AIR – Analyse, Interprétation et Reconnaissance de gestes 2D et 3D pour de nouvelles interactions HM

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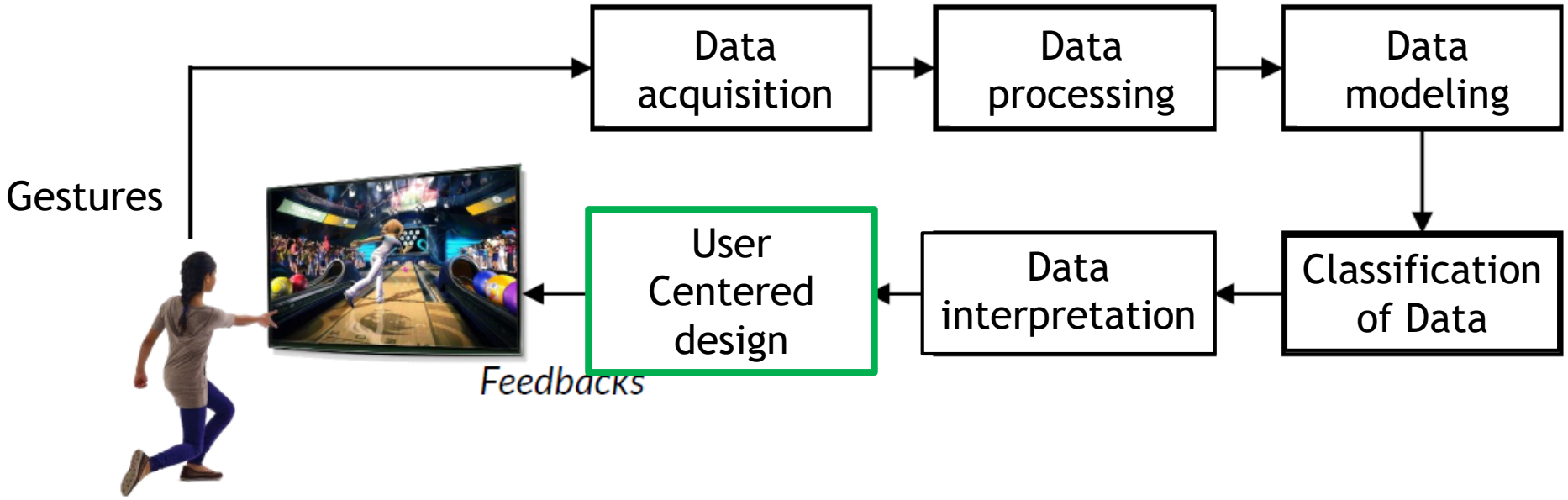
Context

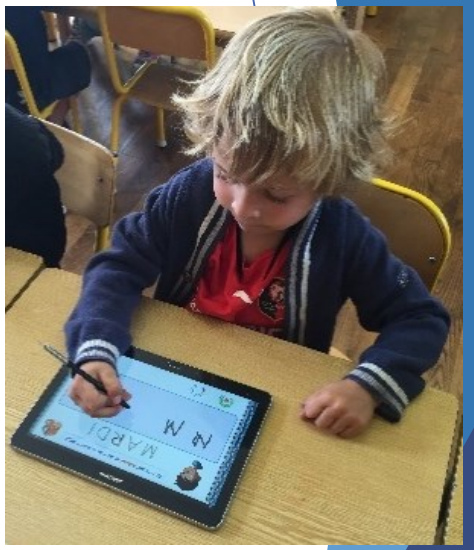

Data acquisition
Data processing
Data modeling
Classification of Data
Data interpretation
User Centered design
Gestures
Feedbacks

Contents

- Transition *(attempt)* between:
  - Previous courses and why user-centered design
- User-Centered design (UCD)
  - Part designed with the support of Sylvain Fleury (LOUSTIC)
  - Goals
  - Implementation
  - Approaches
- User eXperience (UX) data analysis
  - What do you already know about data analysis? (statistical significance, ...)
- …

Intuiscript - Kaligo

Digital Learning : PIA - IntuiScript (2015-2017)



PIA /AAP 3 : « Innovative services and digital content for learning fundamentals at school »

- Digital workbook to learn the handwriting at school
  - Target : handwriting learning at kindergarten
- Marketing process: First sale in 2017 (Kaligo)

IntuiScript - Main project partners

- **Script&Go (Learn&Go)**
  - Company specialised in creating digital solutions and applications for stylus enabled tablets.
  - Role: development of software on tablet computer and network infrastructure
- **IRISA laboratory / IntuiDoc team**
  - More than 20 years on research work and the analysis and recognition of handwriting and graphical gesture
  - Role: assure the technological innovation
- **Microsoft Education**
  - Expert in ITC used in teaching
  - Role: make available an immersive classroom at Issy-les-Moulineaux

IntuiScript - Associated project partners

- **LOUSTIC laboratory**
  - Support of the usage laboratory of the information and communications technology for the experimentations.
  - Role: Support with the test protocols, supervision of experimentations and evaluation forms.

- **Brittany Region**
  - Support and implication of the Regional Council of Brittany in the project
  - Role: funding of a digital educational area, from the training of ESPE students to the buying of digital devices

- **Rennes Academy/ ESPE**
  - Educational expertise / support of experimentations with academic advisor
  - Role: design an educational content and experimental infrastructural support

IntuiScript - Targets

- Main target:
  - Make easier the handwriting learning by digital learning in the continuum of the traditional teaching methods.

- Targets:
  - Provide an adapted numeric solution for the **learning of graphomotor gesture and the handwriting of children**
  - Get an **educational method enriched by numeric tools**
  - Formalise the solution with **digital notebook** at the service of teachers and children.
  - Favour self-evaluation with an **automatic expertise of handwriting**
  - Obtain an **interconnected digital class**

IntuiScript - Description

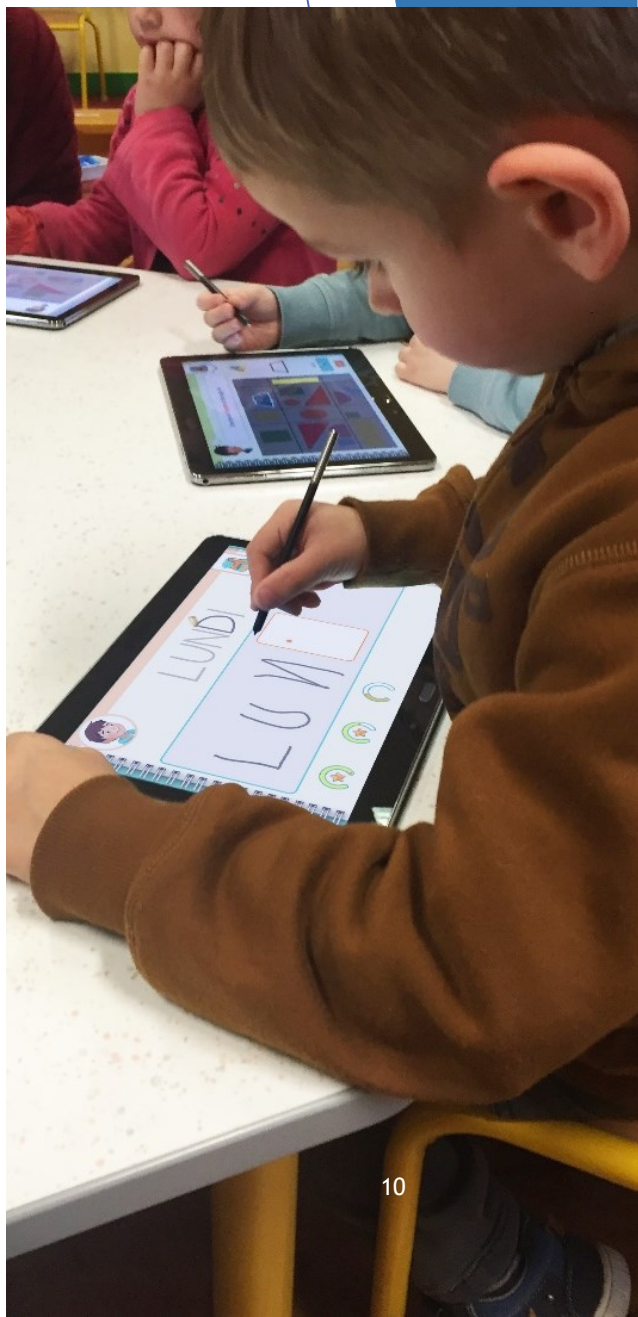
- **Digital learning**

  Educational methods made-to-measure

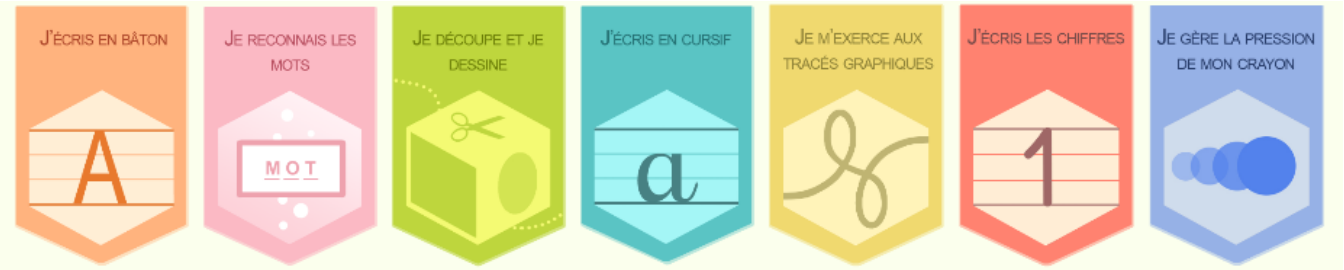
  Desire of learning

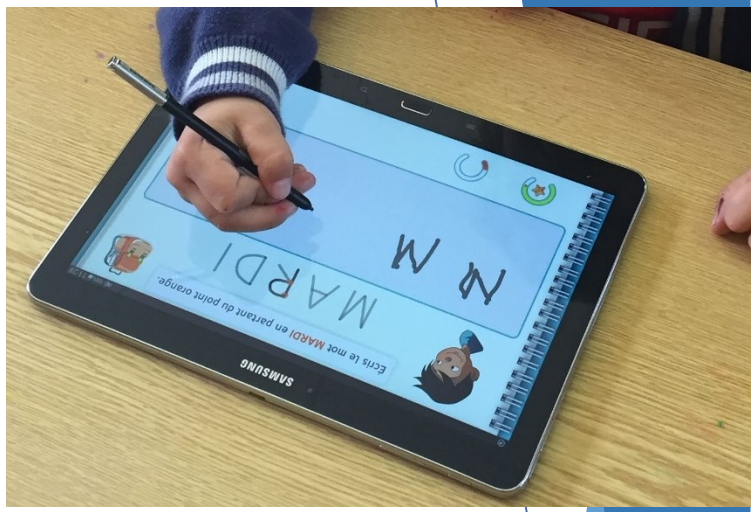
  Collaborative Working

- **A digital solution**
  - For the current teaching practices covering all the handwritten productions of children
  - Explicitly Customizable by the teacher: work on the teaching session
  - Automatically Customizable to the child: monitoring its evolution
  - Promote self-assessment of children with automatic handwriting expertise
  - Solution hosted in clouds
    - **At school**: archiving and evaluating progress
    - **At home**: consultation of the digital workbook



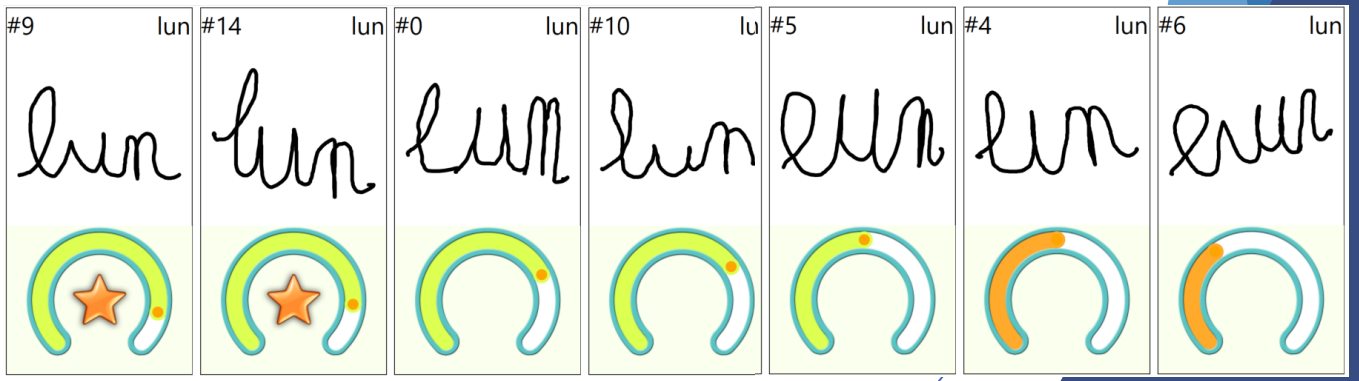
IntuiScript – Design of contents





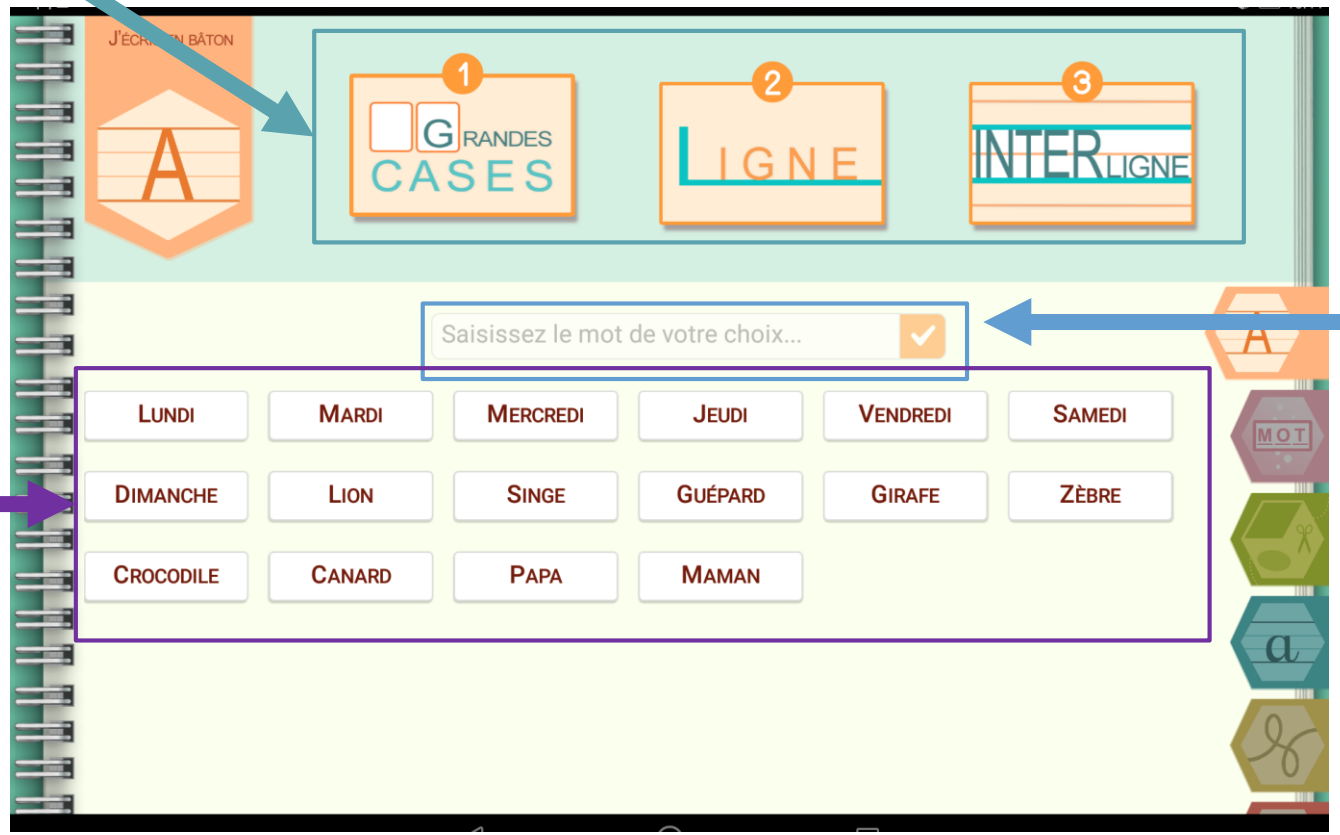
- **Definition of educational objectives and creation of educational scenarios**
  - 7 exercises available
    - **Block Letters (writing of letters)**
    - **Identification of a text**
    - **Cursive writing**
    - **Block letters (writing of digits)**
    - **Graphical Identification**
    - **Cursive writing preparation**
    - **Stylus pressure acquisition**

- *The digital notebook provides immediate feedback*



Template n°1 : Block letters (writing of letters)

- **Description:** Block letter writing within a word context
- **Customisation:**
  - Word context: already defined word or new word
  - Writing space customisation: size and background of the writing space

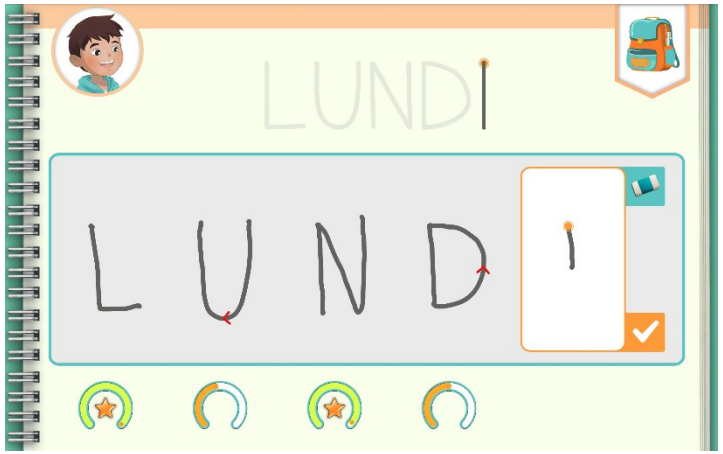


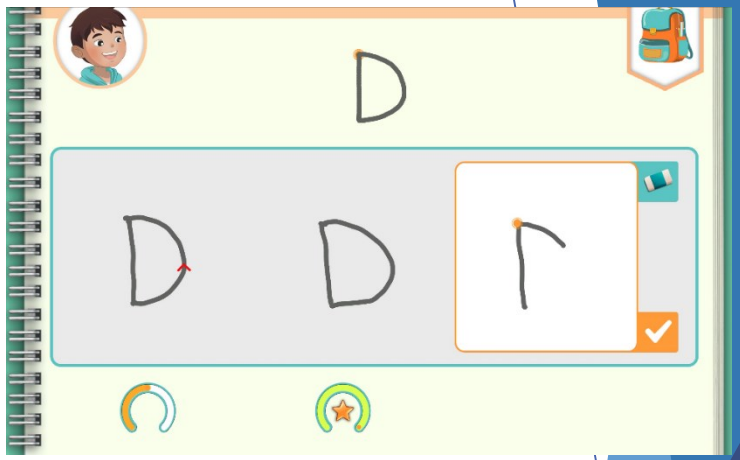
Template n°4 : Cursive Writing

- **Customisation:**
  - Word context: already defined word or new word
  - Writing space customisation: size and background of the writing space
  - Writing constraints: attached letters, bigrams, trigrams

Template n°1 : Block letters (writing of letters)

- **Description :**
  - Block letter writing within a word context





Initial child knowledge

- Full word writing
- Static model
- No analysis

Learning of letters

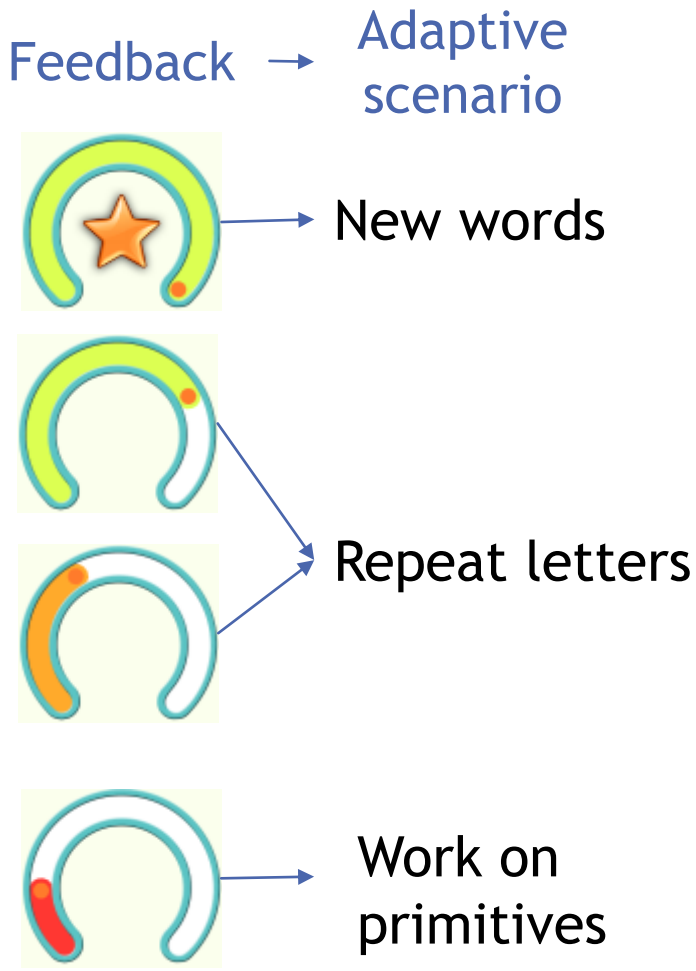
- Writing of a word letter by letter
- Dynamic model
- Handwriting Analysis

Personalised Remediation

- Writing record
- Storage of student data

Writing analysis – In-line feedback

- Dynamic guidance:
  - Automatic playing of the letter model
  - Replay the dynamic model
  - Replay of the children production
- Prompt feedback:
  - Colour-scale indicator
- Remediation:
  - Adaptation of the pedagogical scenario



Writing analysis – How to evaluate handwriting?

Handwriting quality

(Dinehart, 2015)

Legibility

- Linked to: readiness
- Based on: letter shape

Kinematic

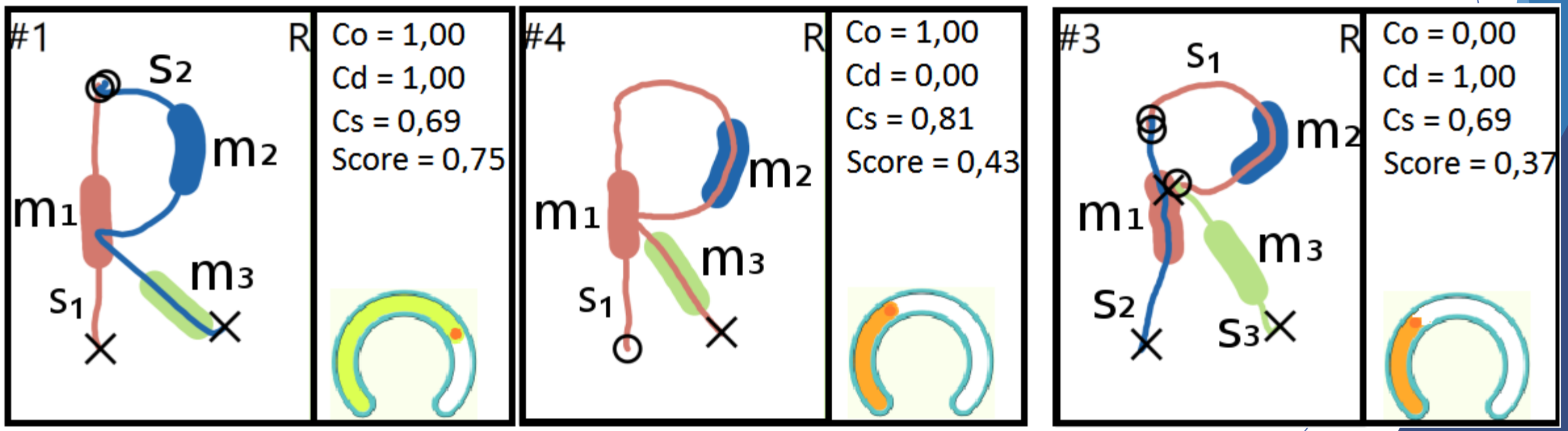
- Linked to: writing process
- Based on: order, direction, fluidity

Writing analysis – Colour-scale indicator computation

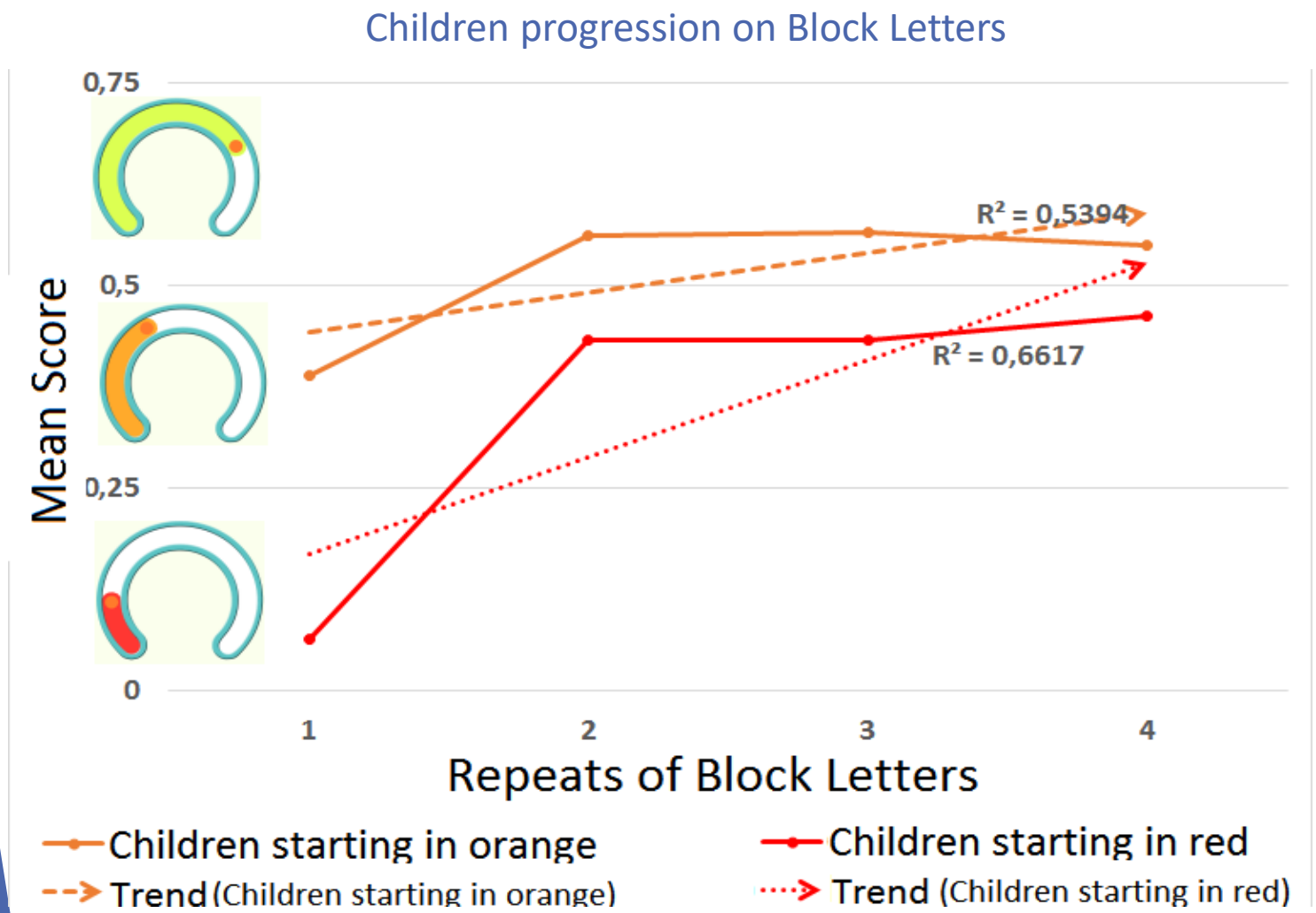
- Global score s_g decomposition:

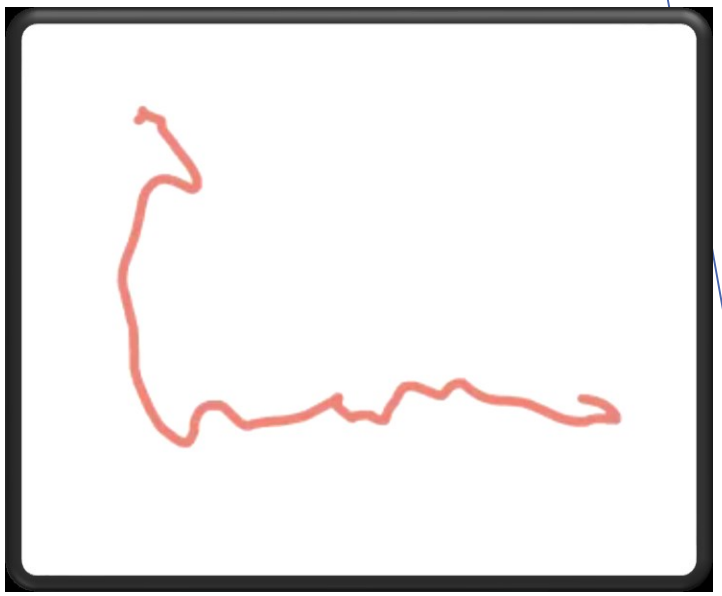
$$s_g = \min(\alpha_s c_s, 1.0) \times \mathcal{P}(c_o, c_d) \; where \; \mathcal{P}(c_o, c_d) = \begin{cases} 1 \; if \; c_o + c_d = 2 \\ \alpha_1 \; if \; c_o + c_d = 1 \\ \alpha_0 \; if \; c_o + c_d = 0 \end{cases}$$

and $\alpha_s = 1.1, \alpha_1 = 0.49, \alpha_0 = 0.35$.



Experimentations – 1st results

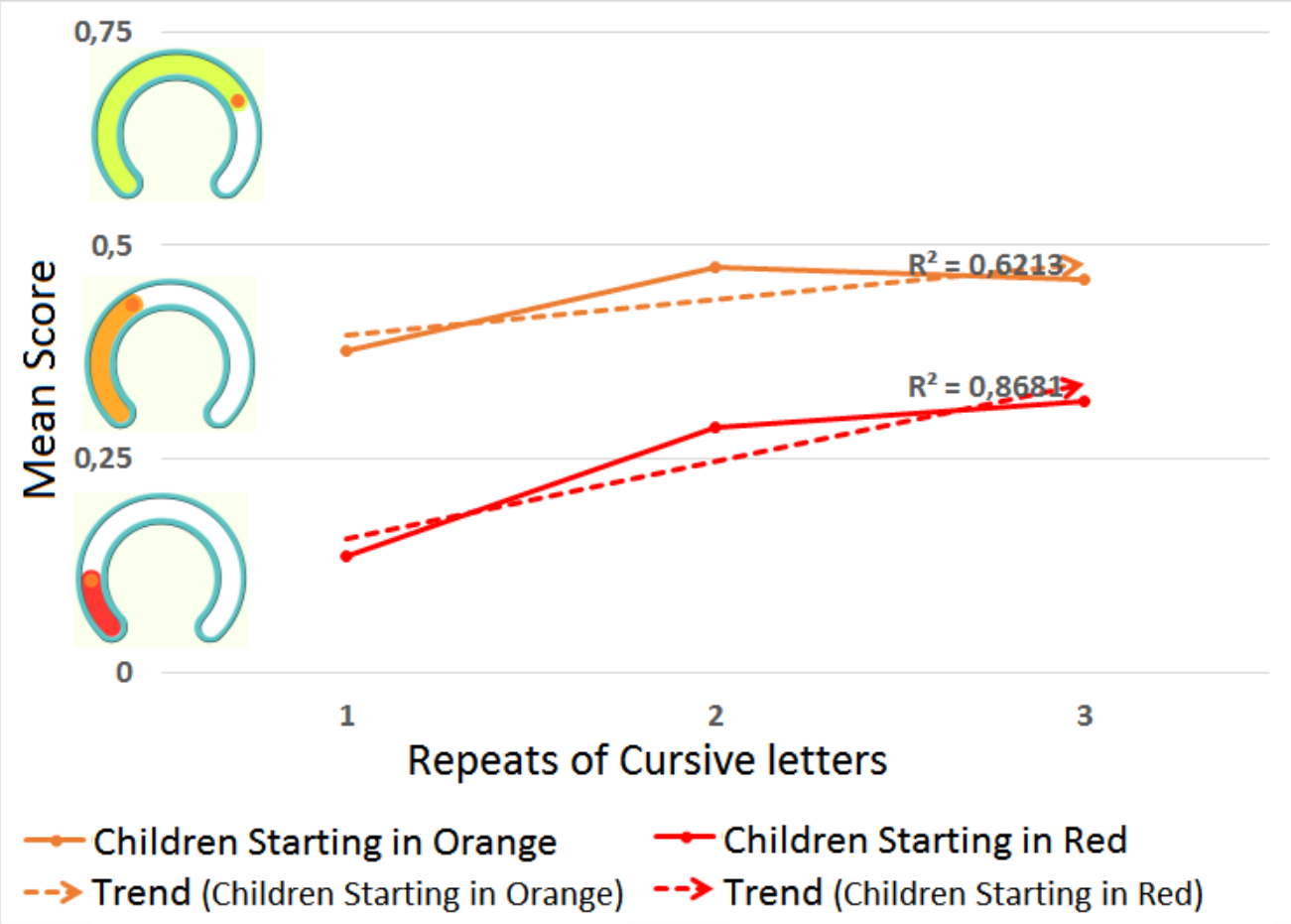


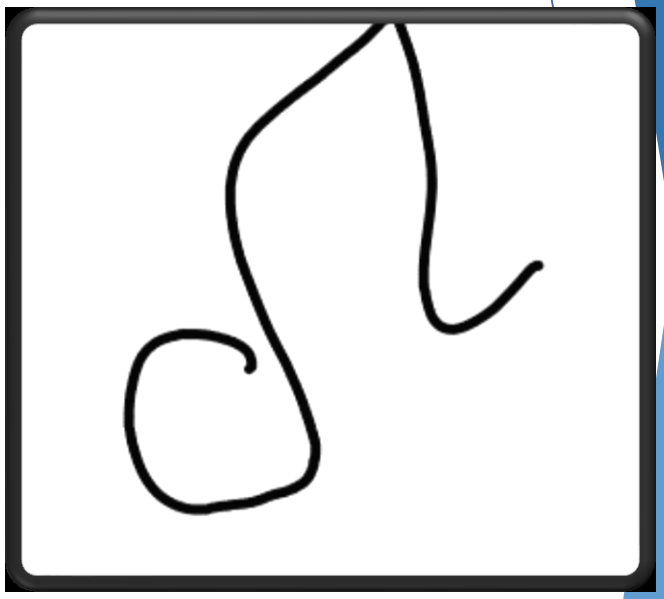


Children writing: L, N and D

Experimentations – 1st results

Children progression on Cursive Letters





Children writing: d and i

How to define efficient solution/model?

- State of the art:
  - Evaluation of writing skills [Rosenblum2003]:
    - Mainly based on the time spent writing a specific text
    - Requires an expert to assess readability
    - Too subjective, computer analysis are more accurate, sensitive and reliable
  - Document analysis [*cf.* CM E. Anquetil]:
    - Many works on: recognition, word spotting, …
    - Always assuming the writer is an adult, *i.e.* an expert
    - State-of-the-art models are inefficient for children writing analysis

- Conclusion:

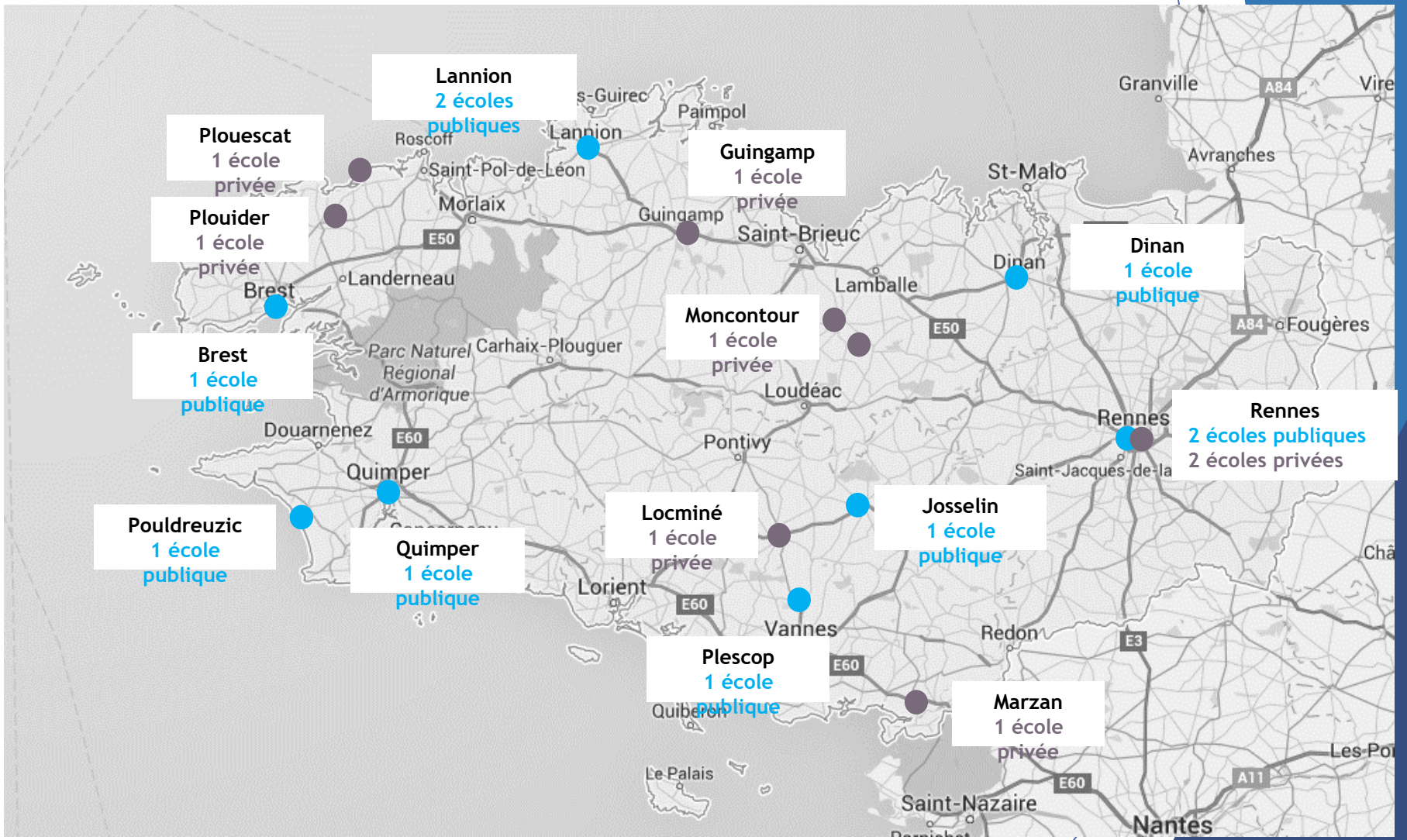
We need a **user-centered design** to defined

an adapted analysis model, and an efficient numerical notebook

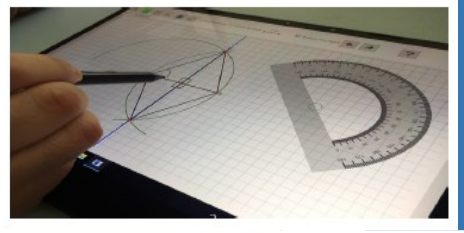
IntuiScript – experimental schools

User Centred Design

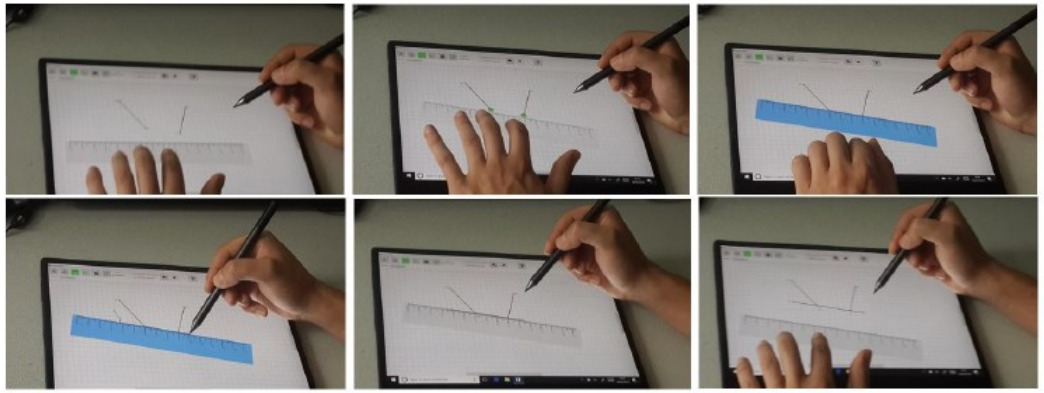
- Number of schools: 17 (public et private)
- Number of classes: 40
- Number of students: about **1000**



UCD for HCI and digital learning



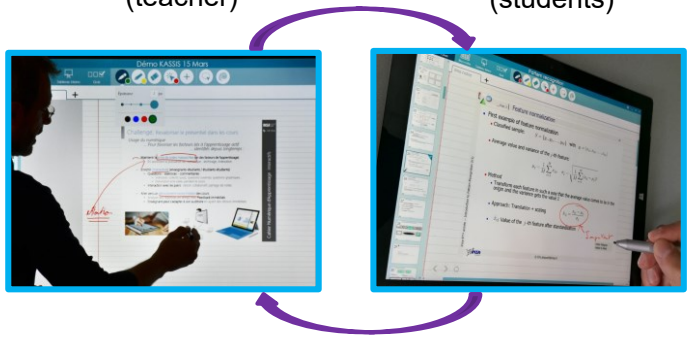
kaligo IntuiGéo KASSIS

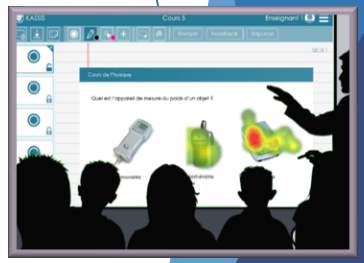


- Same objectives:
  - Definition of each template in accordance with school program
  - Progressive validation of each template: in-class tests,
  - Implication of users in the improvement of the notebook:
    - pressure template, pen holding, teacher dashboard content, ...

Interactive screen (teacher)

Tablets with stylus (students)





- Compromise for the definition of the skills evaluation:
  - between teachers, educational experts, and computer scientists
  - with an access to weights of the sub-scores allowing teacher to work on a specific skill

User centred design - Motivations

1. Economic

- The HMI part represents 50 to 90 % of the development costs of a project
- The state/ministry supports this type of actions: Cadix 2013 report
  - "Our technology-centric companies – pushed into this by all the national innovation aid programs for decades – have forgotten the **"user experience"** that makes, or does not make, the success of an innovation. But it is design that makes the link, which is the gear between technology and usage and which adds the imaginary part that makes objects desirable. Whether this technology is banalised or new. »

2. Scientific and technical challenges

- People/Human: the most unpredictable variable
- Activities: mainly complexes

3. UCD = framework with rigorous methods and approaches

4. Professional

- Companies/services make apps for users, not just for machines

User-centered design – objectives and origins

The goal of the user-centered design process is to obtain a product that is functional, operational and satisfies the user [Ames2001]

- Design of a system that is:
  - ergonomic (user-friendly)
  - useful (utilité, usefulness/utility)
  - usability (utilisabilité)
- Based on:
  - Acceptability
  - User experience (UX)
  - Affordance (facilité/perception)

Ergonomy - definition

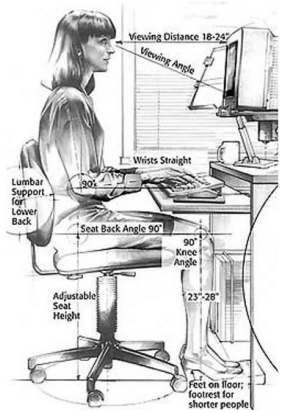
- Racines : "ergon" (travail) et "nomos" (loi)

- Ergonomie :
  - «*L'ensemble des connaissances scientifiques relatives à l'Homme nécessaires pour concevoir des outils, des machines et des dispositifs qui puissent être utilisés avec le maximum de confort, de sécurité et d'efficacité.*» (Alain Wisner)

- Ergonomy ⇔ human engineering
  - *Ergonomics (or human factors) is the **scientific discipline** concerned with the understanding of interactions among humans and other elements of a system, and the **profession** that applies theory, principles, data, and other methods to design in order to optimize human well-being and overall system performance.* (International Ergonomics Association, 2000)

Ergonomy - definition

- Physiological => postural requirements
- Organizational => space organization
- Cognitive => perceptual, mental



Usefulness / utility - definition

- The utility of an object is simply how practical and useful it is.

«*L'utilité est la capacité d'un objet à servir la réalisation d'une activité humaine.*» [Nogier2013]

Usability - definition

- ISO 9241 :
  - **”A product is said to be usable when it can be used with effectiveness, efficiency and satisfaction by given users, seeking to achieve given objectives, in a given context of use.”**
    - **Effectiveness**: the user must succeed in doing what he wants to do
    - **Efficiency**: the user must be able to do it quickly and with as few errors as possible
    - **Satisfaction**: aesthetic features, learnability, comfort

[Nielsen2003] defines usability as a “quality attribute” of a product that is concerned with 5 quality components; learnability, efficiency, memorability, errors and satisfaction.

Usability vs. Utility [Nielsen2003]

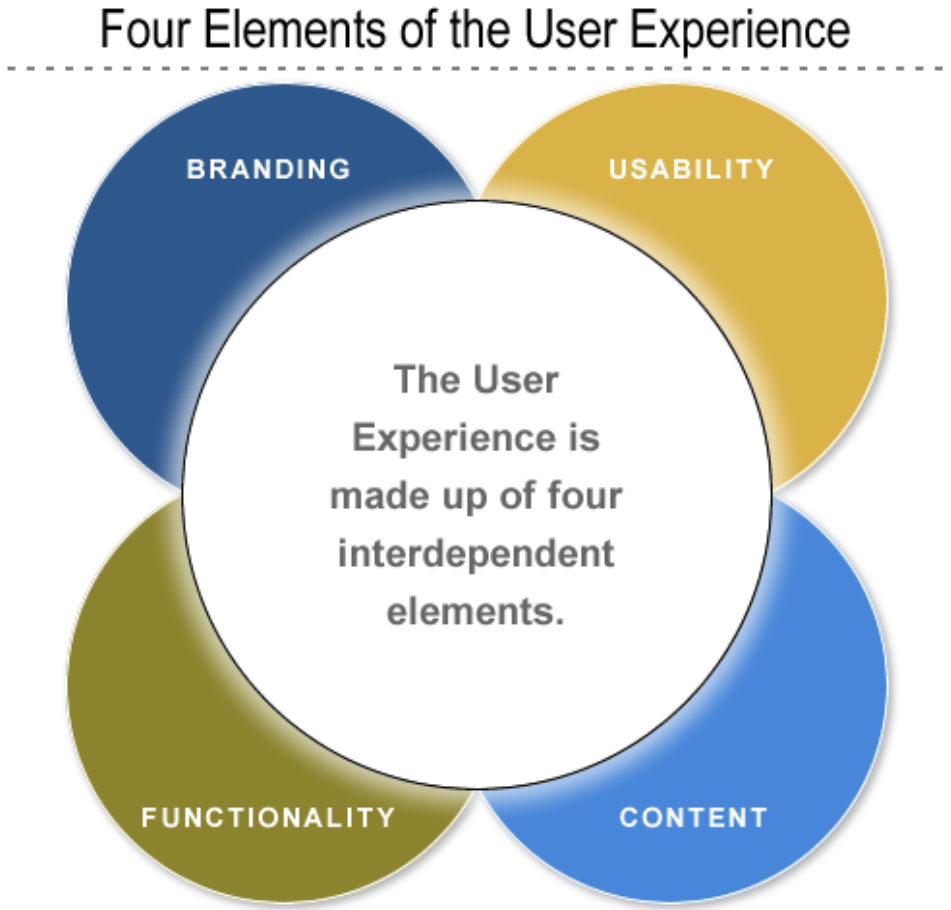
- Closely related, but not the same thing
- Both critical in producing a quality product:
  - Needs to be operated easily and intuitively (usability)
  - Needs to accomplish the given task (utility)
- Differences:
  - Utility is solely concerned with usefulness
  - Usability includes:
    - utility,
    - but also efficiency, safety, memorability, learnability and satisfaction

User Experience (UX) - definition

User experience is a term describing the “overall experience and satisfaction” of a user whilst interacting with a system [Crew2006]

- Feeling of the user during the use of the product
- Rational benefit + emotional impact

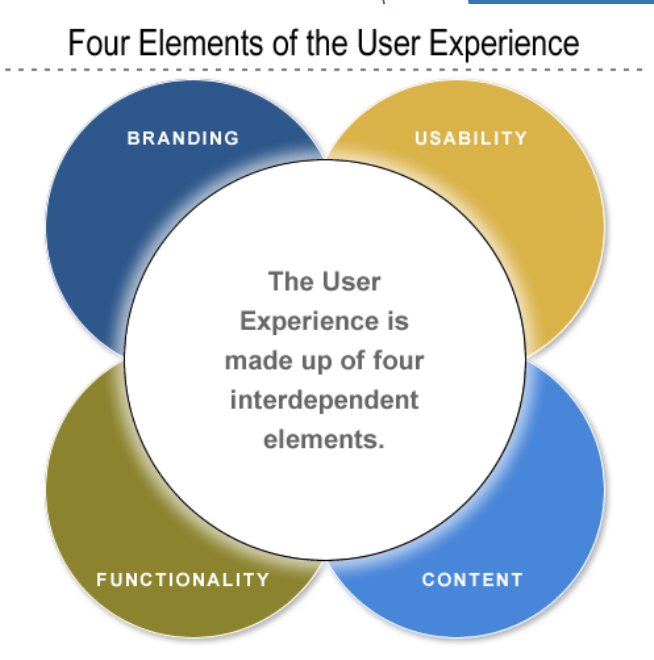
User Experience (UX) - definition



But, how can we quantify and measure these seemingly intangible elements?

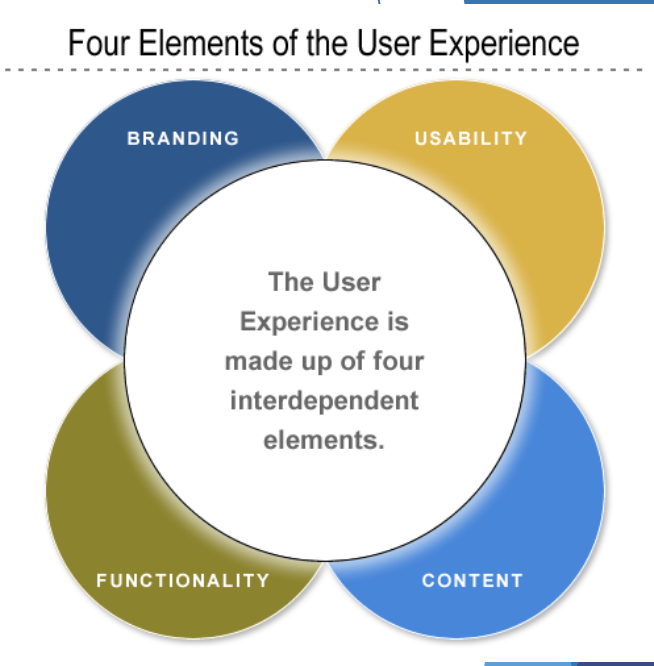
(next lesson)

Usability vs. User Experience [Rubinoff2004]



- Both concerned with the satisfaction of the user
- Good user experience:
  - Relies on a usable, functional, aesthetically pleasing, enjoyable and memorable product
  - Encapsulates usability, and also considers the user's emotions towards the product.
- Differences:
  - usability considers the user's satisfaction with the interface,
  - user experience considers more whether the user is emotionally fulfilled.

Utility vs. User Experience [Rubinoff2004]



- Both concerned with functionality.
- Differences:
  - Utility is not really concerned with the user at all
  - User experience is heavily user-orientated
  - User experience is concerned by more things than only functionality (emotional fulfillment and satisfaction with the product).

Affordance - Definition

- Ability of an object to suggest its own use

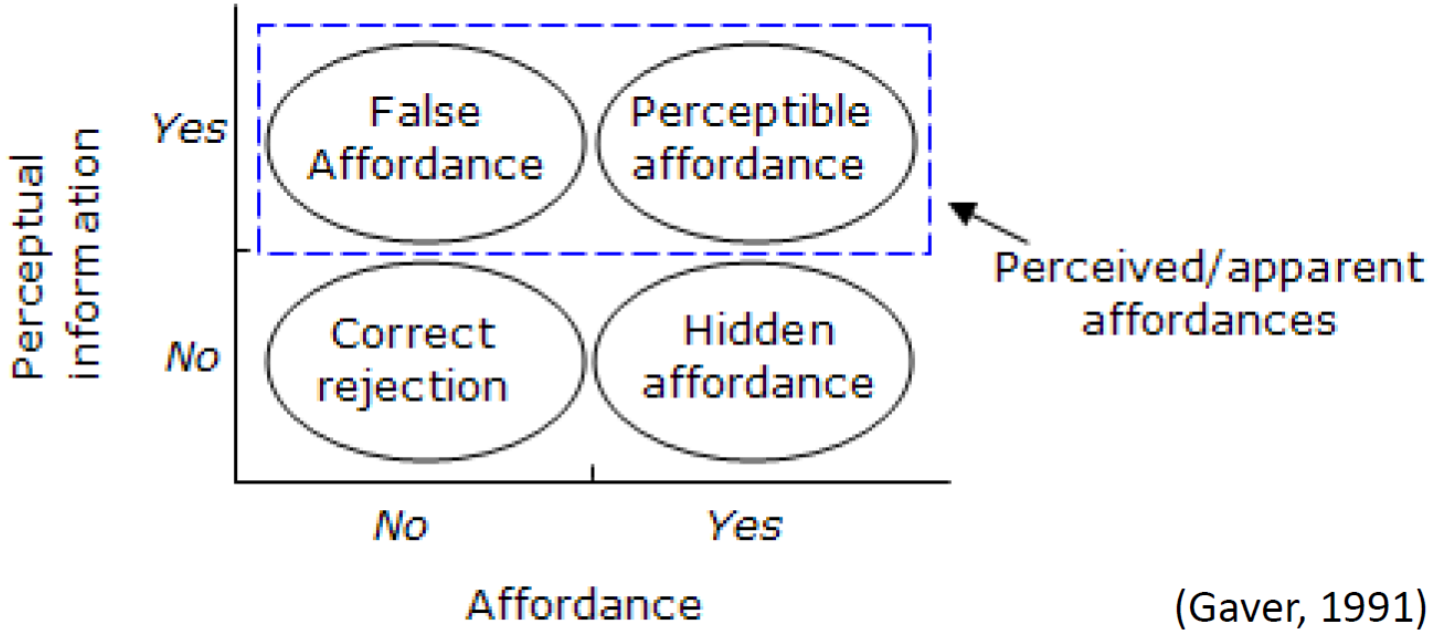
- Perceptible Affordance

How to use?

Make it understandable

Affordance - Definition

- Distinction by Don Norman between affordance (possible uses of the object) and the perceptible information that indicates affordances



(Gaver, 1991)

Affordance - Definition

- False affordance

Affordance - Definition

- Hidden affordance

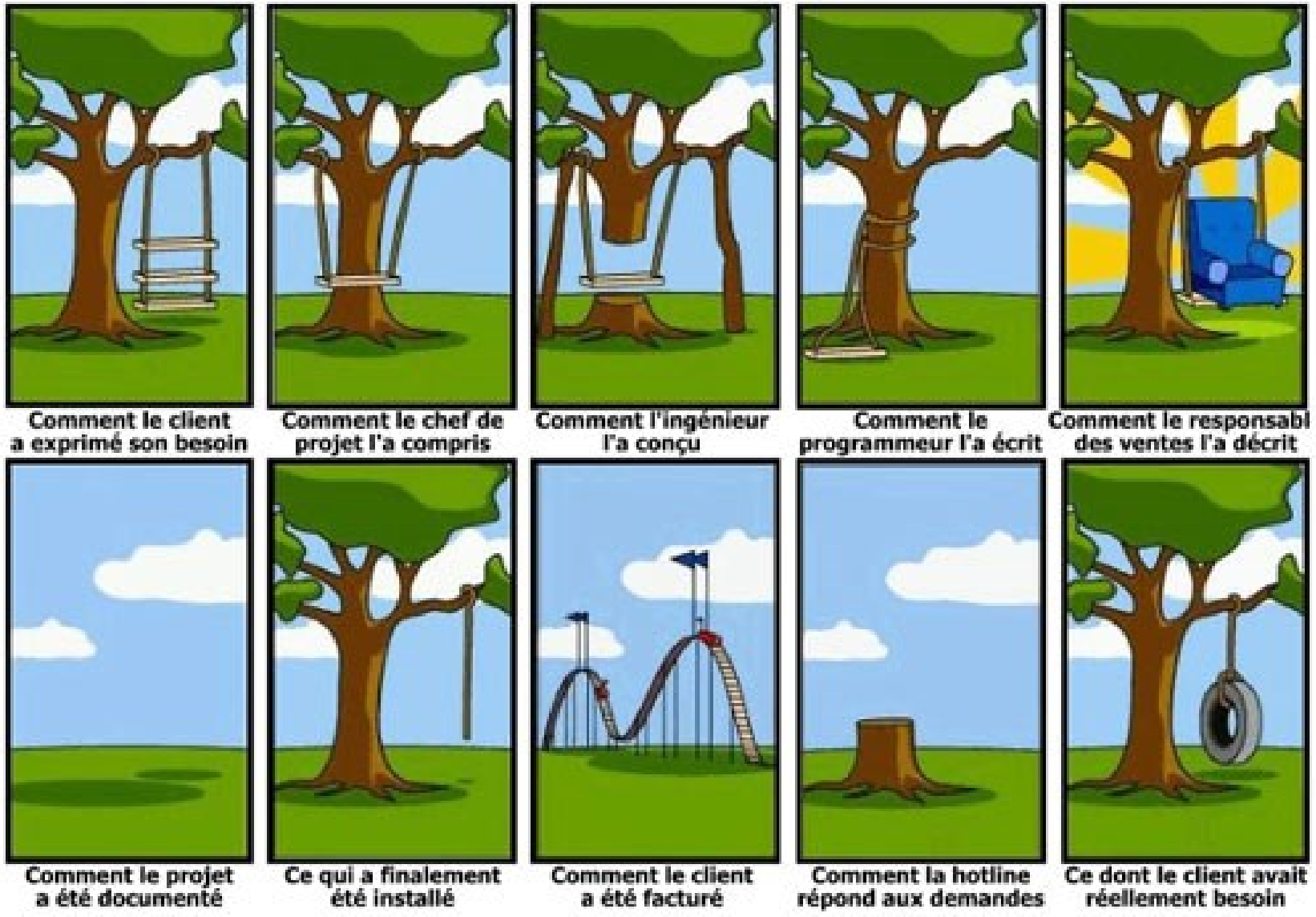
The user centered design

- ISO 9241-210 :
  - Design approach, where the **needs**, **expectations** and **characteristics** of **end users** are **taken into account at each stage** of the product development process.

- Based on the idea that end-sers are best placed to evaluate the product.

- In this approach, the development of product is *a priori* guided by the characteristics, needs and requirements of the end-users, rather than by technical possibilities.

UDC => avoid the recurring problem:



UCD and research

- Wendy Mackay
- Michel Beaudouin-Lafon
- James Landay
- Elisabeth Delozanne
- …

Iterative design(1998)

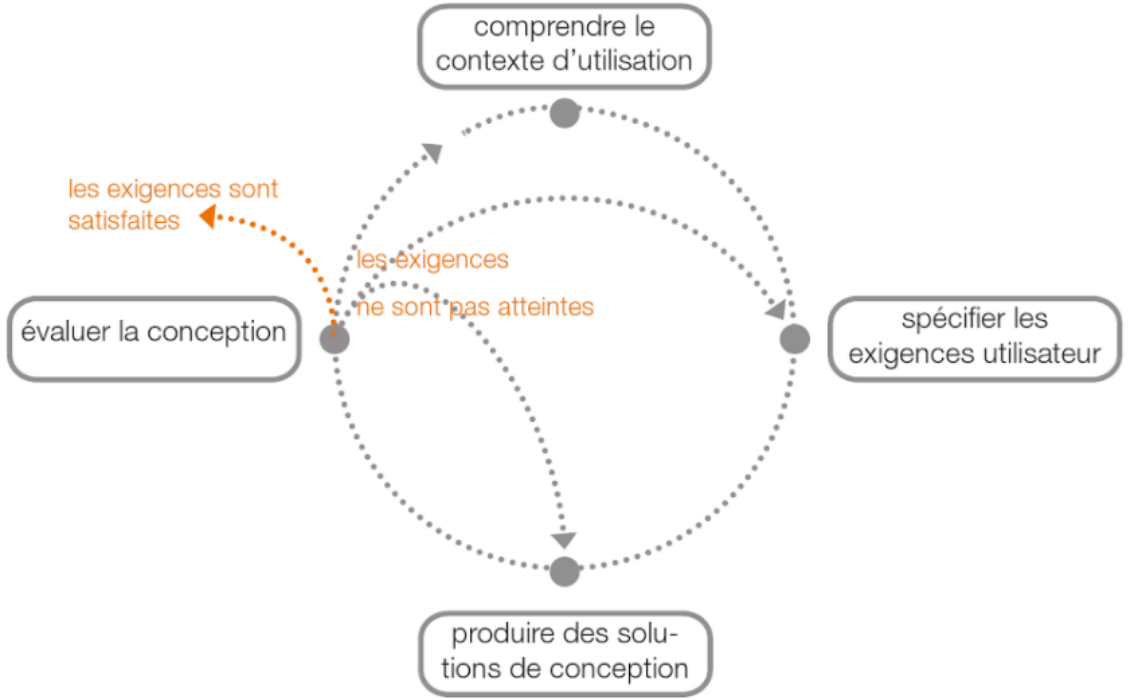


Figure 2.6. *Les quatre phases principales de la CCU, selon le schéma de la norme ISO 9241-210 [ISO 10]*

- Ref.:
  - Their work, courses, talks!
  - books :
    - *'Le design interactif: Du web design aux objets connectés',* B. Drouillat ; Dunod, 2016.
    - *'Méthode agile centrée utilisateurs',* G. Pujolle, M. Cosquer, and D. Deuff ; Hermes Science Publications, 2013.

The User Centered Design

- Five application and implementation criteria (ISO 9241-210 standard):

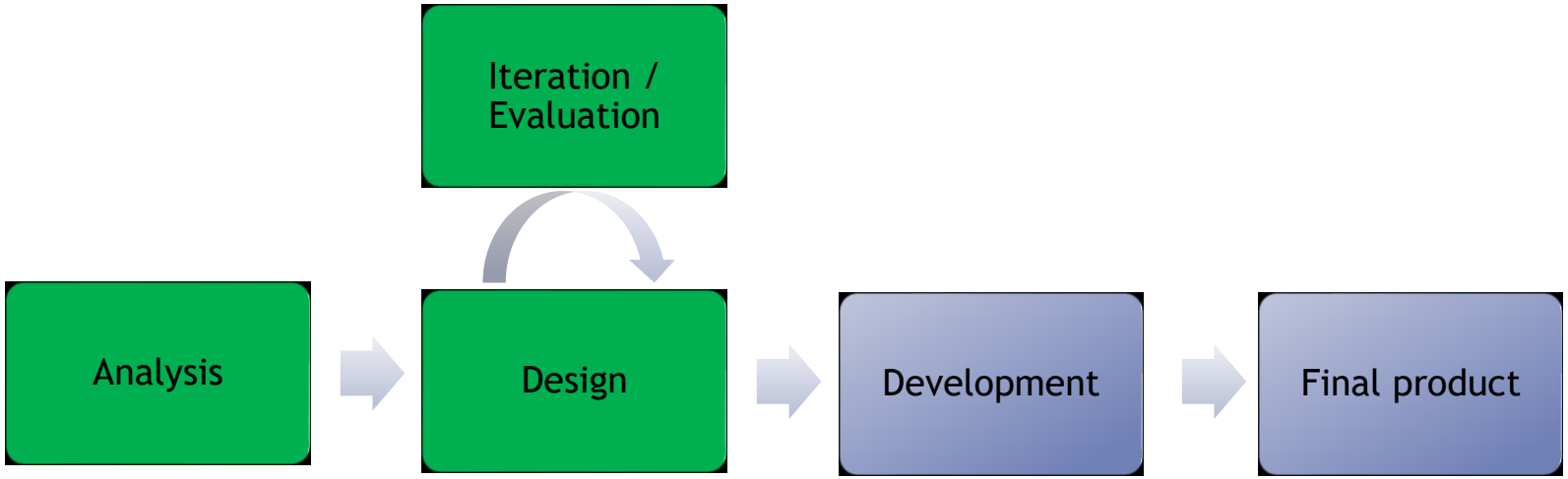
1. Upstream consideration of users, their tasks and their environment
2. Active participation of users, ensuring fidelity to the needs and requirements related to their tasks
3. Appropriate distribution of functions between users and technology
4. Iteration of the design solutions, until satisfaction of the needs and requirements expressed by the users
5. Intervention of a multidisciplinary design team, aiming for an optimal user experience

Who should take part in UCD?

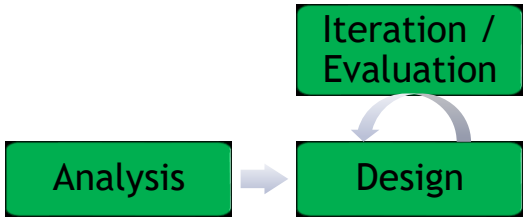
- A team
- Ideally
  - Specialists in user interaction/experience (UX)
  - Ergonomists
  - Marketing
  - Technical Writers
  - Test Engineers
  - IT Developers
  - Graphic deigners
  - Users

UCD - Consideration of users upstream

- The UCD approach = iterative process usually comprising 3 phases :



About the analysis step



Discovery of the context and needs

- Design briefing
- Benchmark
- Secondary research

User reseach

- Interviews
- Surveys
- Observations in situation
- Audience analysis
- Cards sorting

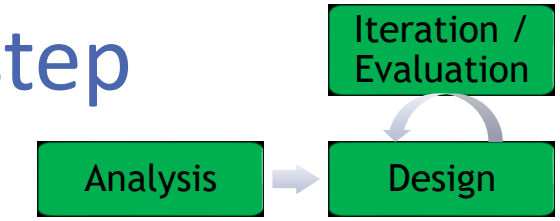
Src :Le design interactif, B. Drouillard - DUNOD

Card sorting:

- Modeling the structuring of knowledge in humans

Src : Usaddict

About the analysis step



Discovery of the context and needs

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- Observations in situation
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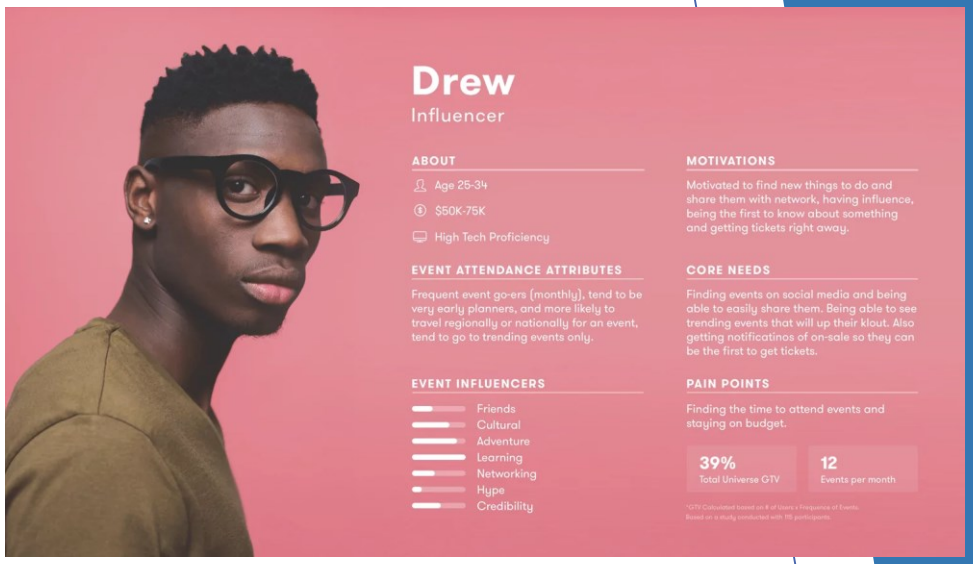
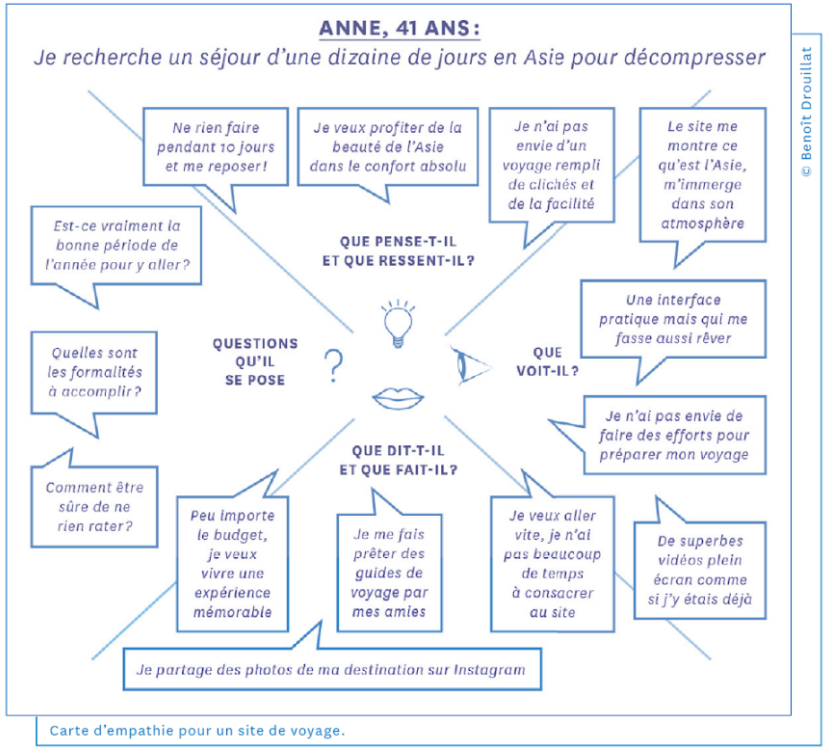
Data modeling

- Empathy Map
- Alignment diagram
- Experience Mapping
- Personas

Src: Le design interactif, B. Drouillard - DUNOD

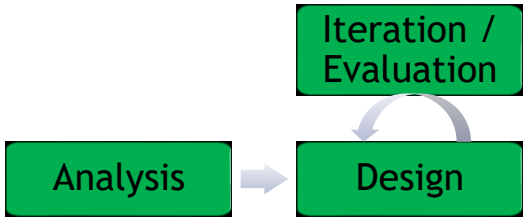


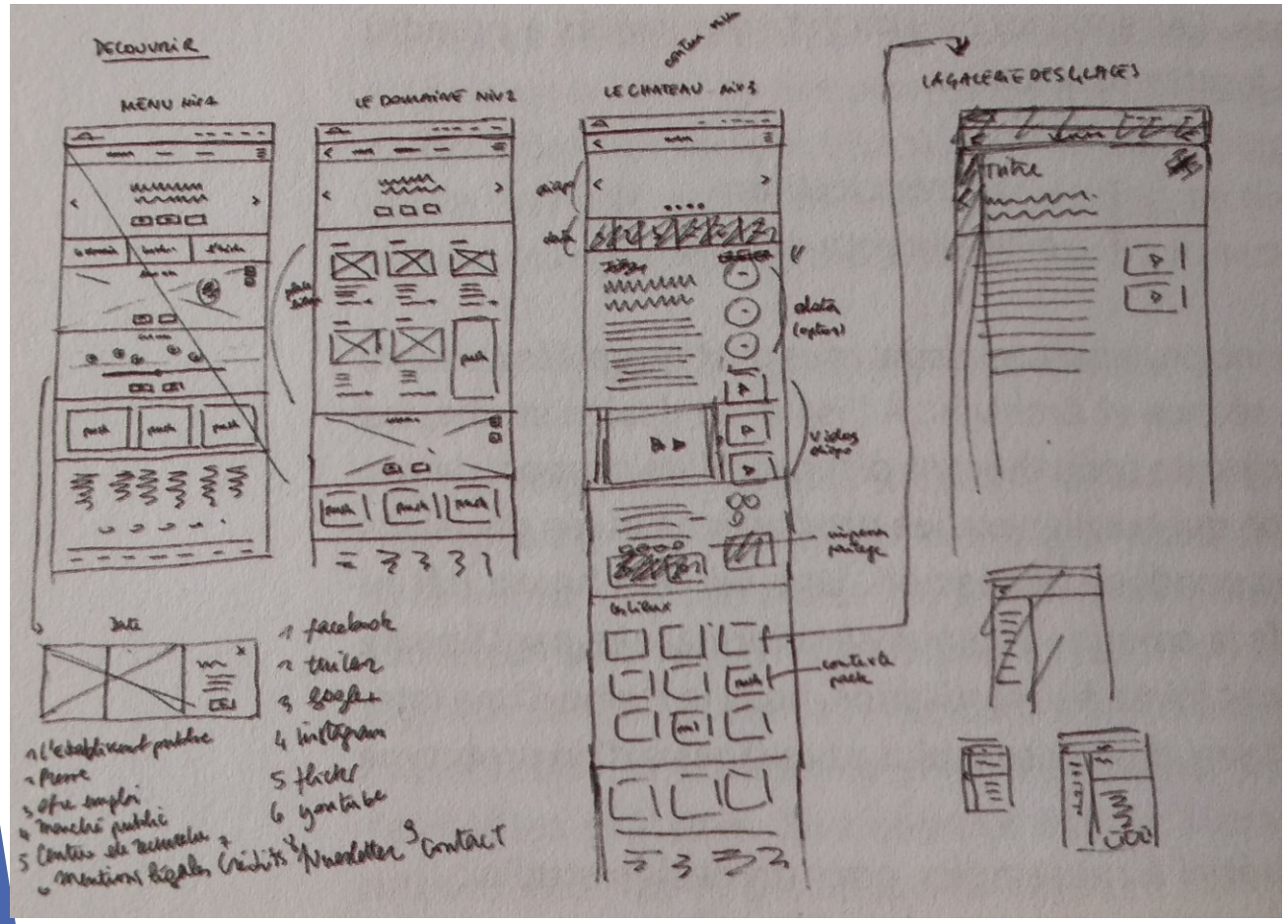
Src : UserGuiding



Carte d'empathie pour un site de voyage.

About the analysis step

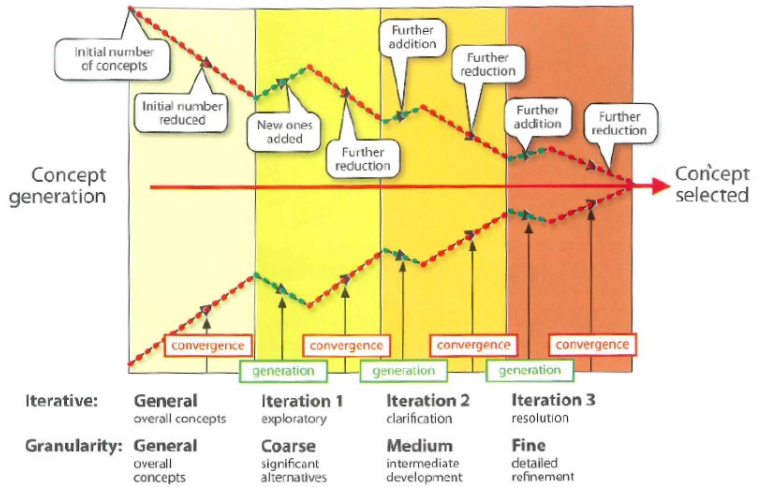




Src: Le Design Interactif, B. Drouillart (© M. Rouit et G. Al Rifaï)

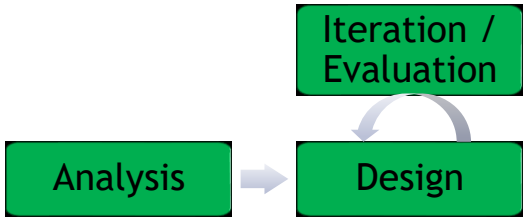
Ideation and exploration of solutions

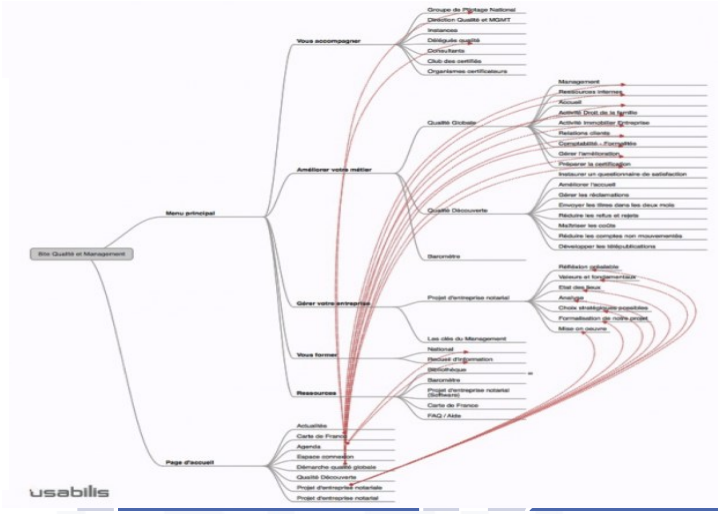
- Design studio
- Sketches and models
- Moodboard



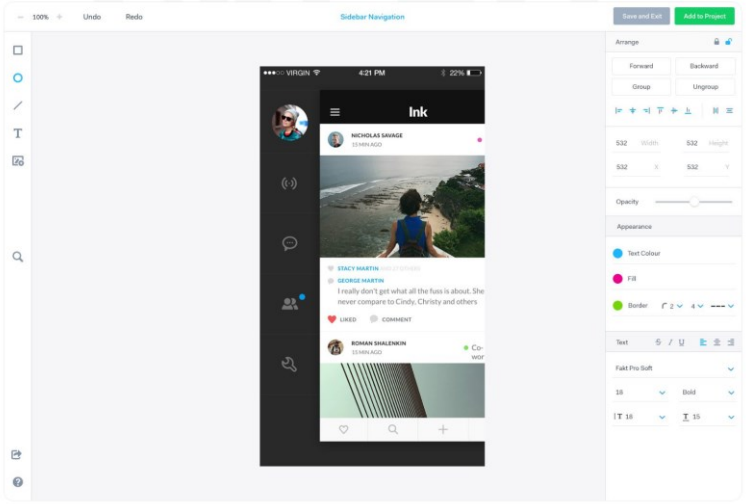
Src :Le design interactif, B. Drouillard - DUNOD

About the analysis step





Src : Usaddict

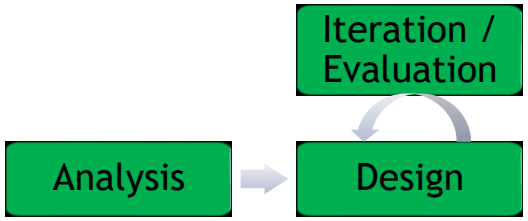


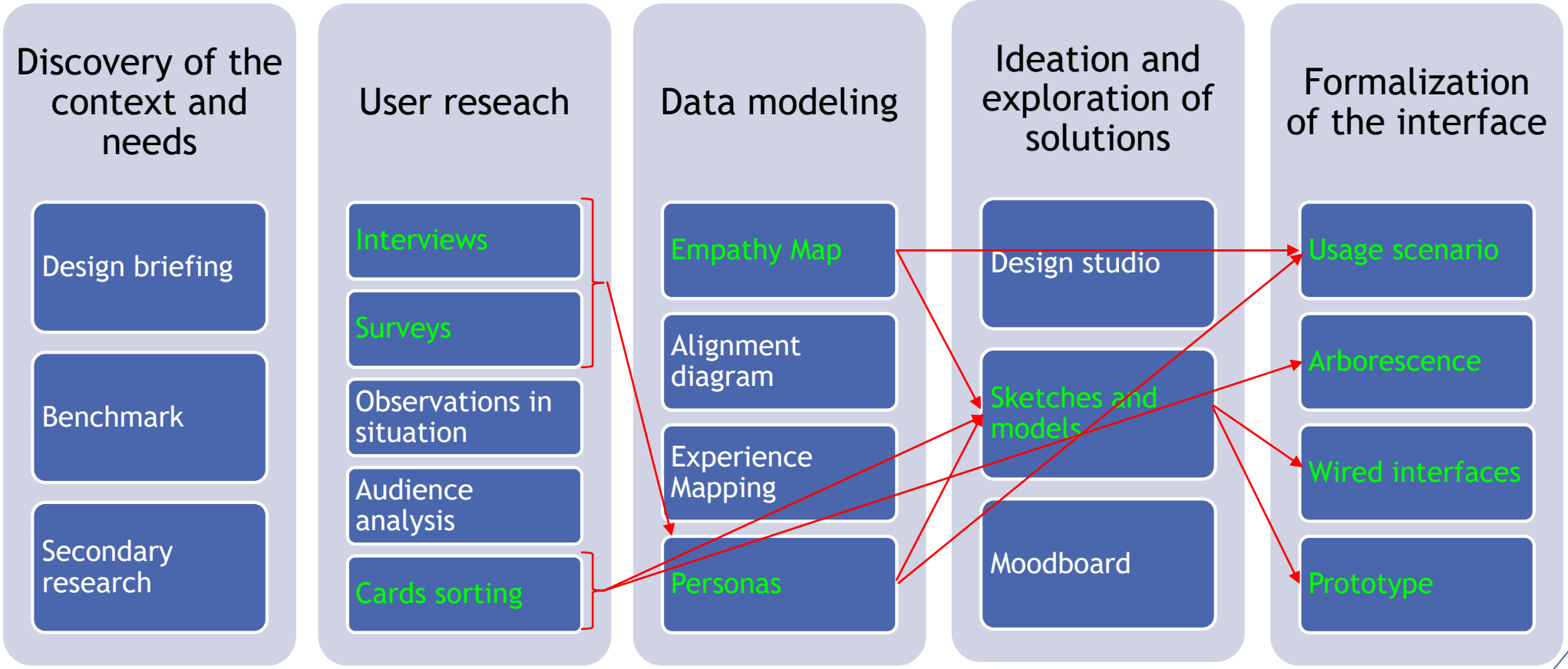
Interface filaire annotée.

Formalization of the interface

- Usage scenario
- Arborescence
- Wired interfaces
- Prototype

About the analysis step

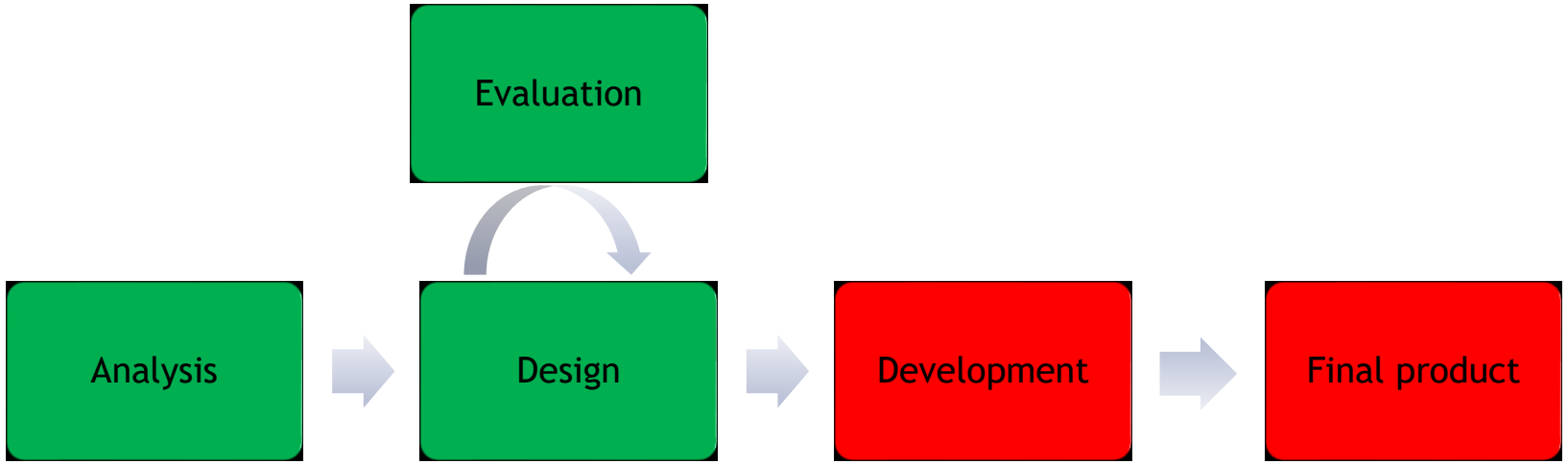


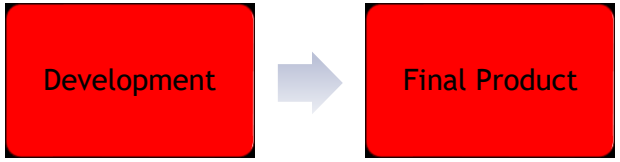


Src :Le design interactif, B. Drouillard - DUNOD

UCD – Beyond the 3 phases?

- Deficiency of the iterative process with his 3 phases



How to handle 

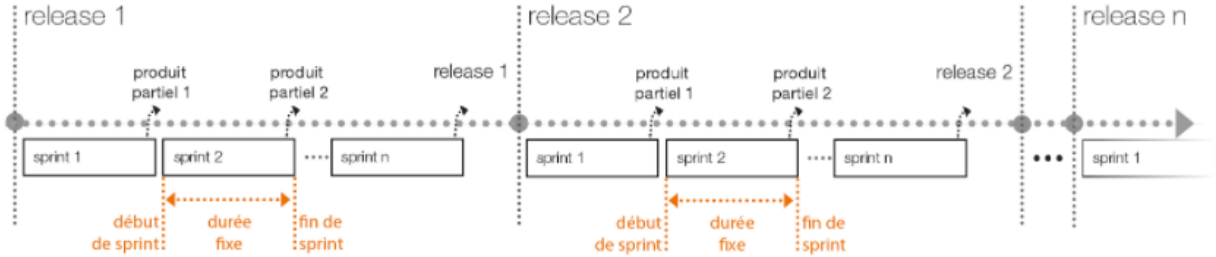
by onboarding users?

- **U**ser-**C**entered **A**gile Method (UCA) [Pujolle2013]

- Consideration of users and uses during all phases of the project
  - **Diversity of users** (accessibility context)
  - The **diversity of uses** (mobility context)

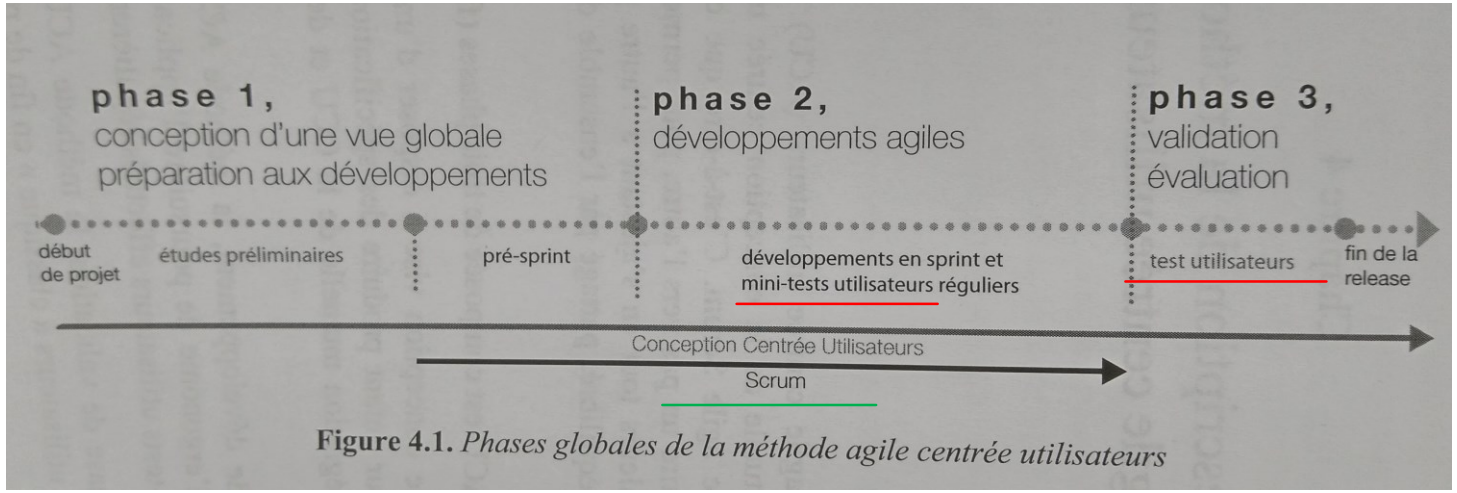
User-Centered Agile Method (UCA) [Pujolle2013]

- **Mutual integration** of:
  - User Centered Design (UCD)
  - Development in iterative Agile method: Scrum



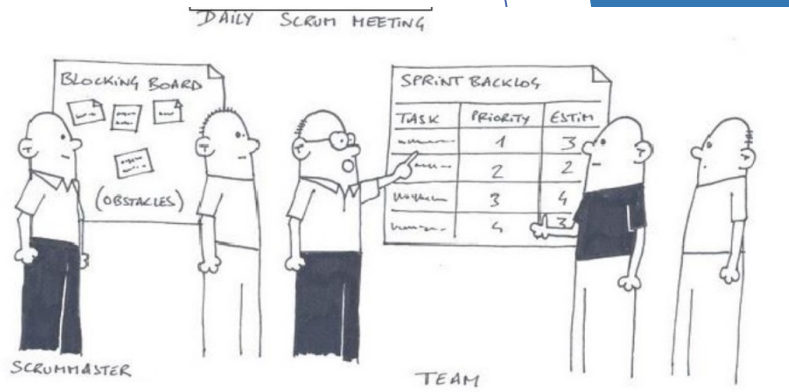
[Pujolle2013]

Figure 2.1. *Processus itératif de la méthode agile Scrum basée sur des sprints de durée fixe*



[Pujolle2013]

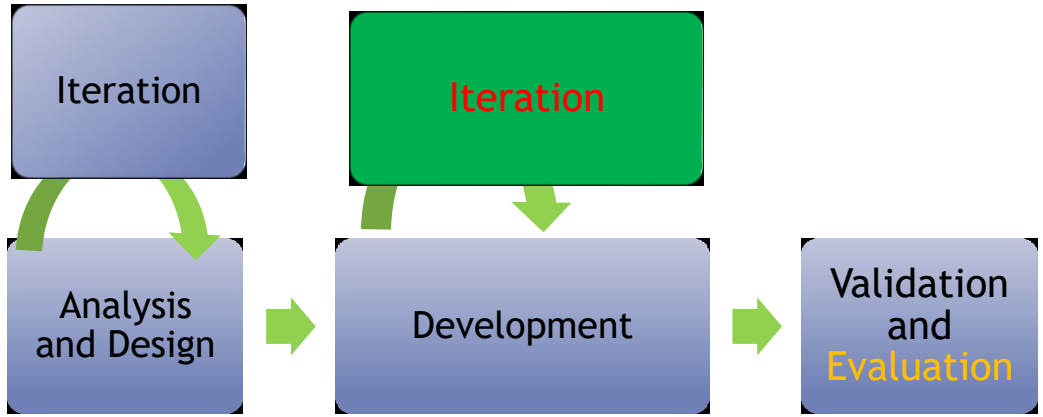
Figure 4.1. *Phases globales de la méthode agile centrée utilisateurs*



Src : https://fr.slideshare.net/veltanletharius/scrum-9758730

UCA – Agile method & UCD

- Mutual integration:
  - Adjustment of phase 1
    - Objective: obtain a global view of the product ⇒ test and evaluation of prototypes
  - Adjustment de la phase 2
    - Objective: integration of mini user tests on 'incomplete' products ⇒ end of sprint
  - Same phase 3
    - Objective: "classic' user tests



UCA – Agile method & UCD

- Adjustment of phase 2
  - integration of user mini-tests on ‘incomplete products => end of sprint
- **Add one artifact**:
  - List of recommendations or ergonomic adjustments, from a mini user test

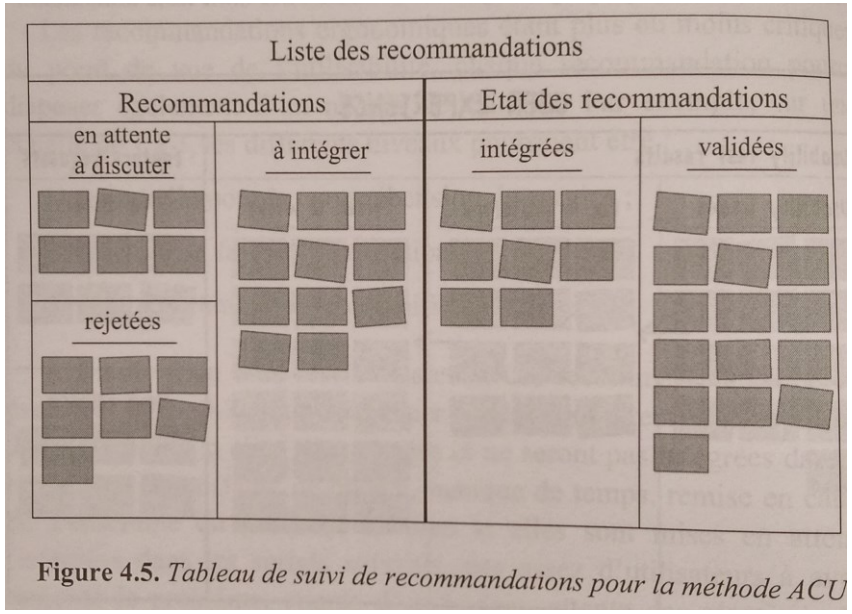
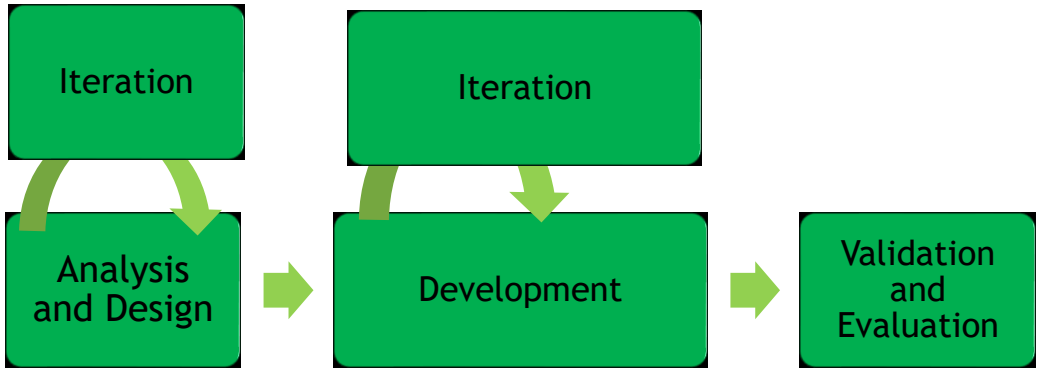


Figure 4.5. *Tableau de suivi de recommandations pour la méthode ACU*

[Pujolle2013]

Conclusion CCU

- Any project can be conducted with a CCU approach:
  - Co-design workshop,
  - Remuneration of testers
  - Surveys disseminated on the internet, …
- Don't cheat, you can't be biased/have a committed position
  - user – possible designer but particular user!!!



Reminder User-centered design – objectives and origins

The goal of the user-centered design process is to obtain a product that is functional, operational and satisfies the user [Ames2001]

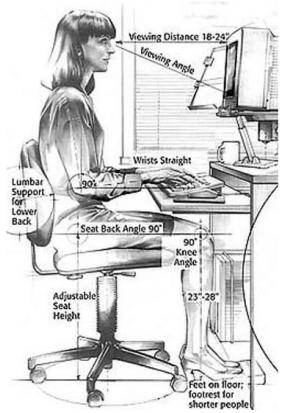
- Design of a system that is:
  - ergonomic (user-friendly)
  - usability (utilisabilité)
  - useful (utilité, usefulness/utility)
- Based on:
  - Acceptability
  - User experience (UX)
  - Affordance (facilité/perception)

How to measure these elements?

- Towards measures of usability
- Towards acceptance models

Reminder: Ergonomy – different types

- Physiological => postural requirements
- Organizational => space organization
- Cognitive => perceptual, mental



From cognitive psychology to cognitive ergonomics

- Generality:
  - Cognitive psychology:
    - Study and understand human cognitive processes
  - Cognitive ergonomics:
    - Apply these notions of psycho. cognitive to the improvement of interfaces, and human/interface interactions
- Focus on cognitive ergonomics:
  - Definition :
    - Applied component of ergonomic cognitive psychology aimed at understanding how complex intellectual behaviors develop in a work situation
  - Principles :
    - Study of mental work situations by applying the methods, concepts, and models of cognitive psychologists

Ergonomic intervention – A double analysis

1. Task analysis

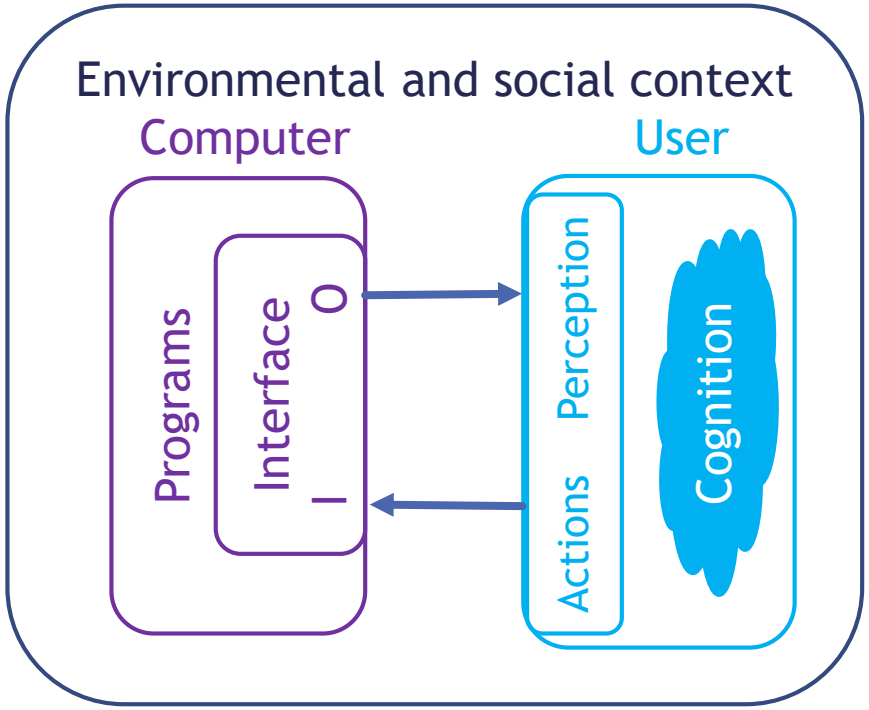
- Prescribed task:
  - What must be done => goal to be achieved
  - In a given environment
  - Sequence of subtasks / actions / user operations

Preferred by designers to the detriment of users

2. Analysis of the corresponding cognitive activity

- Task performed:
  - What is actually done => process and representations mobilized by the user to perform the sub-tasks
- Analysis of behavioral data (i.e. traces of mental activity) similar to psycho methods. experimental cognitive
- Deduction of the potential causes of a behavior by inference (statistical analysis) on the data

Ergonomic intervention – Schematization [Baccino2013]



- Information theory [Shannon1949]
  - Two information processing systems
    1. User
    2. Computer/Interface
  - Each one has:
    - Inputs:
      - Computer: keyboard, input fields, …
      - User: perception,
    - Outputs:
      - Computer: screen, interfaces, …
      - User: actions,

- Two levels of intervention:
  - Interface: input devices (dialog), output devices (screen design)
  - User: task analysis[1], analysis of mental activity (ergonomics)

1: normative documentation (ISO, AFNOR) - HCI Bibliography : Human-Computer Interaction Resources

Ergonomic Intervention – Human Processor Model

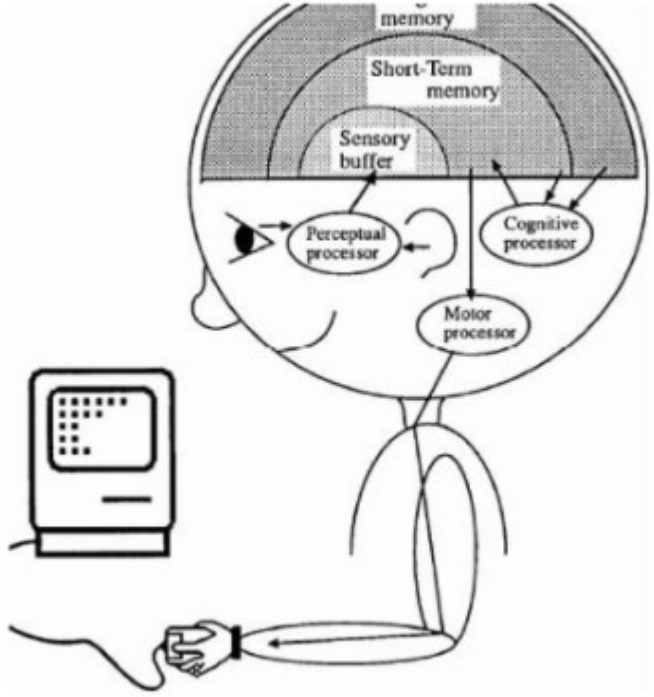
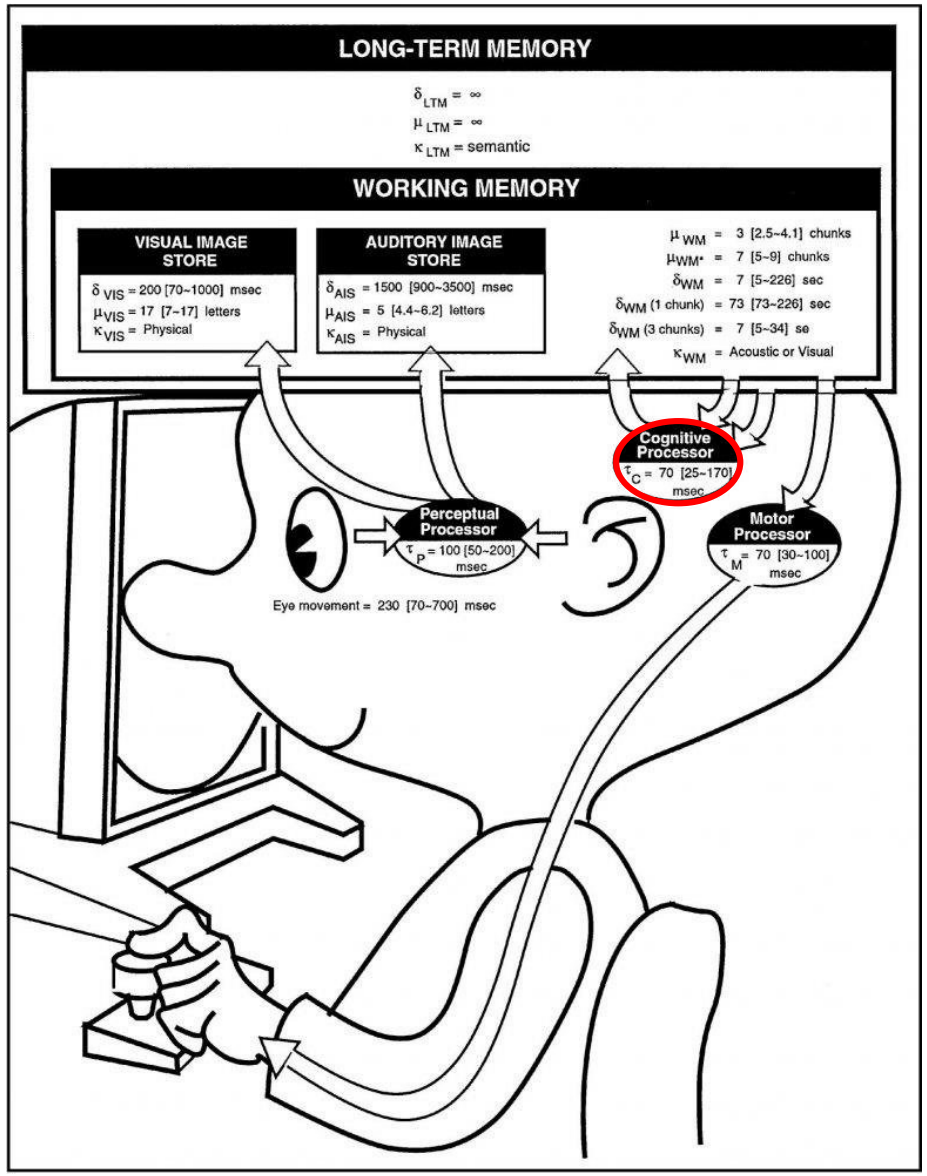


Figure A.1 Modèle du processeur humain [Card 83].

- Human Processor [Card 83]
  - Representation of the human being in the knowledge processing phase
- The individual is a system
  - Taking perceptual stimuli as input data,
  - Performing treatments and
  - Producing outputs, actions

1: normative documentation (ISO, AFNOR) - HCI Bibliography : Human-Computer Interaction Resources

Ergonomic Intervention – Human Processor Model



Src: [Card et al., 1986]

Cognitive ergonomics of HM/HO interactions

- Goals :
  - **Describe and explain** the interactions between an H and a computer system in order to **improve** the well-being of users and the overall efficiency of the systems,
- Levers:
  1. **Usability**:
     - Level of ease with which a user uses a computer product to perform a specific task,
     - ISO 9241 standard:
       - Non-static parameter => evolution / type of user / context of use
       - Need to take these parameters into account for the evaluation (of an interface)
  2. **The interface:**
     - Means (physical or cognitive) by which the Human can use a tool
     - Three types of interfaces:
       - **Linguistic interfaces**: interactions in written or oral form (e.g. command line, menu, etc.)
       - **Direct interfaces**: WIMP, direct interaction by pointing graphical objects (e.g. Windows desktop)
       - **Intelligent interfaces**: active research subject, adaptive interfaces to user behavior (ex: augmented reality, etc.)

Usability - definition

- ISO 9241 standard:
  - "A product is said to be usable when it can be used with effectiveness, efficiency and satisfaction by given users, seeking to achieve given objectives, in a given context of use."

  - **Efficiency:** the user must succeed in doing what he wants to do
  - **Efficiency**: it must be able to do it quickly and with as few errors as possible
  - **Satisfaction:** aesthetic features, learnability, comfort

- [Nielsen2003] defines usability as a "quality attribute" of a product that is concerned with 5 quality components: learnability, efficiency, memorability, errors and satisfaction.

Usability rules and norms

- Two dimensions for usability rules:
  - Preponderance: the rule must absolutely be applied in the design or only suggested
  - Generalization: the rule can be applied in many situations or only to a few specific situations
- Two types of rules according to the weights of each dimension:
  - Standards / Guidelines
- Several approaches:
  - Bastien and Scapin [Scapin1986]: focus on learnability and interface flexibility
  - Nielsen [Nielsen1990]: focuses on error reduction.
- Several norms:
  - Usability norms: **ISO 9241** (ex: screen readability rules)
  - UCD norms: 13407, 14915, 16982 (ex: conception rules – task repartition between U/C, U implication, iterative process)

Usability measurements

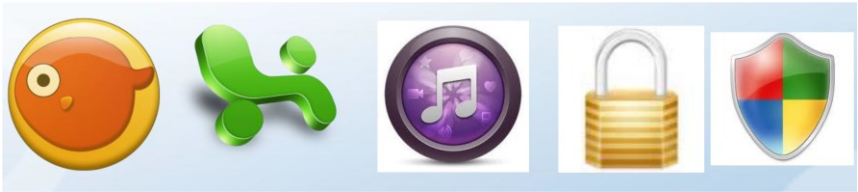
- Objective:
  - assess the system usability (*i.e.* effectiveness, efficiency, user satisfaction)
- Content:
  - set of quantitative measures on human behavior, extracted from an **heuristic evaluation** or from **User experiments/tests**

Heuristic evaluation of Usability (Inspection ergo.)

- Objective:
  - structure the criticisms of a system by a set of simple and general cognitive principles extracted from standards or recommendations
- Principles:
  - Several evaluators (5) independently criticize an interface from the user point of view
  - Critics are based on a set of rules (heuristics list) about:
    - The system state
    - The error prevention
    - The consistency ...
- Advantages/disadvantages
  - + Easy to make
  - - Subjectivity => makes difficult the results generalization
  - => more advanced stage: interviews, questionnaires, user tests => UCD
- Ex:
  - IF the interface uses the user language THEN it must use common concepts, and not use specific technical terms.
  - IF the interface minimizes the user's cognitive load THEN it should not ask the user to remember items from one action to the next, it must leave the information available on the screen until it will not serve anymore.

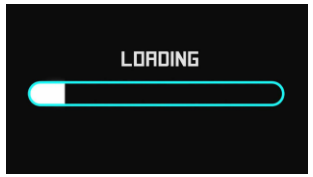
Bastien & Scapin criteria

- Guidance
- Workload
- Explicit control
- Adaptability / Flexibility
- Error management
- Homogeneity/Coherence
- Meaning of codes and denominations
- Compatibility



Guidance

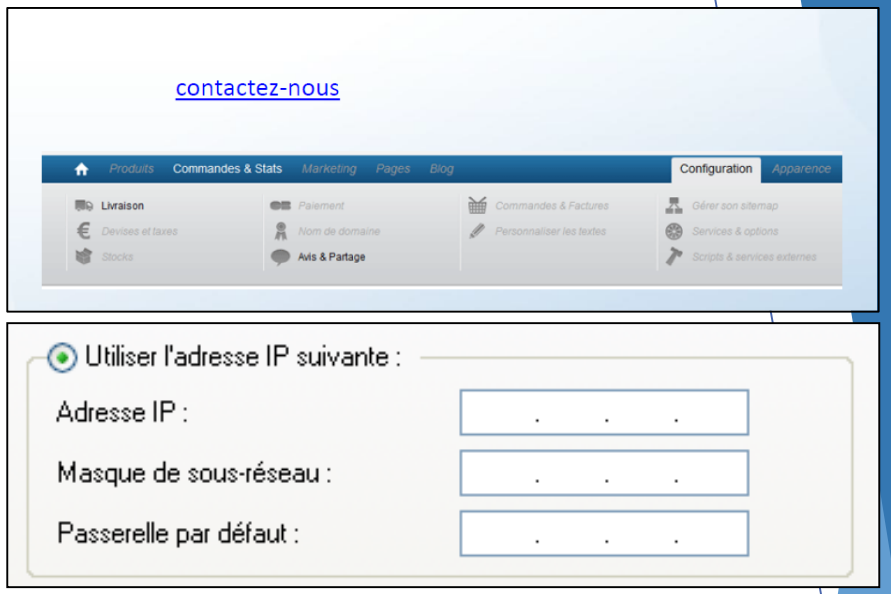
- Objective: to facilitate the use of the system and its learning
- Create feedback and feed-forward for:
  - reduce cognitive load
  - prevent error situations
  - reassure (e.g. progress of an operation)



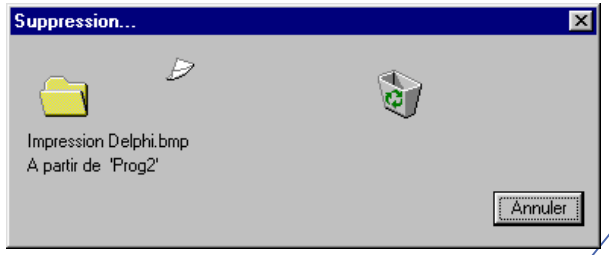
- Human perception of response time:
  - t < 0.1 sec: perceived as instantaneous
  - t < 1 sec: the delay is perceived, but does not disturb the user
  - t > 10 seconds: the user will want to do something else while waiting
  - For long delays: change of cursor, progress bar, …

Guidance - Recommendations

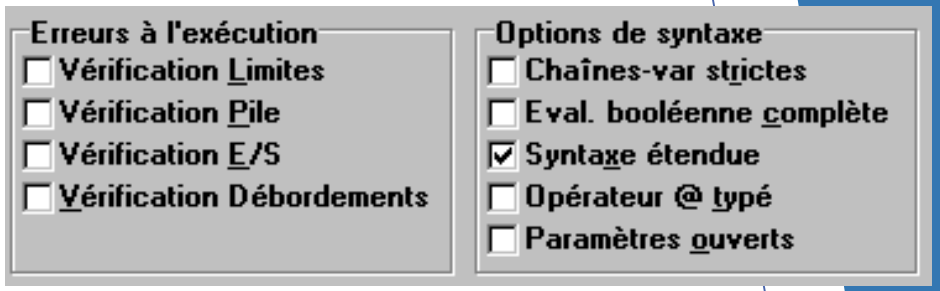
- *Feed-forward (Incitement)*
  - gray out unavailable commands
  - provide the list and format for entering the expected data
  - set “smart” defaults



- *Feed-back*
  - any user action => change of presentation of the interface
  - indicate the operating modes of the system
  - report long processing with a waiting message
  - always show user input
  - make the processing carried out by the system visible



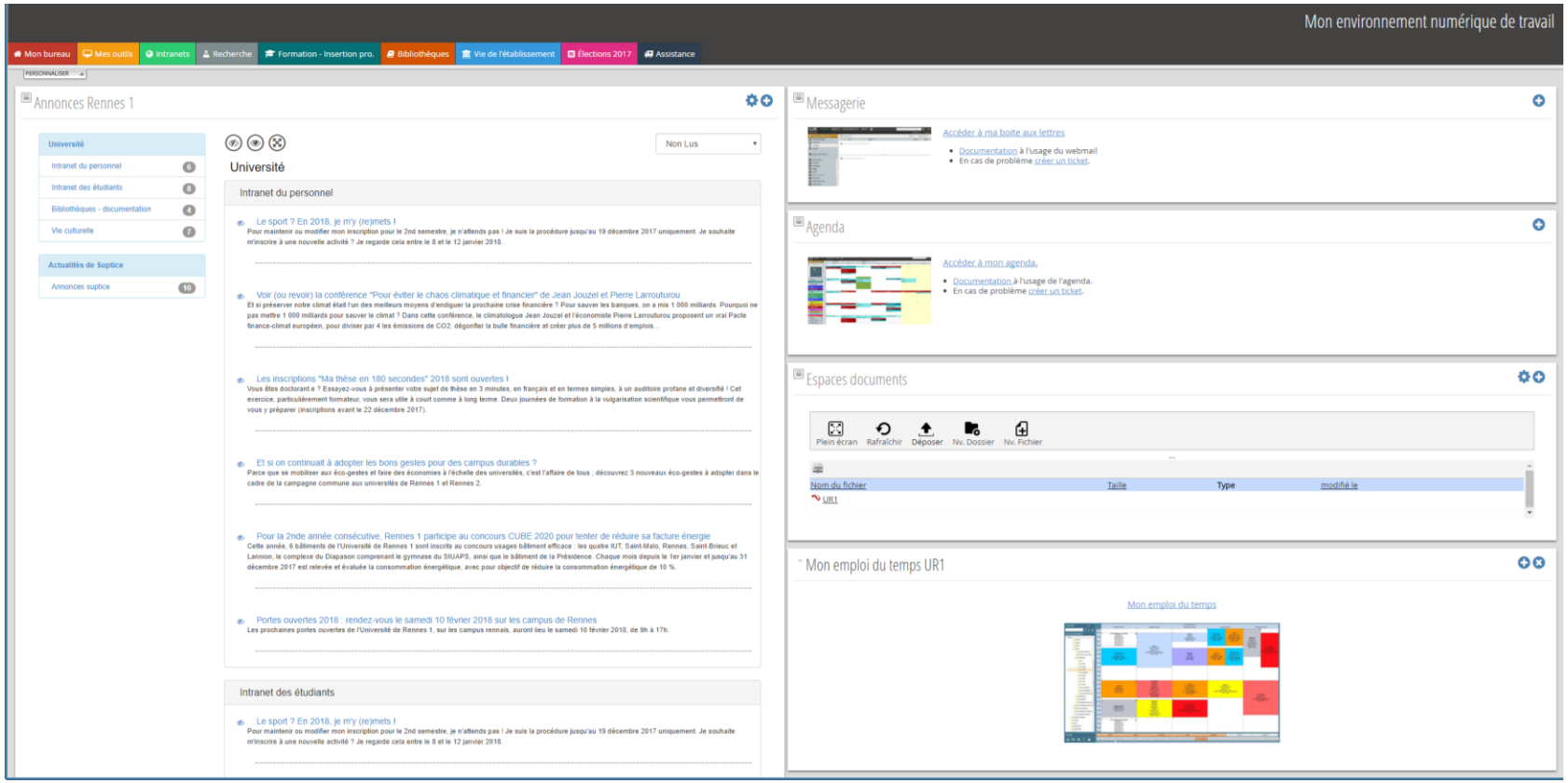
Guidance - Recommendations



- Grouping / distinction (graphic design)
  - Group information of the same type by the same format or the same position
  - Highlight different information with a separate presentation
- Readability (typography)
  - Use a straight font (sans serif)
  - Use contrast: dark letters on a light background

Workload

- Principle: Set of means aimed at **reducing the perceptual and memory load of the user**



Workload - Recommendations

- Show only relevant information
- Reduce the number of elementary actions
  - minimize inputs/reads
  - avoid overly wordy texts
- Perform automatic processing
  - no entry of deductible information (i.e. calculations, reporting of information, etc.)

Workload - Recommendations

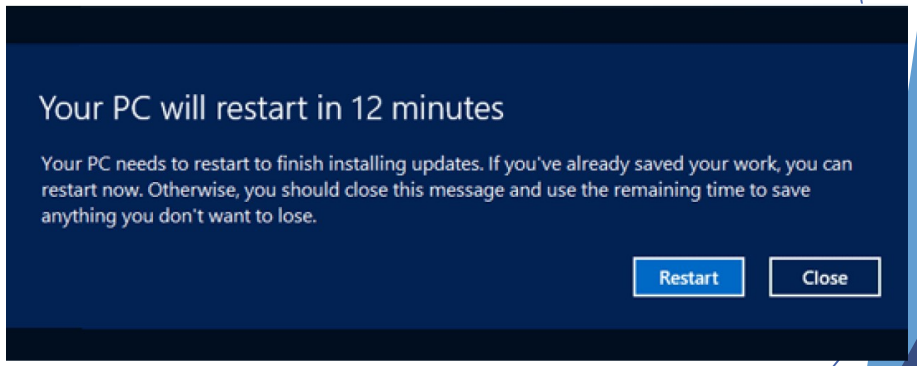
- Present **only the necessary information**
  - *less is more*: limit the number of widgets and windows that introduce additional manipulations
  - Hide or delete non-essential information
  - Use the natural order of things where possible

- Prefer :
  - **Direct manipulations** when entering commands or arguments
    - point and click instead of remember and type
  - **A small number of generic commands**
    - *Recognizing* is easier than *remembering*

Explicit Control - Recommendations

- Definition: consideration by the system of user actions, and user control over the processing of their actions

- Explicit actions
- User control: backspace



Flexibility/adaptability

- Objective: to take into account the diversity of users and situations

- Examples:
  - settings: preferences, options, dashboards
  - take into account the different levels of expertise
    - 1st use, occasional use, repeated use
  - spelling correction
  - multiple representation of concepts
    - associate several presentation objects with a given concept
    - variations on a single basic form
  - ability to solve a problem in more than one way
    - Right click + "delete" / drag and drop
  - respect for the rhythm of the user
  - avoid imposing an order for information entries

Flexibility - Recommendations

- **Allow:**
  - activating keyboard or mouse commands
  - The configuration of the software by the user according to his preferences
  - Provide a quick way to access menu commands
- **Adaptability: dynamic personalization without explicit user action**
- Experienced users should be able to quickly use the most common operations
- **Workarounds:**
  - icons
  - abbreviations (Ctrl-s)
  - mnemonics (Alt-f-e)
  - special keys (Xerox Star: move, copy, properties...)
  - auto-completion, anticipated typing (ahead type)
  - navigation mechanisms, historical
  - redo

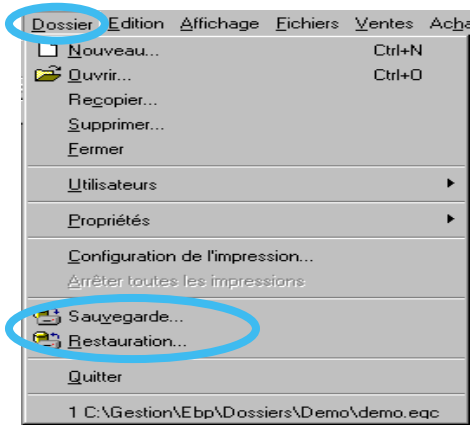
Homogeneity

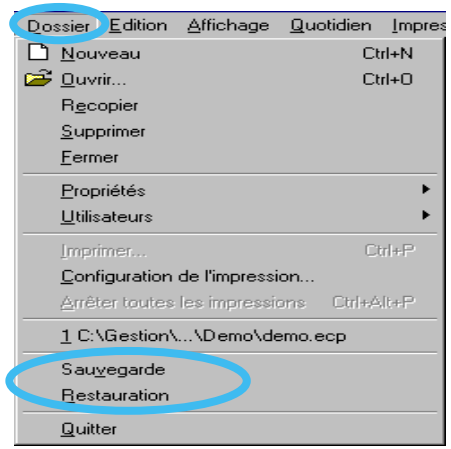
- Concerns the overall consistency of the interface
  - internal: inside an application
  - external: between applications, with the system metaphor
- Principle: a system that looks familiar is perceived as easy to use
- Interest: facilitate learning and use
- Risk: slowing down or blocking development (inertia of standards)

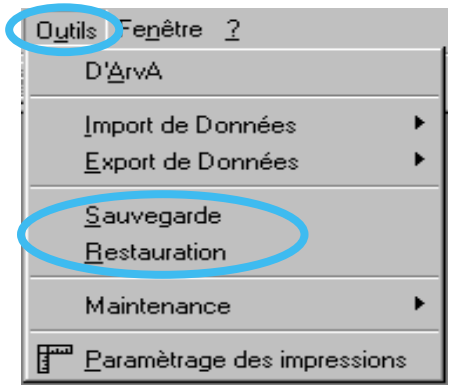
Homogénéité - Recommandation

- Master Plan:
  - the windows must follow the same layout scheme
  - Ex.: search box at the top right

- Constant semantics:
  - mouse buttons, vocabulary designating software commands
  - Ex.: open / copy-paste / preferences / ...







Compatibility

- Definition : Ability of the system to integrate into user activity

- Principles :
  - Use of the user's language
  - Consistent presentation of information / to other working media
    - ex.: electronic version of a paper form
  - Compatibility between the user's task and his access to commands
    - ex.: frequent commands at the first level of the menus

Bastien & Scapin criteria

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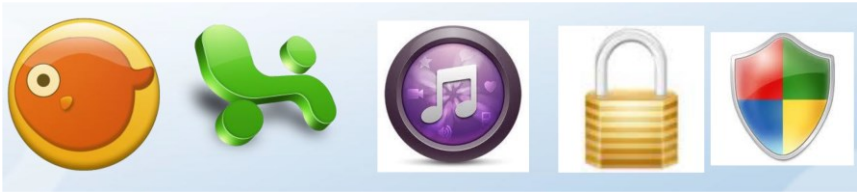


Usability measurements

- Objective:
  - assess the system usability (*i.e.* effectiveness, efficiency, user satisfaction)

- Content:
  - set of quantitative measures on human behavior, extracted from
    - an **heuristic evaluation**: Bastien & Scapin criteria [1], Nielsen & Molich [2]
      - Quantitative: number of usability problems in each category.
      - Qualitative: detailed description of individual usability problems.
    - or from **User experiments/tests**

[1] A. Bastien and D. L. Scapin, “Ergonomic criteria for the evaluation of human-computer interfaces,” Technical report No. 156, INRIA, Roquencourt, France, 1993.(url)
[2] J. Nielsen and R. Molich, “Heuristic evaluation of user interfaces,” *Proc. ACM CHI'90*, Seattle, WA, 1-5 April 1990, pp. 249-256. (url)

User test for usability measurements

- Objective:
  - Evaluation of interface and components, validation of hypotheses about the user behavior change when interface modifications

- Principles:
  - A hypothesis = **a prediction**, made by the experimenter, **about the user's behavior** in certain situations
  - Test different experimental conditions (*i.e.* different versions, or different components)
  - Based on:
    - objective, reproducible and independent facts
    - explicit objective criterion to confirm or refute the hypotheses emitted, from phenomena caused or observed
    - a knowledge transmissible to all

User test for usability measurements

- Method:
  1. Identify/detect the usability problem and extract some hypotheses about the origin
     - general level hypothesis = prediction of the user behavior in a specific situation
     - operational level hypothesis = Selection of dependent (*i.e.* behavioral measures) and independent variables (*i.e.* origins)
  2. Create experimental condition to test these hypotheses and define the user performance measures
     - experimental conditions ~ experimental factors ~ independent variables (independent of the user's behavior)
     - the measures ~ dependent variables (depend on the behavior of the user)
  3. Conduct the user tests
     - Selection of users ⇔ Design of experiment: intra-subject – inter-subject approach
  4. Analyze the extracted data with statistical tests
  5. Correct the usability problem
- Advantages/disadvantages
  - + Most powerful method
  - + Objectivity
  - - User selection
  - - Confounding variable influencing both the dependent variable and independent variable

User test for usability measurements

- The dependent variable (DV) expresses the effect of the independent variable (IV) on the behavior of the user

- **The DV measures a performance:**
  - **Qualitative values:** answers, true/false, Yes/No, … ~ evaluations by questionnaire and interviews
  - **Ordered values:** items sort, … ~ evaluations by questionnaire and interviews
  - **Quantitative values:** time, %, number of X, … ~observational evaluation

	Usability measurements		
	Effectiveness	**Efficiency**	**User satisfaction**
Task suitability	% of goals achieved	Time to complete the task	Satisfaction scale
Suitable for the expert user	Number of important functions used	Relative efficiency compared to an expert	Satisfaction scale
Learnability	% of learned functions	Learning time	Ease of use scale
Error tolerance	% of errors corrected	Time spent correcting errors	Ease of correction scale

Reminder User-centered design – objectives and origins

The goal of the user-centered design process is to obtain a product that is functional, operational and satisfies the user [Ames2001]

- Design of a system that is:
  1. ergonomic (user-friendly)
  2. usability (utilisabilité)
  3. useful (utilité, usefulness/utility)
- Based on:
  - Acceptability
  - User experience (UX)
  - Affordance (facilité/perception)

How to measure these elements?

- Towards measures of usability
- Towards acceptance models

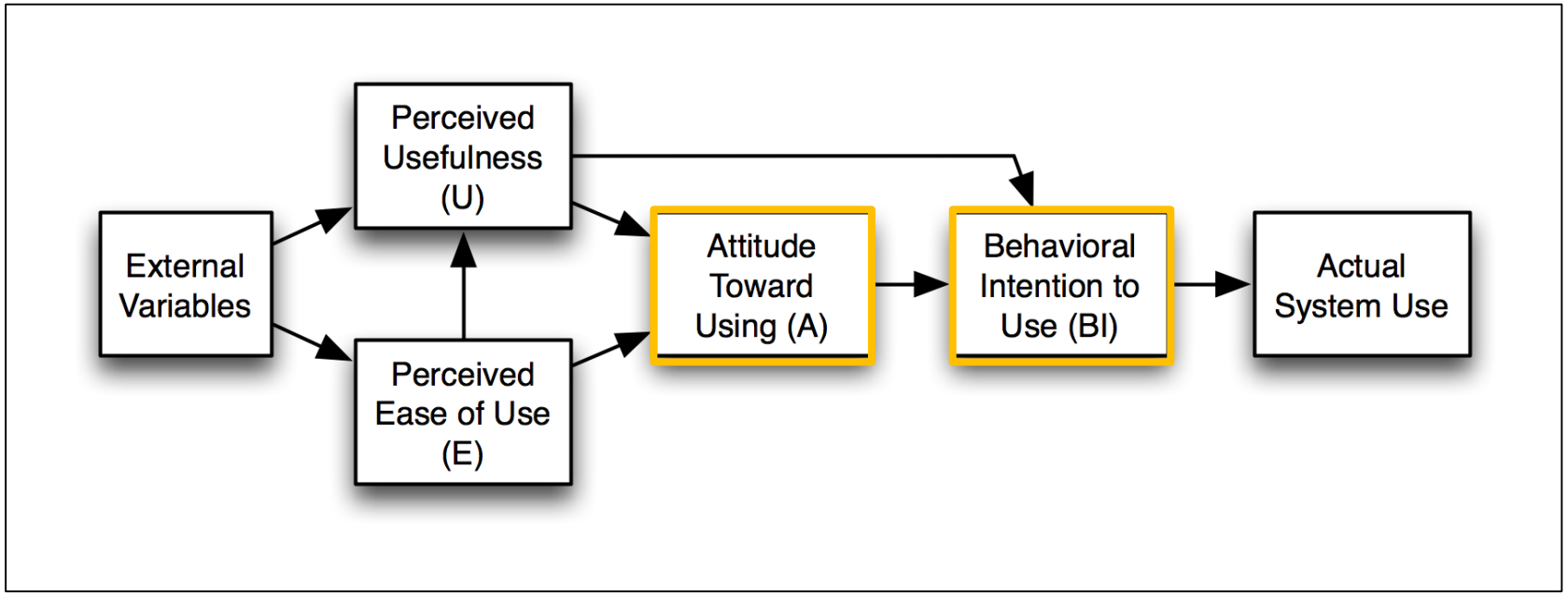
User acceptance model

- Objective:
  - Understand and model the user acceptance of an information system/technology (IT)
- Principle:
  - **Define the factors that influence user decision about how and when they will use new IT.**
  - Understand how various interventions can influence the known determinants of IT adoption and use.
- One main model in the literature:
  - From: TAM - **T**echnology **A**cceptance **M**odel [Davis1989, Bagozzi1992]
  - to its improvement & generalization: UTAUT - **U**nified **T**heory of **A**cceptance and **U**se of **T**echnology (UTAUT) [Venkatesh2003]

User acceptance model – TAM [Davis1989, Bagozzi1992]

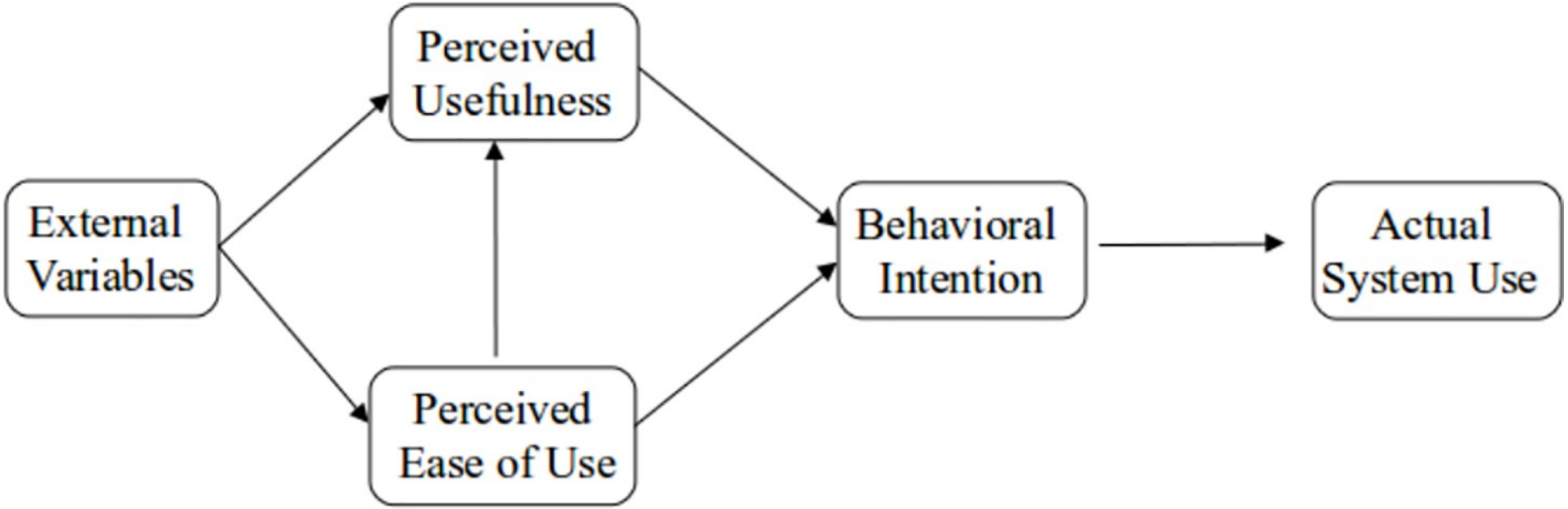
- TAM (**T**echnology **A**cceptance **M**odel):
  - An information systems theory
  - Extension of **T**heory of **R**easoned **A**ction (TRA) [Ajzen1974]
- Models how users come to accept and use a technology.
- Two influence factors:
  - **Perceived ease-of-use** (PEOU) – "the degree to which a person believes that using a particular system would be free from effort" [Davis1989].
  - **Perceived usefulness** (PU) – "the degree to which a person believes that using a particular system would enhance his or her job performance".
- Factor measurement with:
  - A psychometric scale: 5(or 7)-point Likert scale,
  - Or Osgood's differential semantic scales.

User acceptance model – TAM



[Davis1989]

User acceptance model – TAM



[Davis1996]

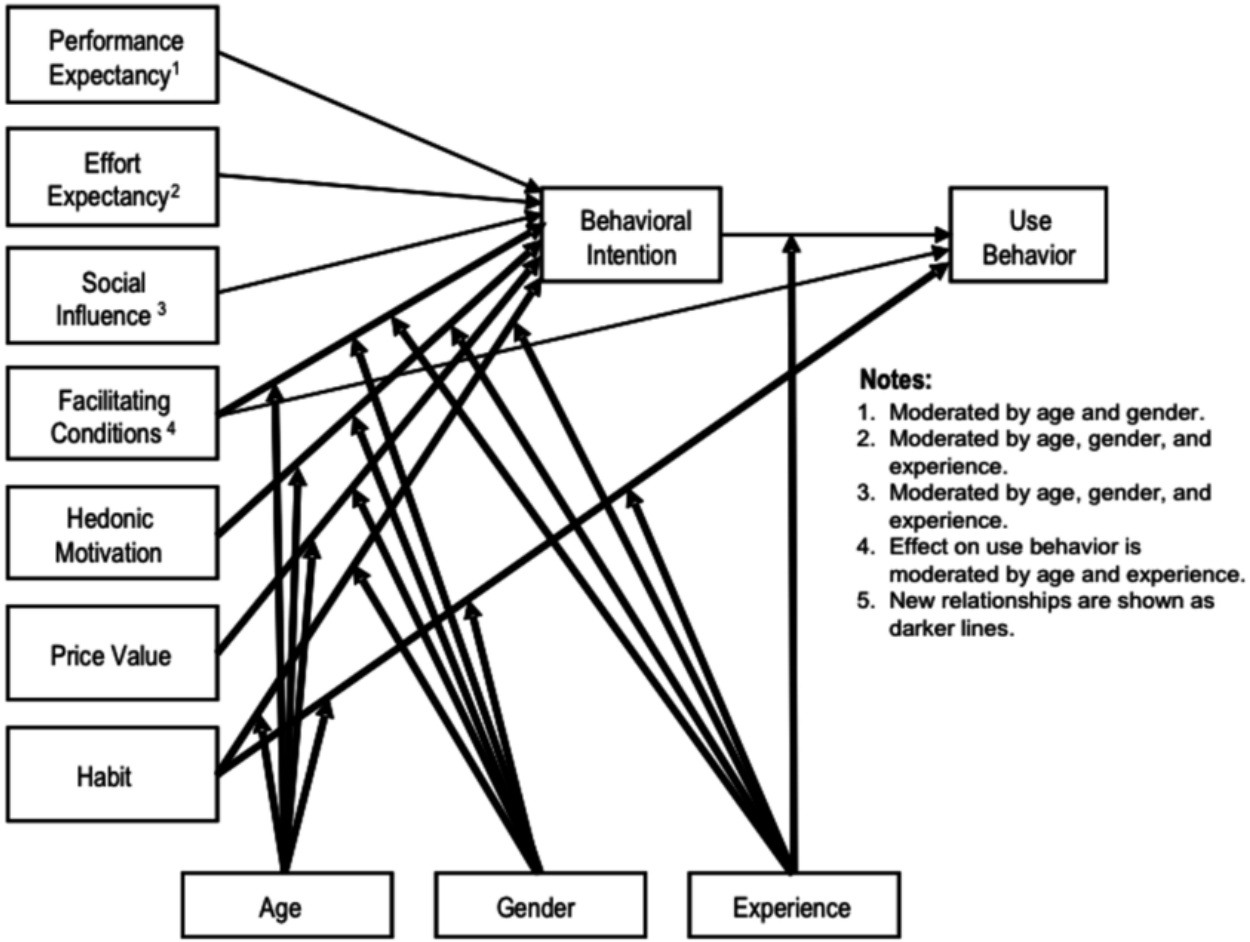
User acceptance measure - UTAUT

UTAUT - **U**nified **T**heory of **A**cceptance and **U**se of **T**echnology (UTAUT) [Venkatesh2003]

- Aims to explain:
  1. User intentions to use an information system
  2. Subsequent usage behavior.

- 4 key constructs:
  1. Performance expectancy,
  2. Effort expectancy,
  3. Social influence,
  4. Facilitating conditions.

User acceptance measure - UTAUT



[Venkatesh2012]

Data analysis

- Essential task

- Based on statistical analysis:
  - Descriptive statistic:
    - For correct description of the extracted data
    - To sum up observation results
  - Inferential statistic:
    - For facts interpretation in an environment where we do not know all the parameters
    - To estimate the results validity

Data analysis – Example [Baccino2013]

User	Expertise (0 novice ; 1 expert)	Comfort (1- very difficult ; 5 - very easy)	Executing time (s)	#visited web pages
1	1	4	120	1
2	1	5	134	2
3	0	2	340	5
4	1	4	95	2
5	0	3	360	6
6	0	1	412	8
7	0	1	356	7
8	0	2	400	5
9	0	2	521	5
10	1	4	154	2

Descriptive statistic

- Based on all extracted measures
- Two main types of descriptive statistic:
  - Numerical sum up: mean, median, frequency, range, standard deviation, variance
  - Graphic sum up: Histograms, distributions,…

Descriptive statistic - Numerical sum up

- Represent the extracted data with statistical indicator

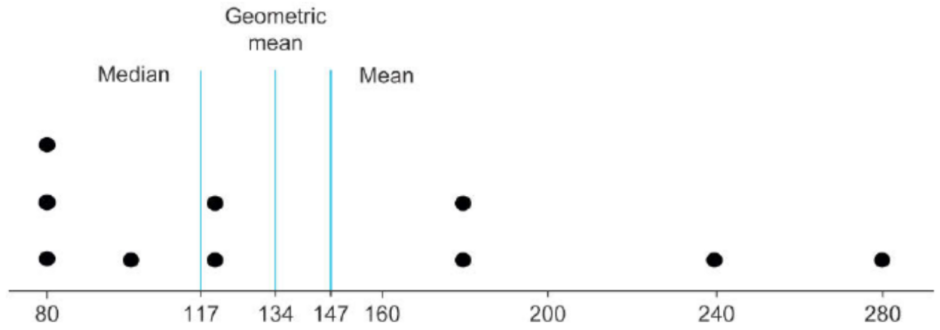
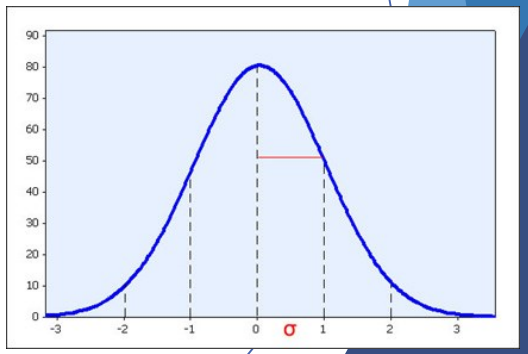


FIGURE A.2 Difference in "average" point estimates

- Measuring Central Tendency
  - Mean: simple but sensitive to outliers
  - Median: simple but powerless with small sample of data (less than 25 or so)
  - Geometric Mean: require log/exp transformation,



- Standard Deviation and Variance
  - measure of the spread of the data around the average.
  - Variance: hard to think in terms of squared differences
  - Standard deviation: an intuitive way to describe the spread of data

Descriptive statistic - Numerical sum up

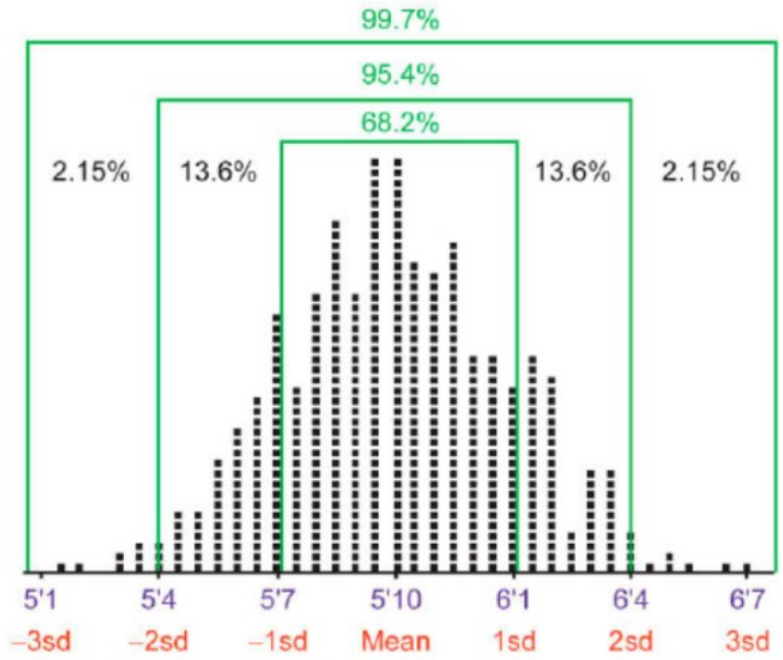
- Frequency:
  - For qualitative descriptors: with contingency table
  - From sub-scale of numerical descriptors : with contingency table

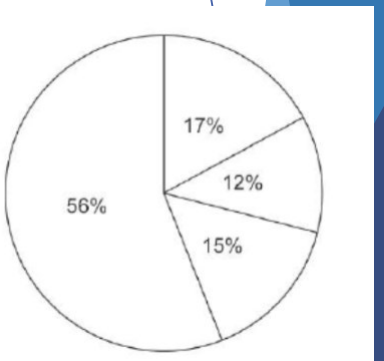
	< 150 s	> 150 s
Expert	3	1
Novice	0	6

	Expertise	Comfort	Executing time (s)	#visited web pages
Mean		2,8	289,2	4,3
Median		2,5	348	5
Frequency (%)	40 % expert			
Range		4	426	7
StDv		1,4	149,76	2,41

Descriptive statistic - Graphical sum up

- Make the understanding easier
- Highlight:
  - The data distribution
    - Normal distribution => Parametric tests
      - Empirical Rule: almost all the values will fall within three standard deviations above and below the mean
    - Non-normal data => projection or non-parametric tests
  - The outliers
- Examples:
  - Histogram:
    - X-axis represents the observed metrics
    - Y-axis represents the independent variable
  - Scatter plot
  - Line or column charts
  - Pie charts





Inferential statistic

- Objective:
  - Explain the user behavior during a specific task and in a specific situation
- Principle:
  - Extract the intensity and reliability of results
- Several conditions for different tests !
- 2 main targets in ergonomic:
  - relational analysis => correlation, and regression
  - difference analysis => hypothesis test

Inferential statistic - conditions

- Variable type:
  - Qualitative and ordered variables => non-parametric tests
  - Quantitative variables => parametric tests
- Sample type:
  - Dependent sample: some sample belong to more than one group
  - Independent sample: all sample belong to at most one group
- Number of conditions, according the test protocol:
  - 1 grp / several interfaces
  - 2 grps / several interfaces

Inferential statistic – relational analysis

- Correlation:
  - Are two measurements associated or independent?
  - Example: is there a significant correlation between perceived usability and likelihood-to-recommend?
- Regression:
  - Can I use one variable to predict the other with reasonable accuracy?
  - Example: if I know the perceived usability as measured with the System Usability Scale (SUS), can I accurately predict likelihood-to-recommend?
- ANOVA:
  - Example: Are the mean scores for websites all the same, or is at least one of them different?

Inferential statistic – relational analysis

- Correlation:
  - Are two measurements associated or independent?
  - Example: is there a significant correlation between perceived usability and likelihood-to-recommend?

$$r = \frac{SS_{xy}}{\sqrt{(SS_{xx})(SS_{yy})}}$$

where:

$$SS_{xx} = \sum (x_i - \bar{x})^2$$

$$SS_{yy} = \sum (y_i - \bar{y})^2$$

$$SS_{xy} = \sum (x_i - \bar{x})(y_i - \bar{y})$$

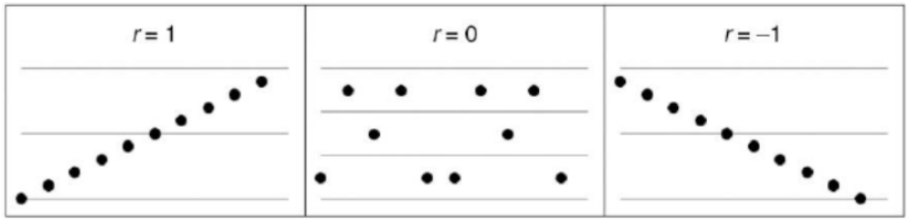


FIGURE 10.1 Scatterplots of various relationships between variables

From left to right: perfect positive correlation, no correlation, and perfect negative correlation.

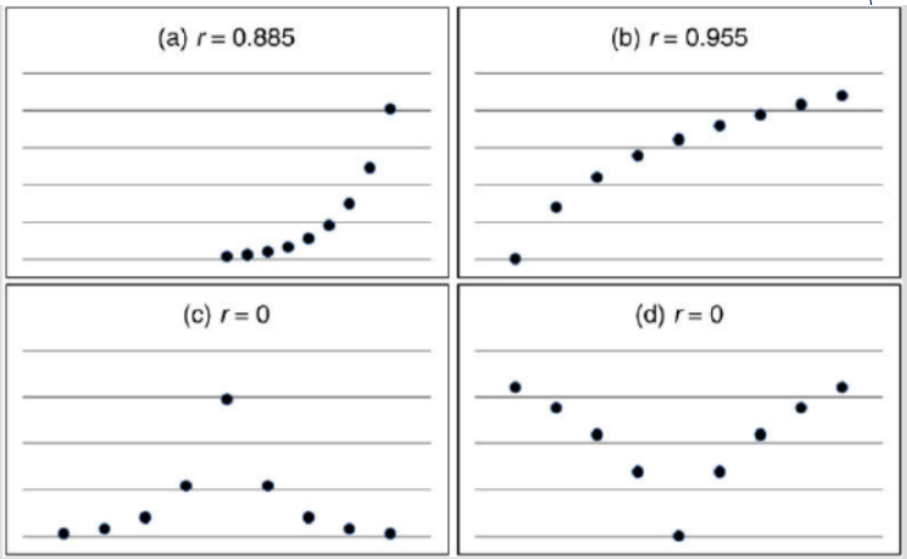


FIGURE 10.3 Graphs of nonlinear patterns

Inferential statistic – relational analysis

- Regression:
  - Can I use one variable to predict the other with reasonable accuracy?
  - Example: if I know the perceived usability as measured with the System Usability Scale (SUS), can I accurately predict likelihood-to-recommend?
- The regression equation takes the general form of:

$$\hat{y} = b_0 + b_1 x + e$$

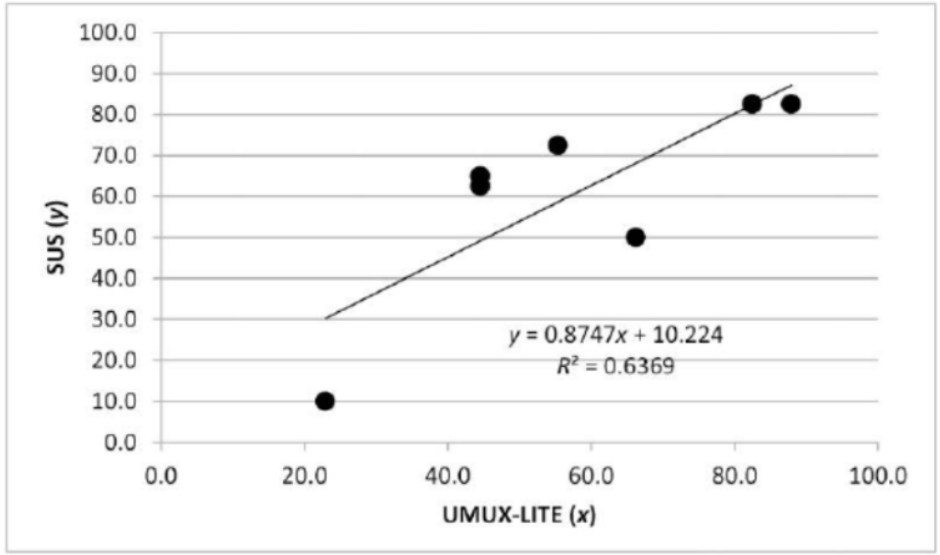


FIGURE 10.4 A least-squares regression line

Inferential statistic – relational analysis

- Tests correlationnels disponibles / conditions

Mesures	2 conditions	> 2 conditions
Var numériques	R de Bravais Pearson	Analyse de regression multiple (ARM)
Var ordinales	Rho de Spearman	
Var nominales	Phi de Cramer	

Inferential statistic – hypothesis analysis

- ANOVA:
  - Example: Are the mean scores for websites all the same, or is at least one of them different?

- Null hypothesis: all means are equal
- Alternative hypothesis: at least one of the means is different from at least one of the others

- Primary assumptions:
  - Representativeness: The samples are representative of the populations to which the researcher intends to generalize the results.
  - Independence: Data collected from each participant should not affect the scores of other participants.
  - Homogeneity of Variance: Each group should have roughly equal standard deviations.
  - Normality: The sampling distributions of the means for each group should be normal.

- ANOVA is considered generally robust to violations of normality and homogeneity of variance.
- But with very unequal sample sizes and vastly different variances => nonparametric test

Inferential statistic – hypothesis analysis

- Tests d'hypothèses disponibles / conditions

Mesures	Echantillon	2 conditions	> 2 conditions
Paramétriques (var numériques)	Ech. Indépendant	T. De Student	ANOVA
	Ech. Dépendant	T. De Student	ANOVA
Non paramétriques (var ordinales)	Ech. Indépendant	Test de Mann Whithney	ANOVA de Kruskal-Wallis
	Ech. Dépendant	Test de Wilcoxon	ANOVA de Friedman
Tableaux de contingence (Var nominales)	Ech. Indépendant	Chi^2 de contingence	Chi^2 de contingence
	Ech. Dépendant	Chi^2 de MacNemar	Q de Cochran

Data Exploration

- Objective:
  - Structure a priori the data.
- Principle:
  - Highlight clusters, or specify scale metrics to succeed in behaviour analysis
- Examples:
  - Reliability analysis of a scale
  - Data classification

Data Exploration

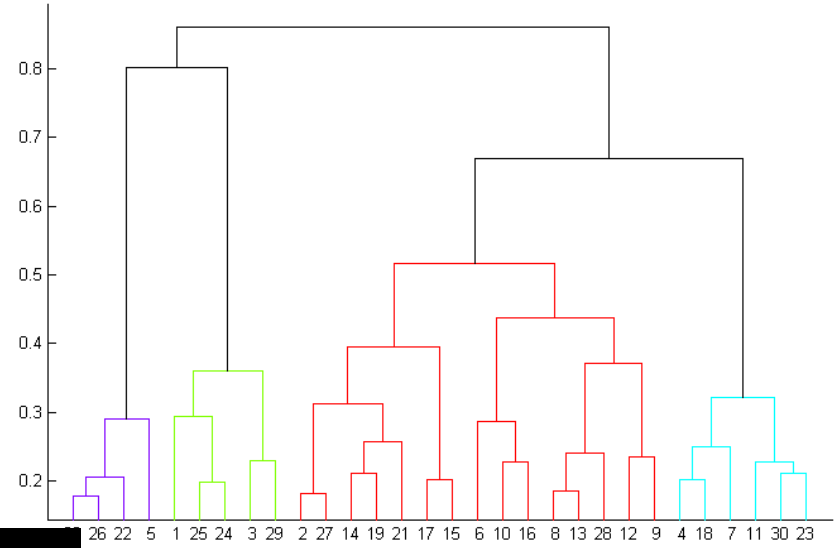
- Reliability analysis of a scale

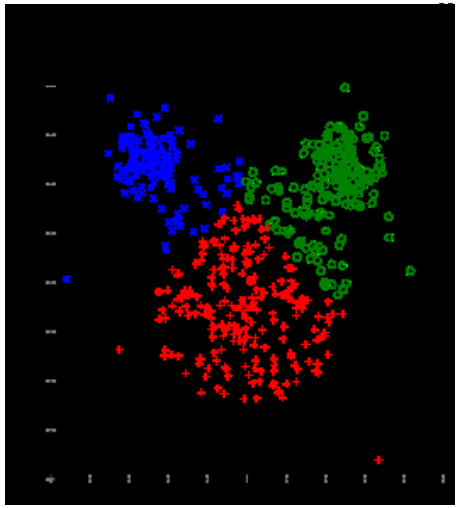
- Principle:
  - Used when behavior is difficult to observe
  - Correlation computation (alpha de Cronbach):
    - to extract the data consistency
    - Between metrics and variances of observed answers for each question
  - Reliability: how the measure (i.e. answer to a question) taken on a scale reflects the true result of the dimension to be measured, relative to the error.

Data Exploration

- Data classification

- Principle:
  - Used when no hypothesis about behavior is made a priori
  - Define clusters of data
  - Mainly based on distance between samples
  - Main approaches in ergonomics:
    - Hierarchical Ascending Classification
    - K-means clustering
  - Difficult with big data





Data analysis - conclusion

- Several statistic methods used in ergonomics
- Selection of the method based on data type and analysis objectives

- About statistic methods:
  - See details: http://eric.univ-lyon2.fr/~ricco/cours/supports_data_mining.html

IntuiScript

Conception d'un cahier numérique pour l'aide à l'apprentissage de l'écriture à l'école en utilisant des tablettes équipées de stylet : la Solution Kaligo

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Professeur
INSA Rennes
–
Responsable équipe IntuiDoc
Laboratoire de l'IRISA

Nathalie BONNETON-BOTTE

MCF Psychologie-LP3C
–
Responsable Master HG2DS
ESPE de Bretagne site de Saint-Brieuc
–

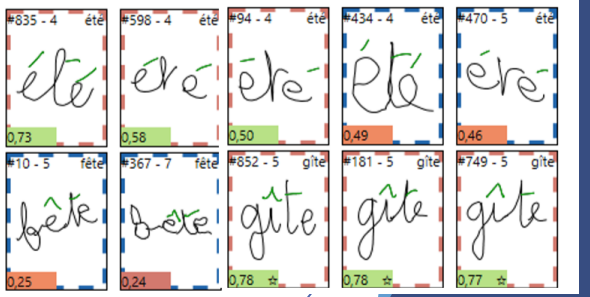
Etude d'impact : évaluation scientifique

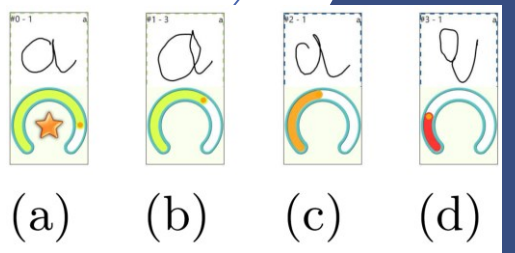
Impact de Kaligo sur l'apprentissage

- **Collaborations / Auteurs**
  - IRISA, ESPE, Loustic et Académie
  - N. Bonneton-Botté, S. Fleury, E. Anquetil, M. Renault, M. Le Magadou, N. Girard, E. Jamet.

- **Revue internationale en préparation**
  - Computers & Education

- **Conditions expérimentales (2017-2018)**
  - **233** enfants (111 filles, 122 garçons)
  - **22** écoles (Grande Section)
    - 9 écoles (137 enfants, utilisant *Kaligo*)
    - 13 écoles (96 enfants, apprentissage classique)
  - **4 mois** d'apprentissage de l'écriture à l'école





Objectifs

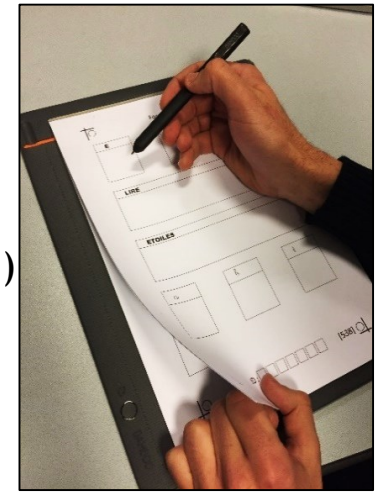
- ✓ Il s'agit d'objectiver l'efficacité d'un entraînement Kaligo d'une durée de 4 mois par comparaison à un entraînement traditionnel réalisé en classe par les enseignants. Nous supposons que l'IA de Kaligo (guidage + feedback) constitue une plus-value pour l'apprentissage de l'écriture manuscrite en dernière année de maternelle.

- ✓ De façon exploratoire, d'observer si l'effet de l'application sera le même au regard du niveau grapho-moteur initial des apprenants.

- ▶

Etude d'impact: Protocol expérimental

233 enfants
22 écoles
(Grande section)



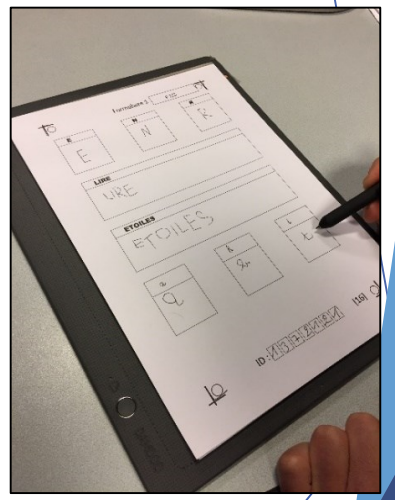
Evaluation initiale sur papier
avec capture numérique

13 écoles (96 enfants)
papier

4 mois
d'apprentissage

9 écoles (137 enfants)

Kaligo



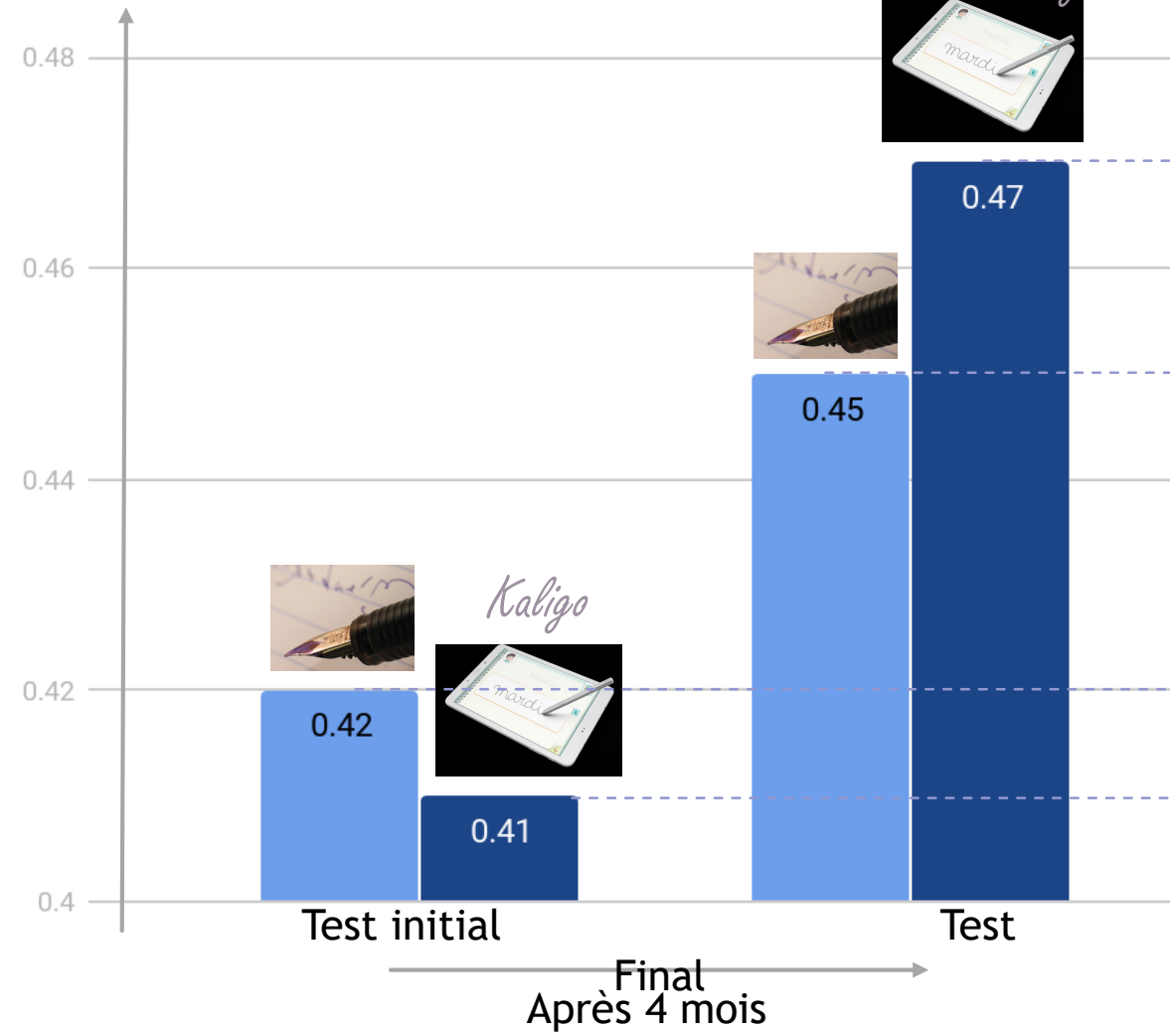
Evaluation finale sur papier
avec capture numérique

TESTS et MESURES

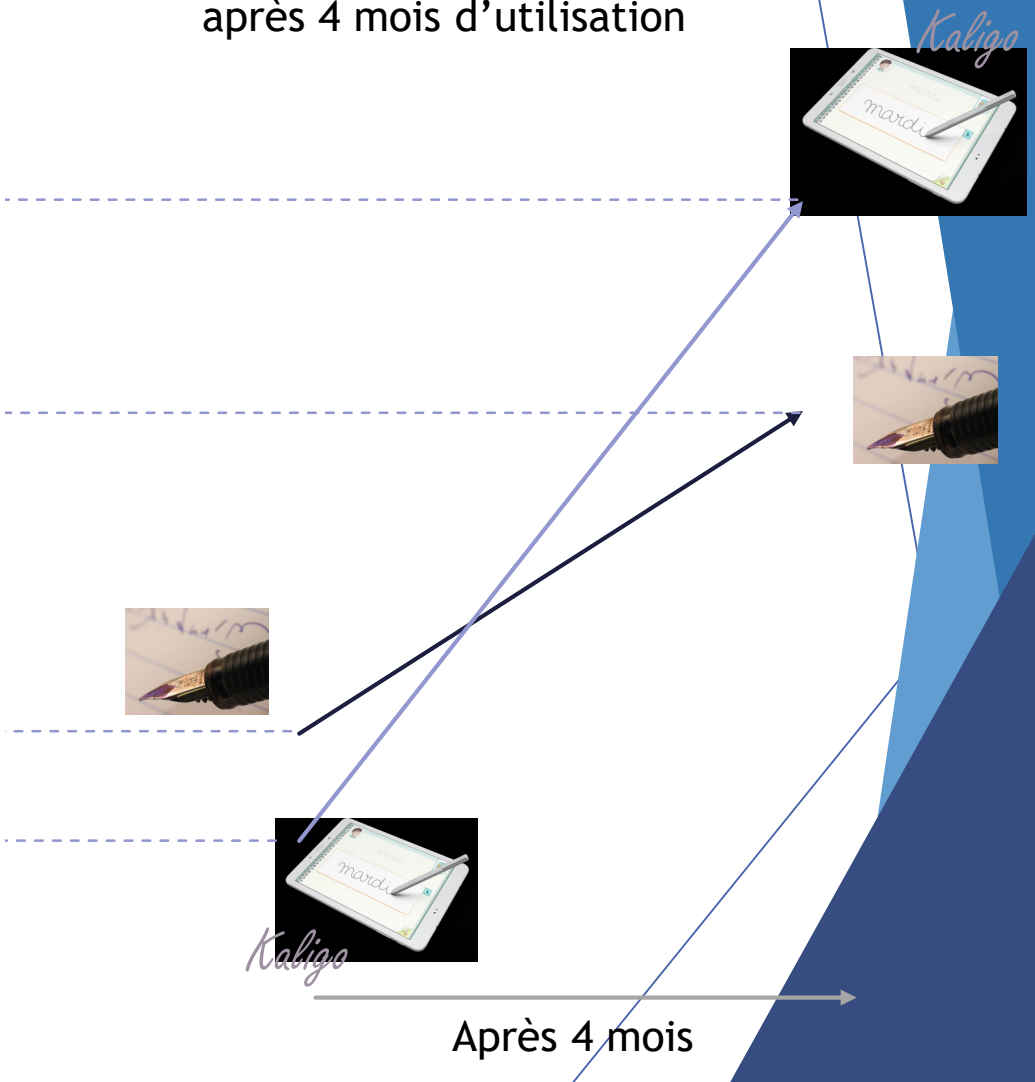
- Pré et Post test: Écriture de lettres isolées, de mots et de pseudo-mots [en capitale et en cursive] en condition papier/stylo sur tablette Wacom.
- 2 Protocoles conçus pour contrebalancer l'ordre de passation des items.
- Enregistrement du score pré- et post- et analyse statistique des progrès réalisés sur la base des scores moyennés.
- Pas de différence statistique au départ entre les deux groupes; des groupes équilibrés (sexe, latéralisation)

Etude d’impact: Premiers résultats

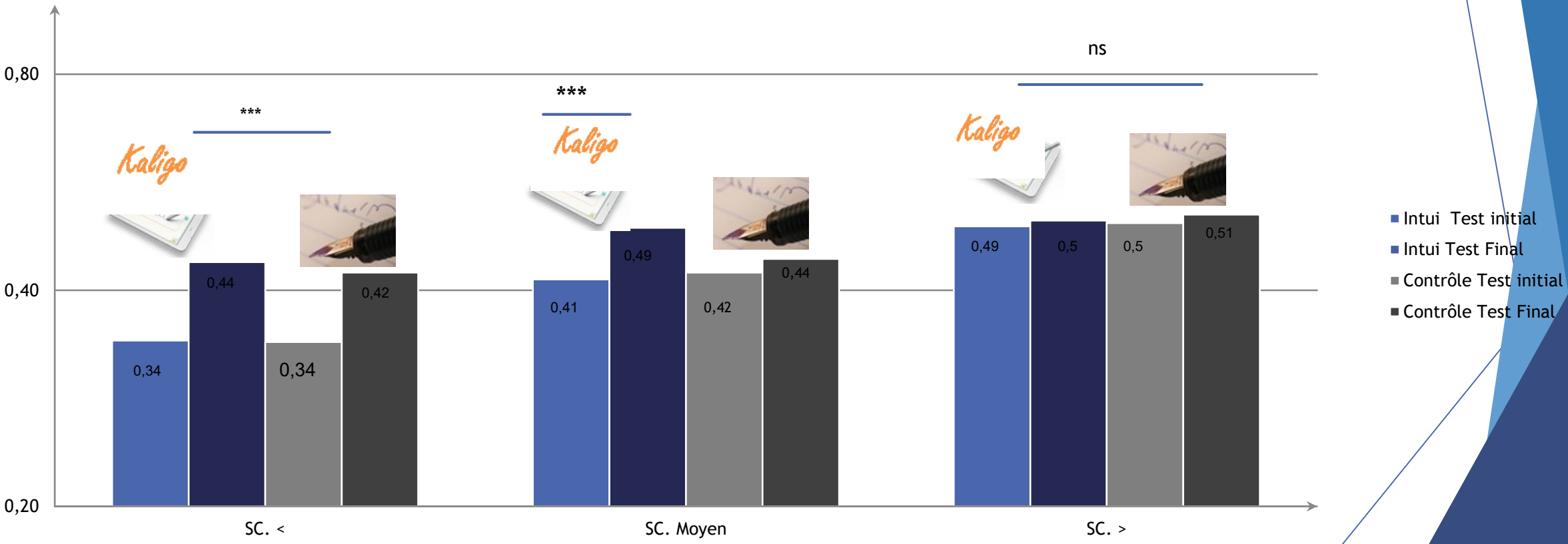
Qualité d’écriture



Différence de progression
après 4 mois d’utilisation



Effet de l'application après 4 mois en fonction du score initial des élèves



Conclusions

- Cette étude a permis de valider:

- ✓ L’efficacité de Kaligo mesuré en contexte scolaire sur une période de 4 mois par comparaison à un entraînement traditionnel
- ✓ La possibilité de transférer les apprentissages à un support papier
- ✓ L’effet différencié de l’application en fonction du niveau initial de l’élève qui contribue à réduire les inégalités scolaires.
- ✓ Une possibilité pour les enseignants d’être plus disponibles pour répondre à des besoins spécifiques.

Conclusion

- When we define model and object for user, we need to validate the approach with users !

- Select an observation/test protocol
- Define the right variable to observe
- Use the right analysis approach to extract conclusion

Conclusion

- The user is a key in IT conception
- User centred design is complex and complete task