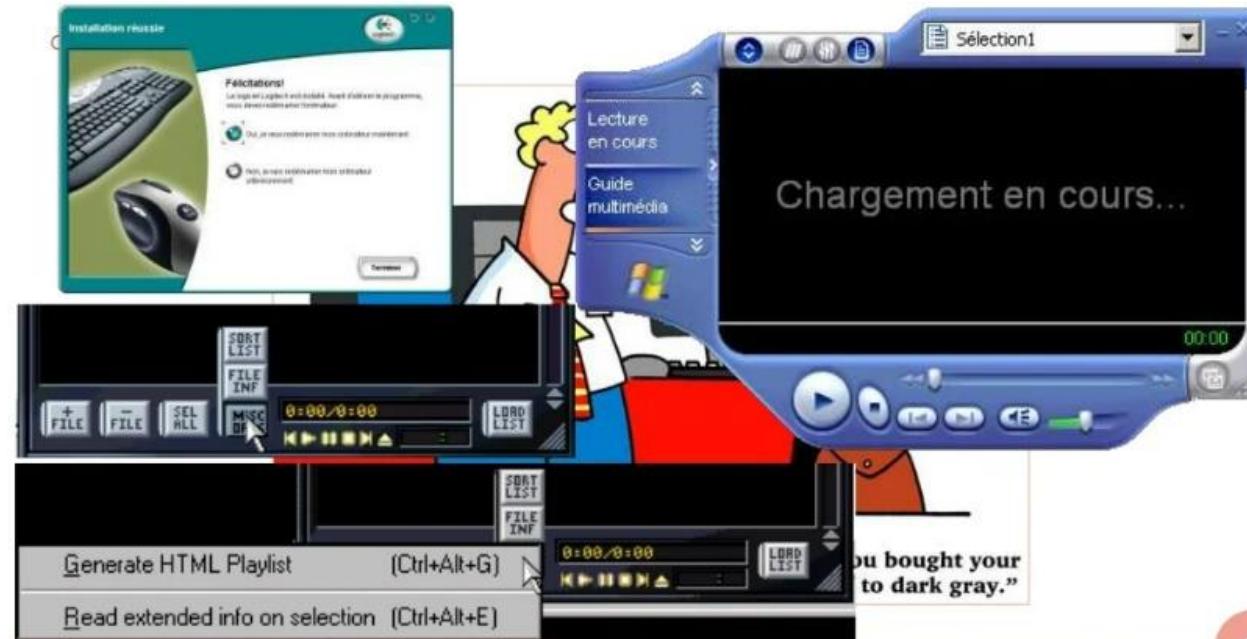
8/8 Ergonomic criteria : compatibility -> with the users

- To do :
 - Take into consideration
 - Age
 - Technological level
 - Handicap



8/8 Ergonomic criteria : compatibility -> with the environment

- Not to do:
 - Examples of application that are not windows like



Evaluation

Evaluation, what?

- Technical quality (idiot-proof)
 - The IHM cannot be misused either inherently, or by use of defensive design principles.
 - It is usable even by someone of low intelligence who would not use it properly.
- Usefulness
 - suitability for the **client**'s high-level objectives
 - Does the software meet the specifications?
 - GL (reliability, technical quality, idiot proof software...)
- Usability
 - ability to allow the **user** to easily reach his objectives
 - is the software easy to use ? quality of the interface/interaction, ergonomics
- Uses
 - actual use of the software
 - Is the software used as intended?
 - GL (feedback, bug tracking), psychology/sociology
- **But the quality of a software is perceived as a whole**
 - User eXperience (UX)

Evaluation, when?

- Formative evaluation (by designers)
 - During design
 - iterative design of models/prototypes
 - user-centered design
 - During development
 - classical quality control methods
 - user testing
 - During use
 - user satisfaction, opinions
 - Bug reports
- Summative evaluation (by super users, prescribers)
 - before a purchase or a download
 - software comparison
 - checklists established by vendors, freelancers...

Ergonomic assessment (Ben Shneiderman)

- 5 central evaluation criteria
 1. Learning time
 2. Speed of execution of the tasks by the couple man/machine
 3. Error rate and ease of recovery
 4. Retention of learning over time
 5. Subjective user satisfaction