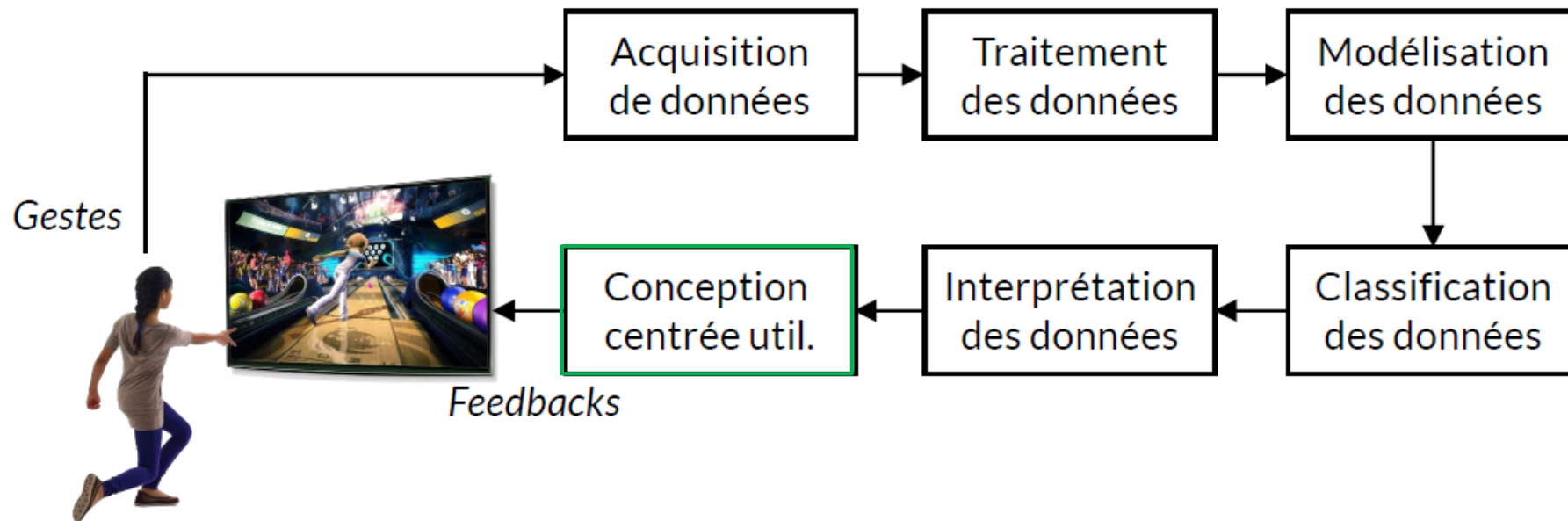


# **AIR – Analyse, Interprétation et Reconnaissance de gestes 2D et 3D pour de nouvelles interactions HM**

Nathalie Girard  
nathalie.girard@irisa.fr

# Contexte



# 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

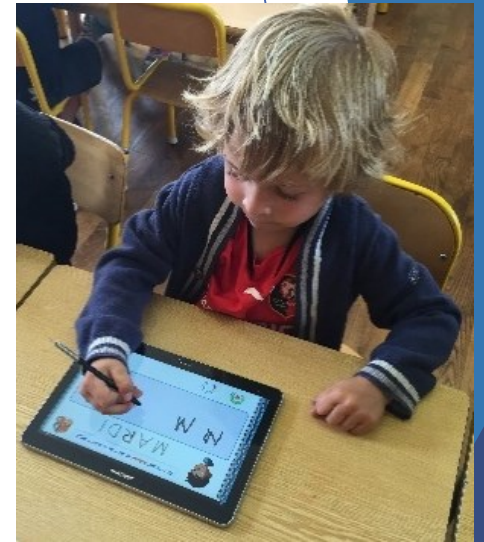




# Digital Learning : PIA - IntuiScript (2015-2017)

**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

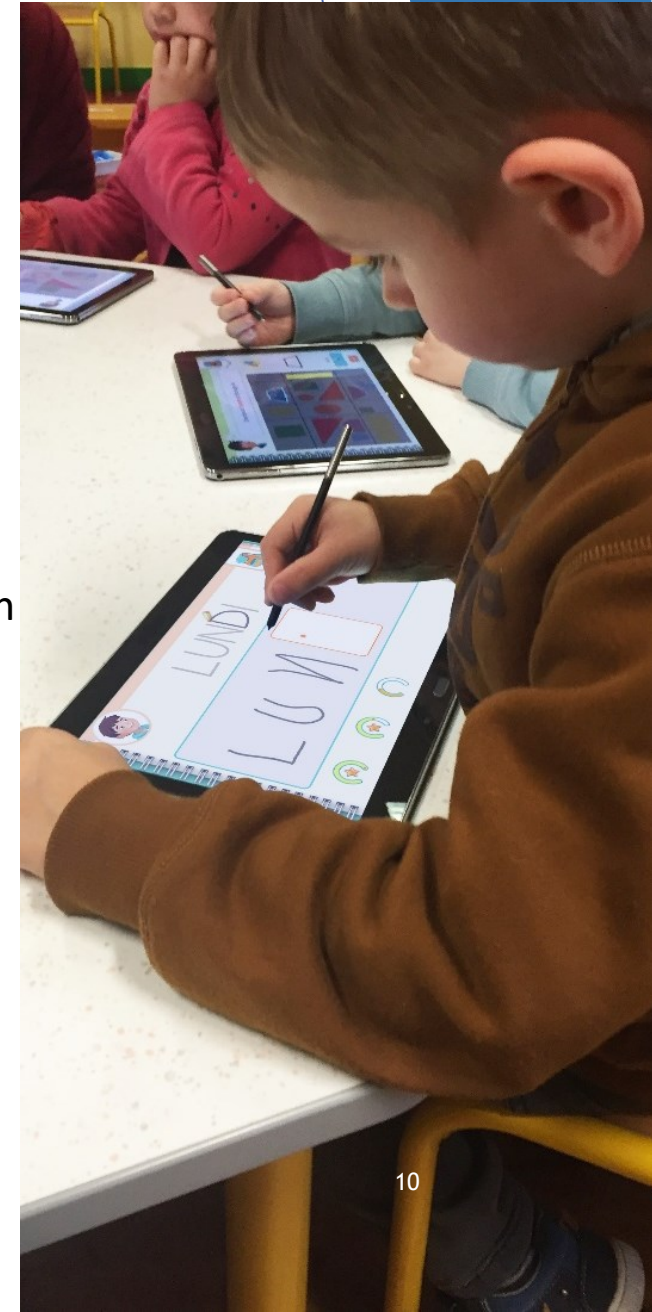
Educational methods  
made-to-measure

Desire of learning

Collaborative Working

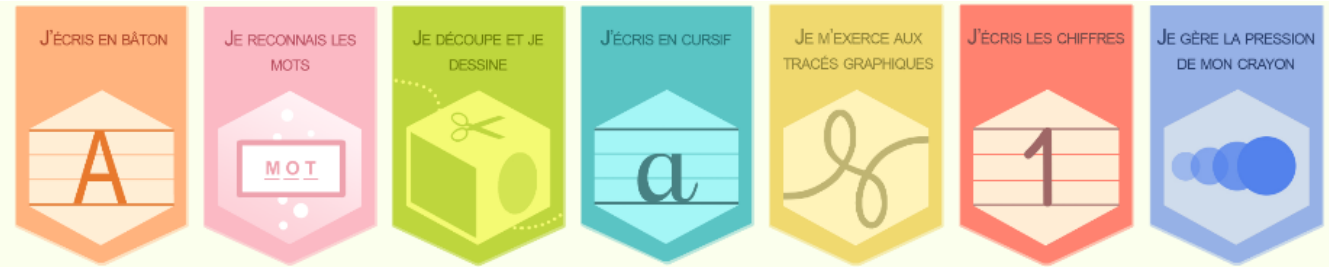
## ► A digital solution

- ❑ 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





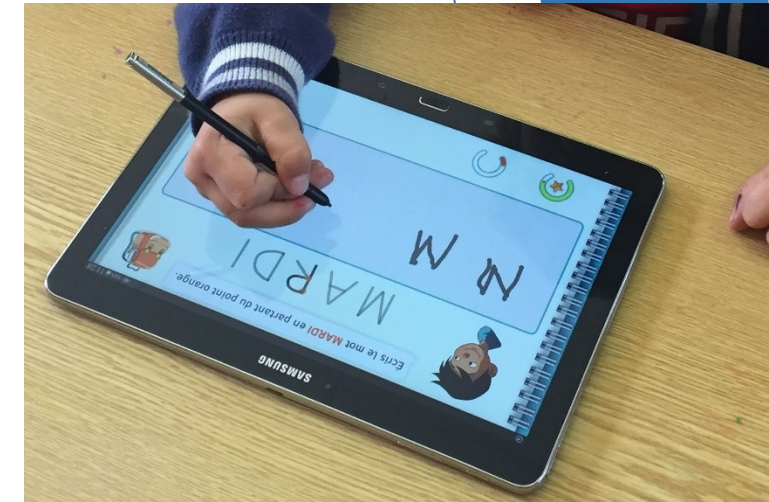
# IntuiScript – Design of contents



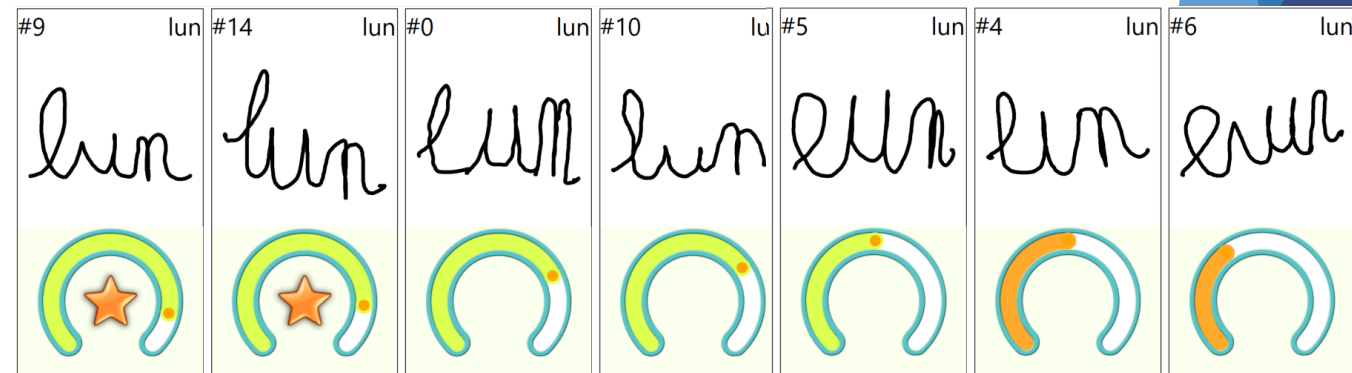
## ► Definition of educational objectives and creation of educational scenarios

☑ 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*



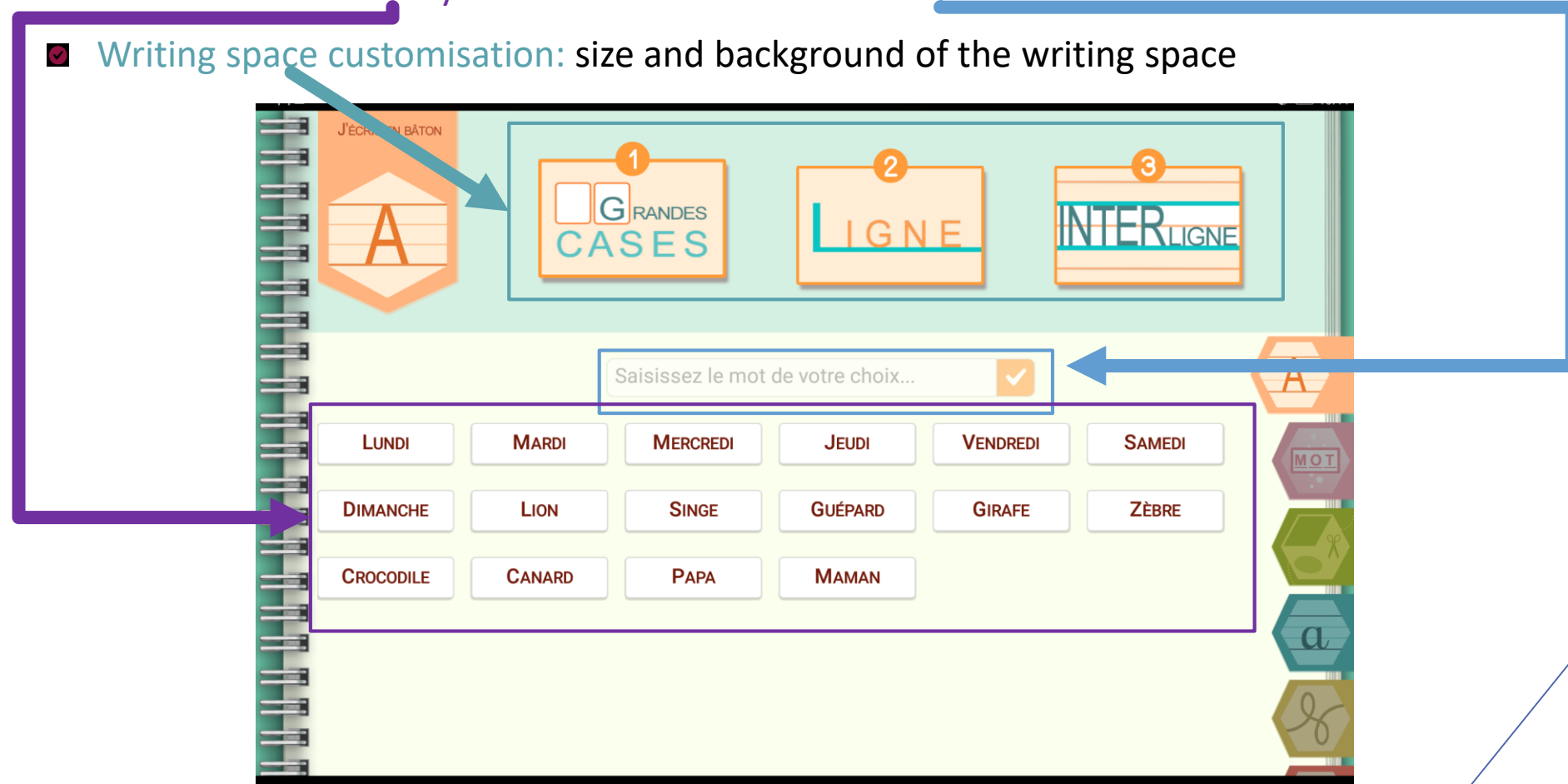
# Template n°1 : Block letters (writing of letters)

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

❑ **Customisation:**

❑ Word context: **already defined word** or **new word**

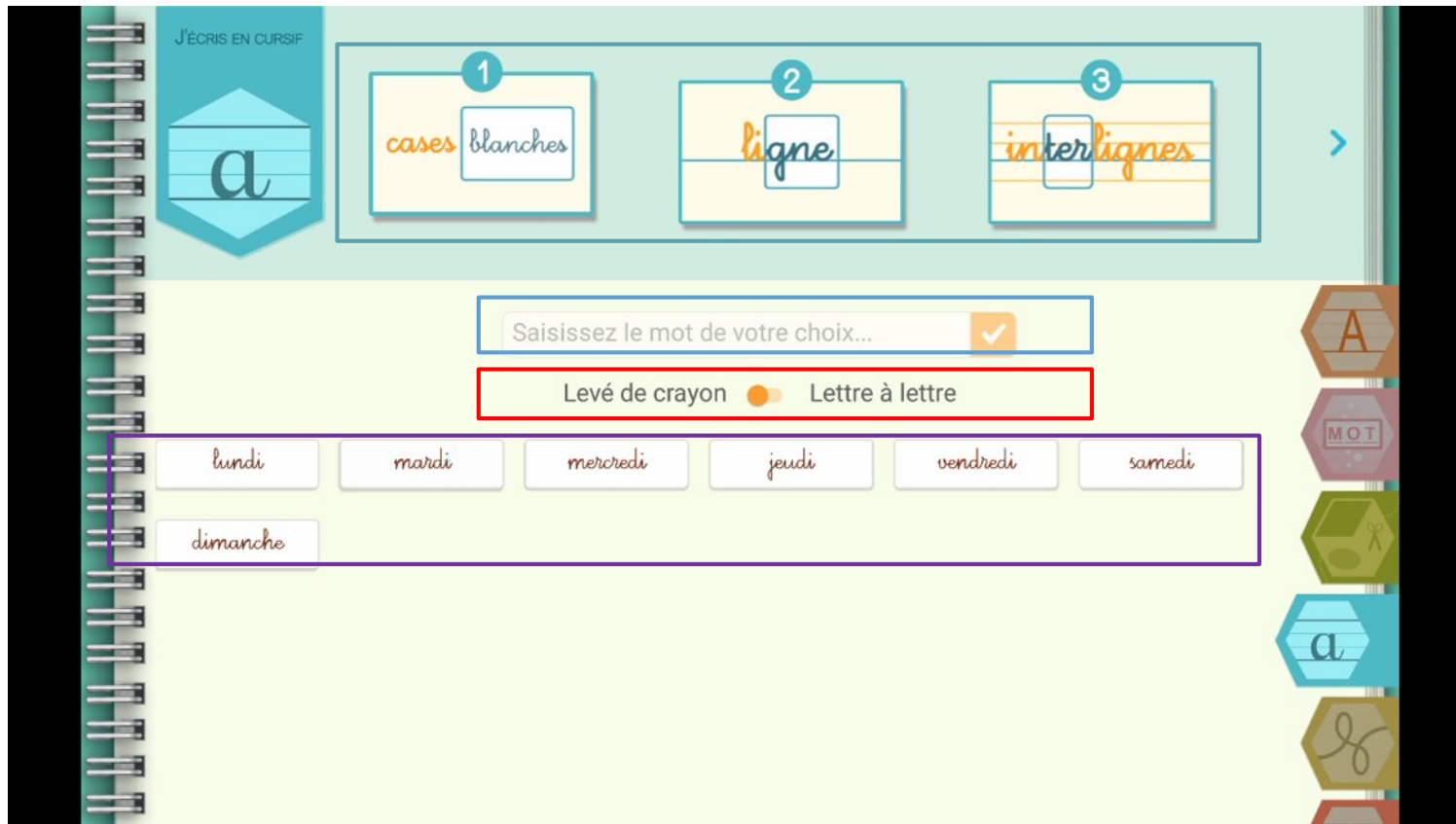
❑ **Writing space customisation:** size and background of the writing space



# 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



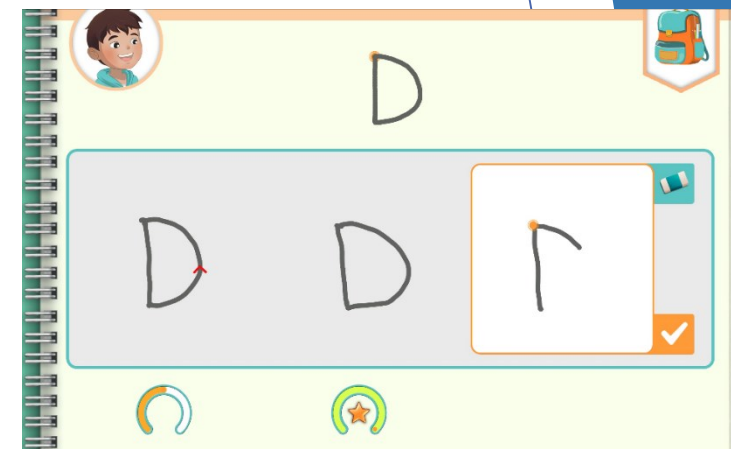
### Initial child knowledge

- Full word writing
- Static model
- No analysis



### Learning of letters

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



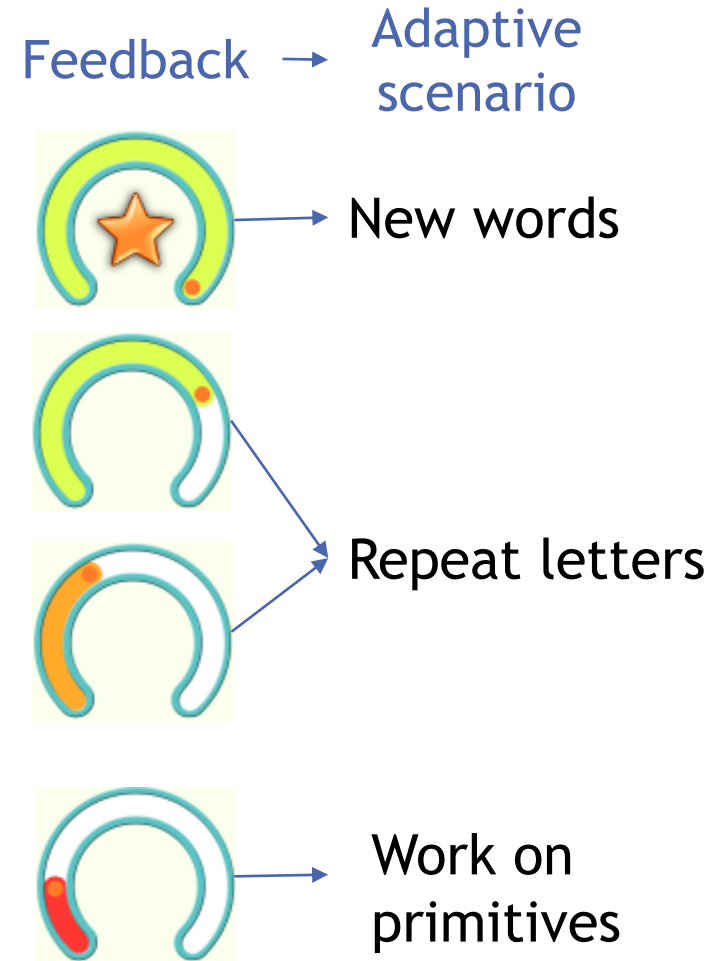
### Personalised Remediation

- 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**

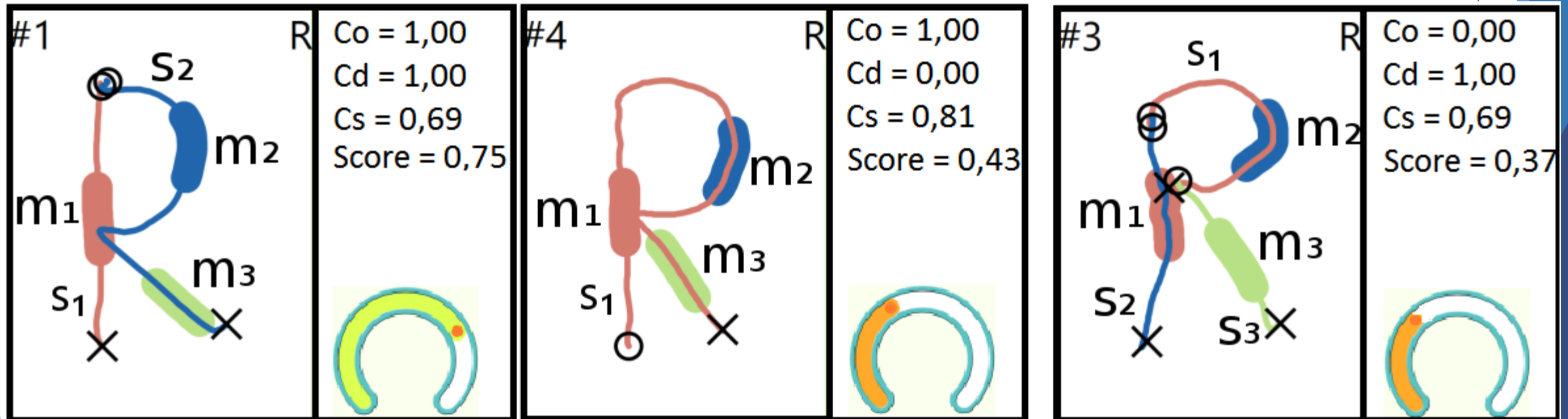
- Linked to: writing process
- Based on: order, direction, fluidity

# Writing analysis – Colour-scale indicator computation

- Global score  $s_g$  decomposition:

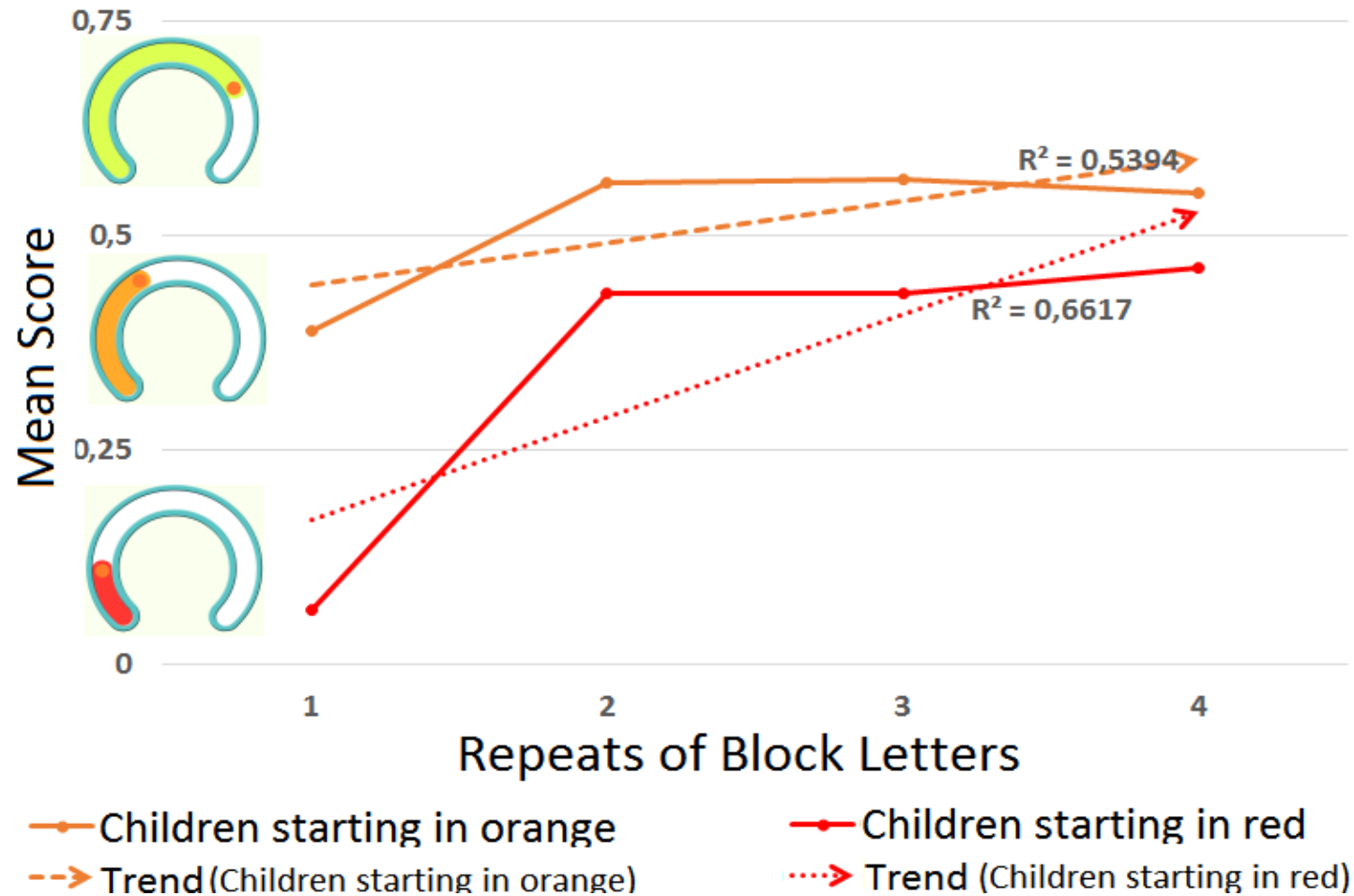
$$\blacktriangleright s_g = \min(\alpha_s c_s, 1.0) \times \mathcal{P}(c_o, c_d) \text{ where } \mathcal{P}(c_o, c_d) = \begin{cases} 1 & \text{if } c_o + c_d = 2 \\ \alpha_1 & \text{if } c_o + c_d = 1 \\ \alpha_0 & \text{if } c_o + c_d = 0 \end{cases}$$

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



# Experimentations – 1<sup>st</sup> results

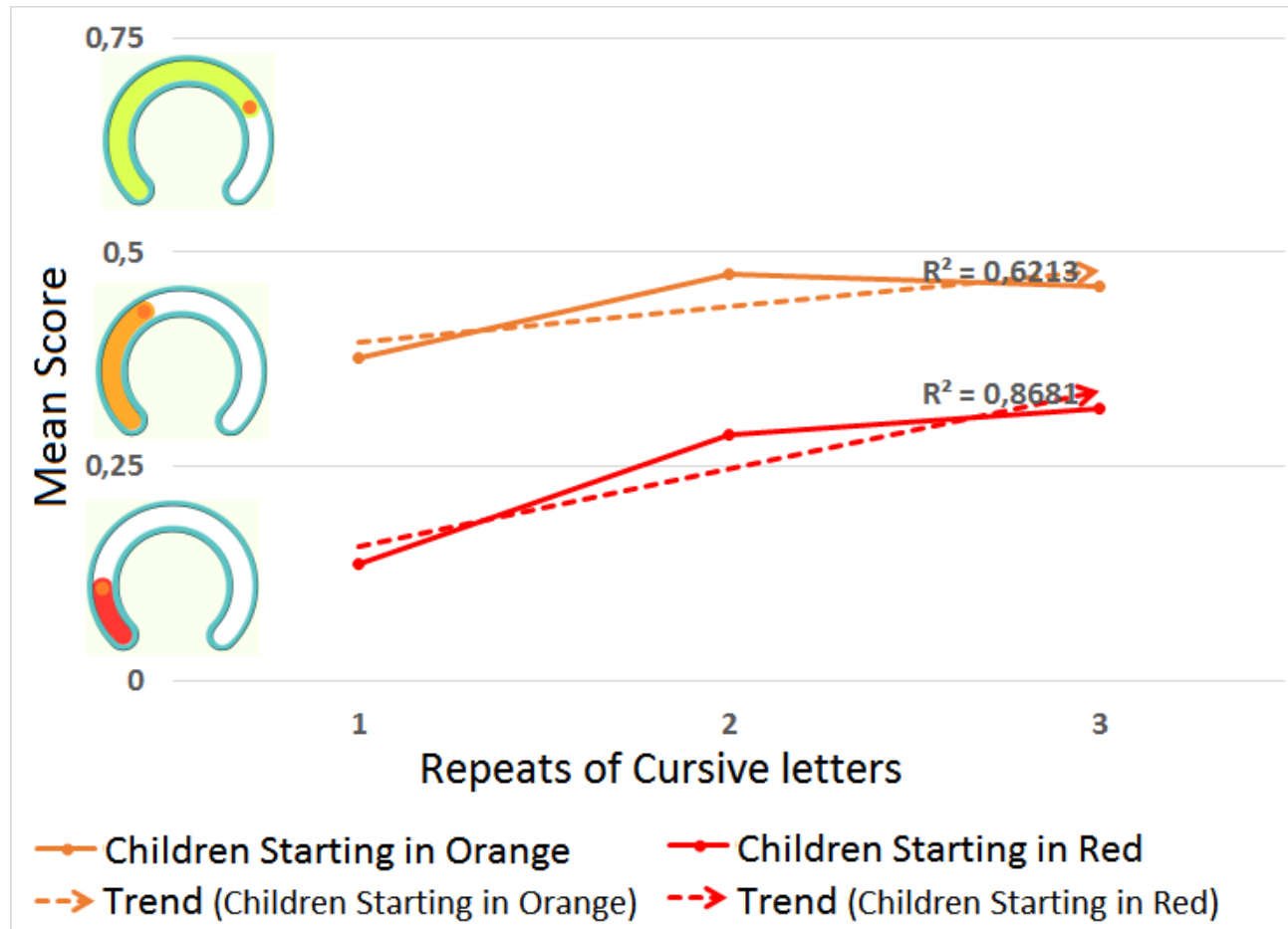
Children progression on Block Letters



Children writing: L, N and D

# Experimentations – 1<sup>st</sup> 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:

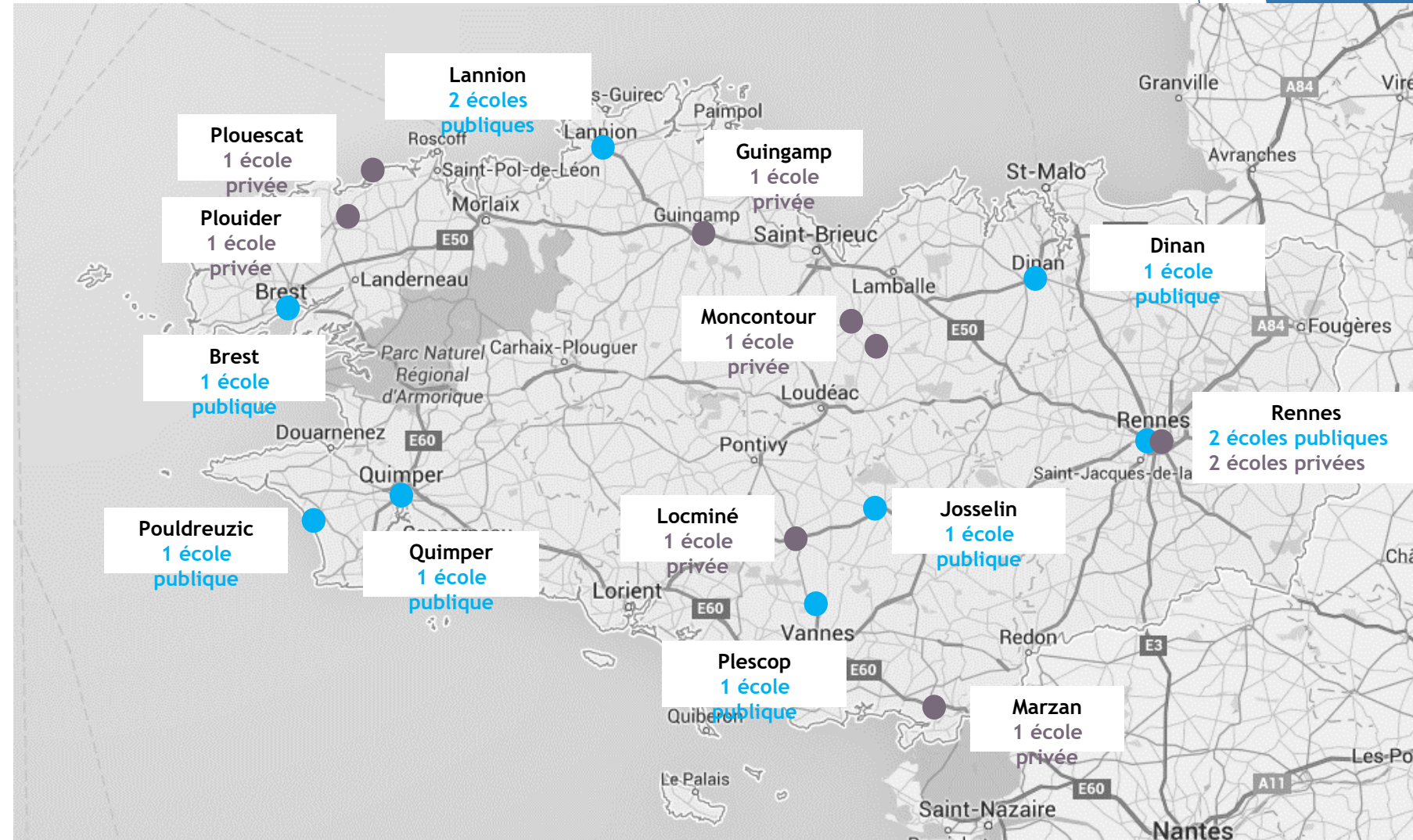
We need a **user-centered design** to defined  
an adapted analysis model, and an efficient numerical notebook



# 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

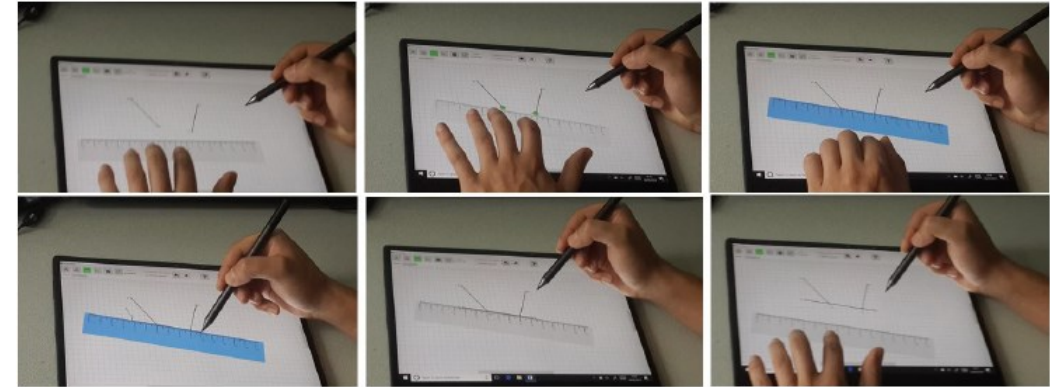
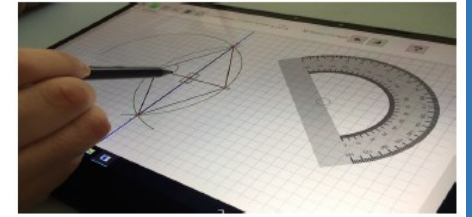
KASSIS

## ► 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, ...

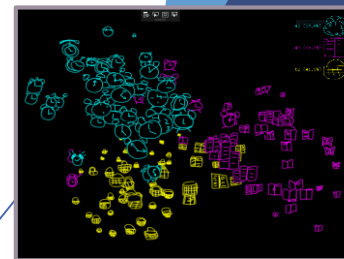
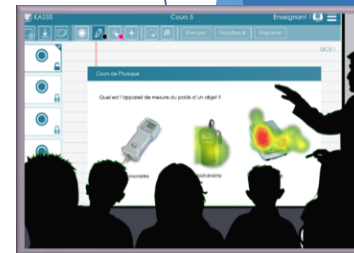
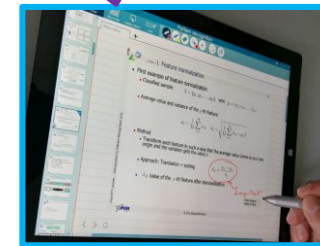
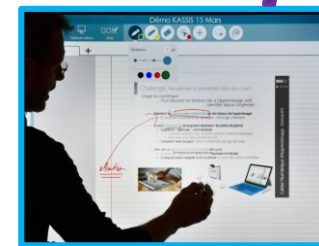
## ► Compromise for the definition of the skills evaluation:

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



Interactive screen  
(teacher)

Tablets with stylus  
(students)



# User centred design - Motivations

## 1. Économiques

- La partie IHM représente 50 à 90 % des coûts de développement d'un projet
- L'état soutien ce type d'actions : rapport Cadix 2013
  - ▶ « Nos entreprises, centrées sur la technologie – poussées en cela par tous les programmes nationaux d'aides à l'innovation depuis des décennies – en ont oublié « **l'expérience utilisateur** » qui fait, ou ne fait pas le succès d'une innovation. Or c'est le design qui fait le lien, qui est l'engrenage entre la technologie et l'usage et qui ajoute **la part d'imaginaire** qui rend les objets désirables. Que cette technologie soit banalisée ou nouvelle. »

## 2. Défis scientifiques et techniques

- Personnes : imprévisibles
- Activités : complexes

## 3. Cadre de travail avec des méthodes et des démarches rigoureuses

## 4. Professionnelles

- Les entreprises/services font des applications pour des utilisateurs, pas seulement pour des 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)

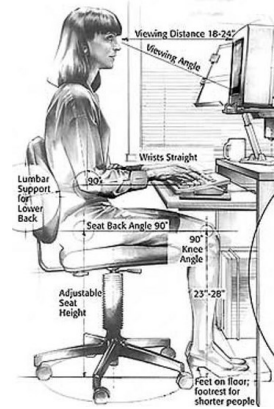
# Ergonomy - definition

- ▶ 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)



# Ergonomics - 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

- ▶ Norme ISO 9241 :
  - ▶ «Un produit est dit utilisable lorsqu'il peut être utilisé avec **efficacité**, **efficience** et **satisfaction** par des utilisateurs donnés, cherchant à atteindre des objectifs donnés, dans un contexte d'utilisation donné.»
    - ▶ **Efficacité**: l'utilisateur doit réussir à faire ce qu'il veut faire
    - ▶ **Efficience**: il doit pouvoir le faire rapidement et avec le moins d'erreurs possible
    - ▶ **Satisfaction**: caractéristiques esthétiques, apprenabilité, confort

[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

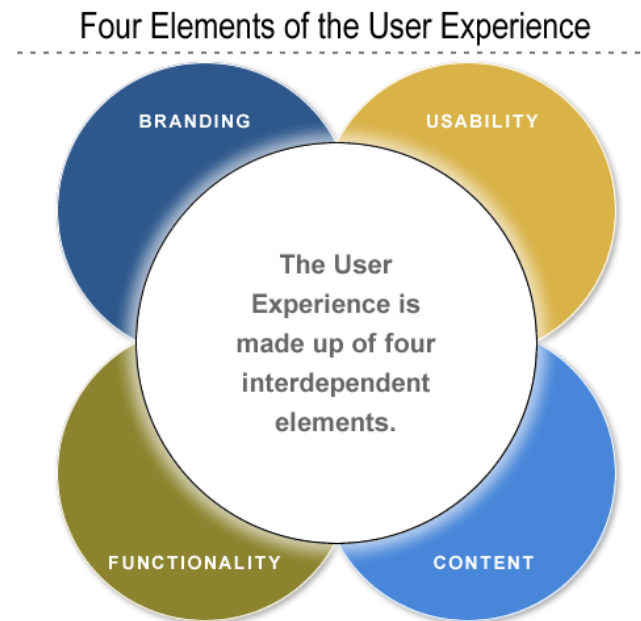
# User Experience (UX) - definition

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

- ▶ Ressenti de l'utilisateur pendant l'usage du produit
- ▶ Bénéfice rationnel + impact émotionnel

# User Experience (UX) - definition

- ▶ The user experience is made up of four interdependent elements:

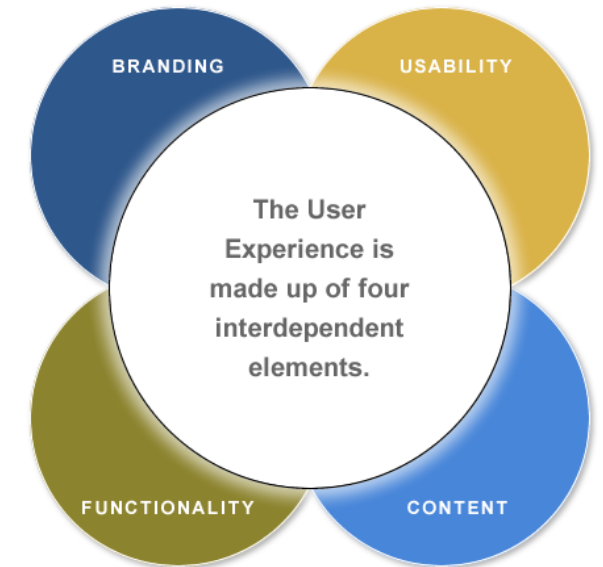


But, how can we quantify and measure these seemingly intangible elements?  
(next lesson)

# Usability vs. User Experience [Rubinoff2004]

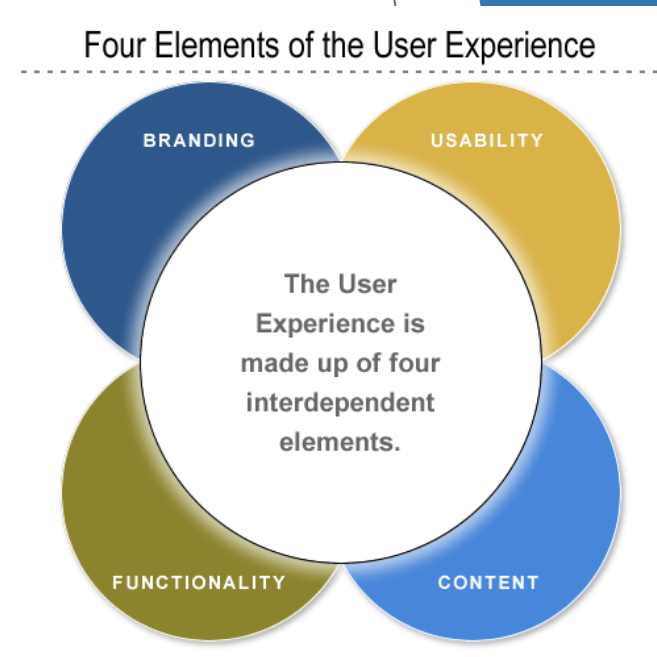
- ▶ Both concerned with the satisfaction of the user
- ▶ Good user experience:
  - ▶ Relies on a usable, functional, aesthetically pleasing, enjoyable and memorable product
  - ▶ Encapsulates usability, and also considers the user's emotions towards the product.
- ▶ Differences:
  - ▶ usability considers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

Four Elements of the User Experience



# 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

- Perceptible Affordance

- ▶ Capacité d'un objet à suggérer sa propre utilisation



How to use?

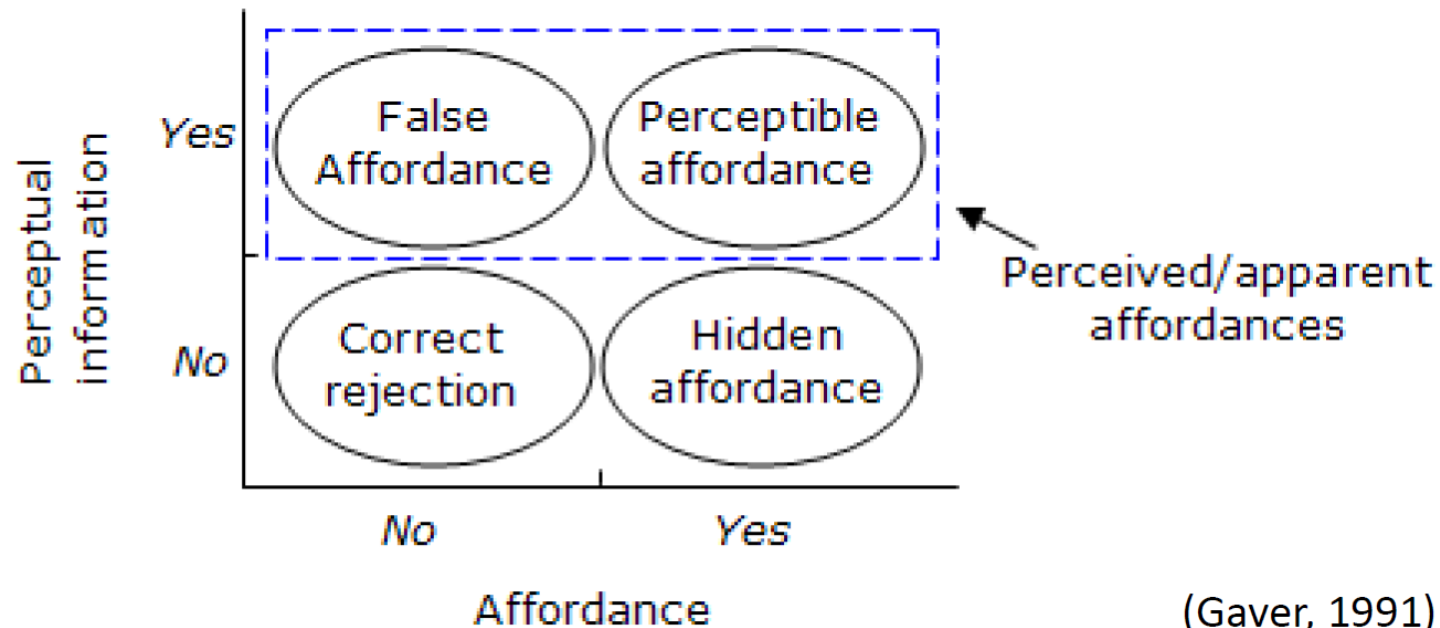


Make it understandable



# Affordance - Definition

- Distinction par Don Norman entre l'affordance (utilisations possibles de l'objet) et les informations perceptibles qui indiquent les affordances



(Gaver, 1991)



# Affordance - Definition

- ▶ False affordance



# Affordance - Definition

- ▶ Hidden affordance

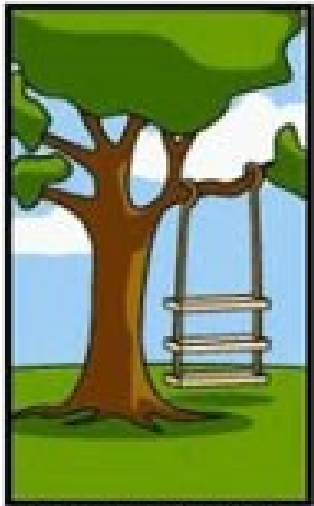


# La conception centrée utilisateur

- Norme ISO 9241-210 :
  - Démarche de conception, où les **besoins**, les **attentes** et les **caractéristiques** des **utilisateurs finaux** sont **pris en compte à chaque étape du processus** de développement d'un produit.
- ▶ Repose sur l'idée que les utilisateurs finaux sont les mieux placés pour évaluer le produit.
- ▶ Dans cette démarche, le développement du produit est *a priori* **guidé par les caractéristiques, besoins et exigences des utilisateurs finaux, plutôt que par des possibilités techniques.**



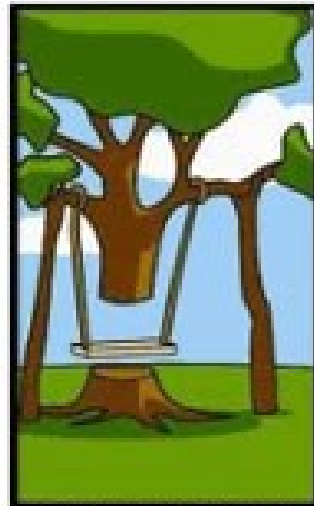
CCU => éviter le problème récurrent :



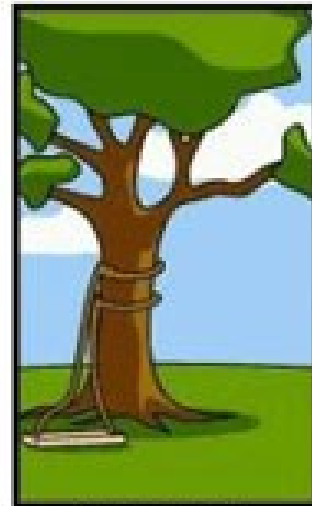
Comment le client a exprimé son besoin



Comment le chef de projet l'a compris



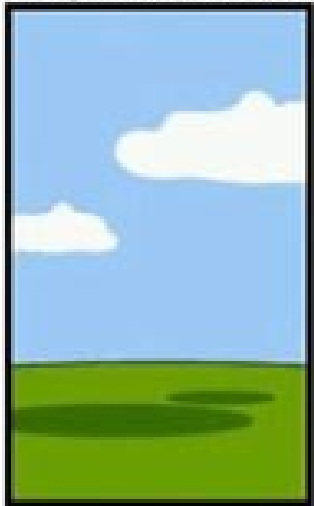
Comment l'ingénieur l'a conçu



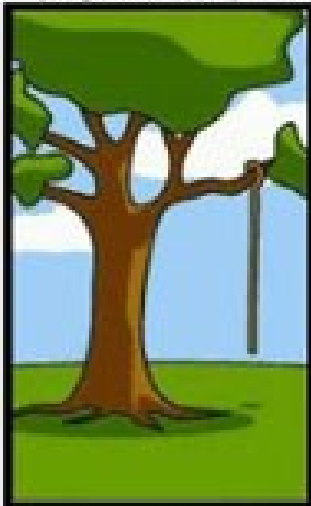
Comment le programmeur l'a écrit



Comment le responsable des ventes l'a décrit



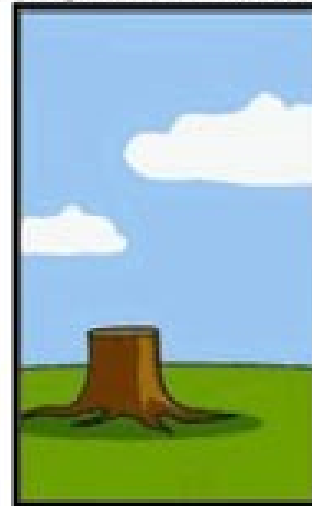
Comment le projet a été documenté



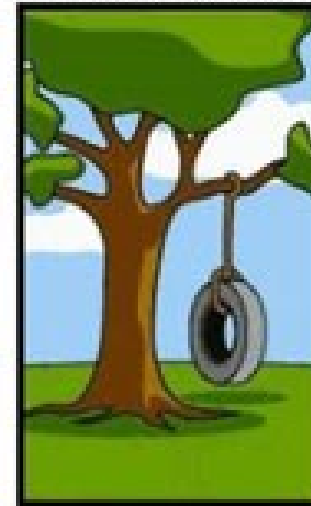
Ce qui a finalement été installé



Comment le client a été facturé



Comment la hotline répond aux demandes



Ce dont le client avait réellement besoin

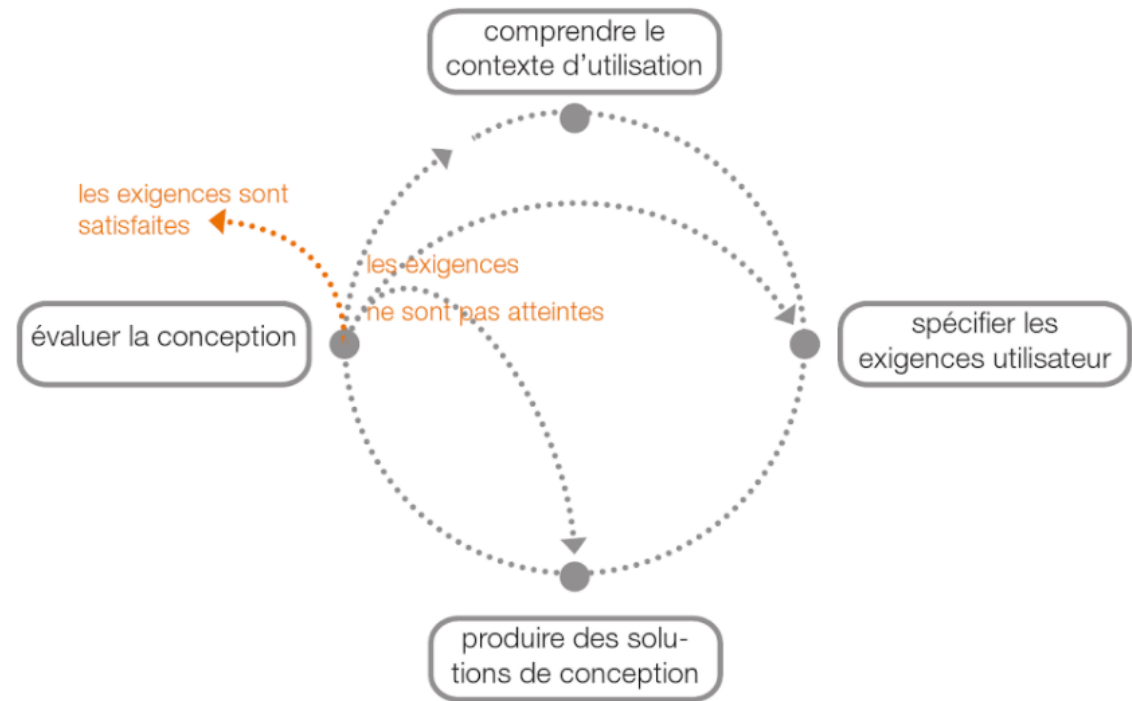
# CCU et recherche

- ▶ [Wendy Mackay](#)
- ▶ [Michel Beaudouin-Lafon](#)
- ▶ [James Landay](#)
- ▶ [Elisabeth Delozanne](#)
- ▶ ...

## ▶ Références:

- ▶ leurs travaux, cours, présentations !
- ▶ les livres :
  - ▶ '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.

La conception  
itérative (1998)



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

# La conception centrée utilisateur

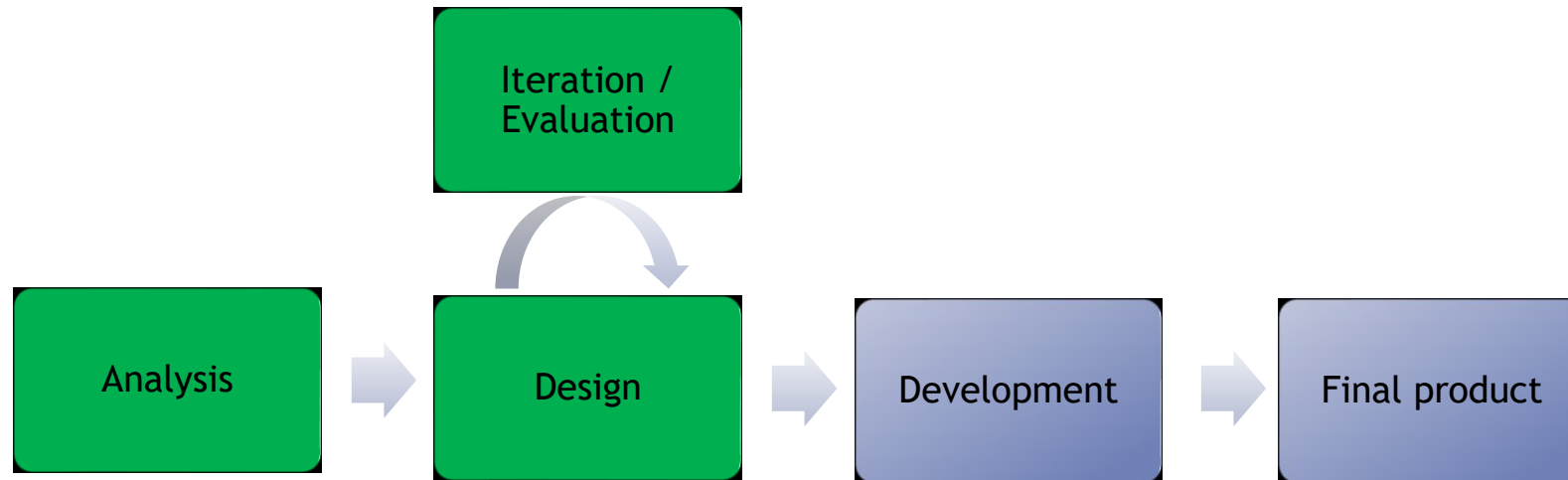
- ▶ Cinq critères d'application et de mise en œuvre (norme ISO 9241-210):
  1. Prise en compte en amont des utilisateurs, de leurs tâches et de leur environnement
  2. Participation active des utilisateurs, garantissant la fidélité des besoins et des exigences liées à leurs tâches
  3. Répartition appropriée des fonctions entre les utilisateurs et la technologie
  4. Itération des solutions de conception, jusqu'à satisfaction des besoins et des exigences exprimés par les utilisateurs
  5. Intervention d'une équipe de conception multidisciplinaire, visant une expérience utilisateur optimale

# Qui doit intervenir en CCU ?

- ▶ Une équipe
- ▶ Idéalement
  - ▶ Spécialistes de l'interaction/l'expérience utilisateur (UX)
  - ▶ Ergonomes
  - ▶ Marketing
  - ▶ Rédacteurs techniques
  - ▶ Ingénieurs spécialisés dans les tests
  - ▶ Développeurs Informatiques
  - ▶ Graphistes
  - ▶ Utilisateurs

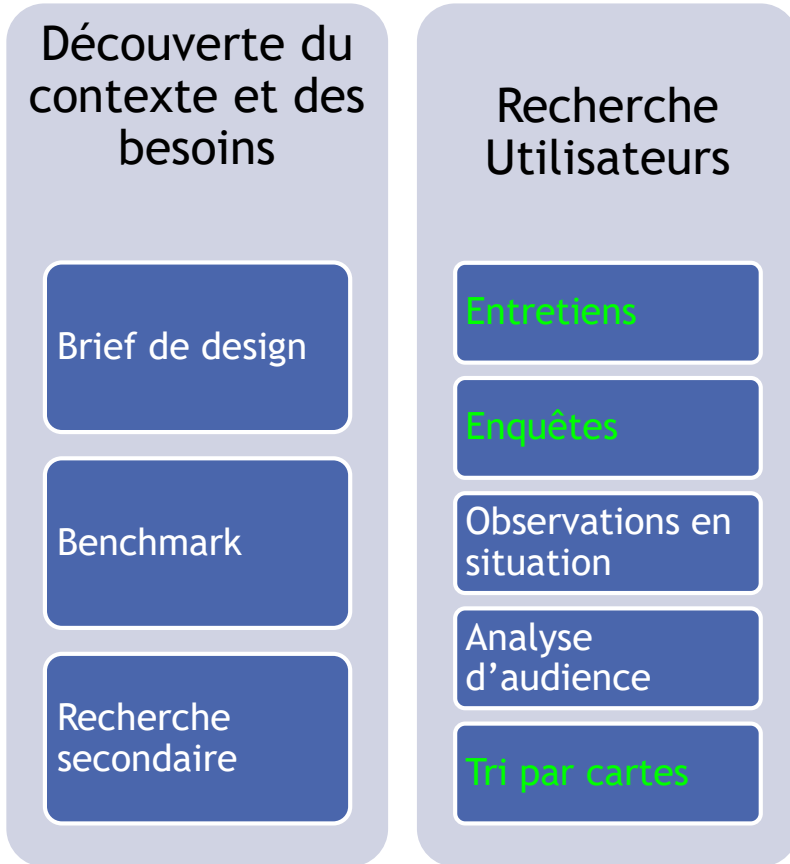
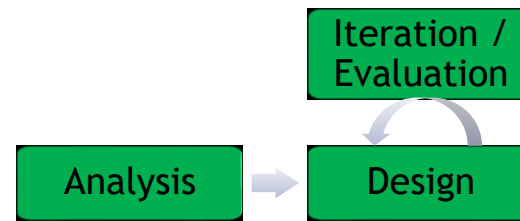
# UCD - Consideration of users upstream

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





# About the UCD phases



## Tri par cartes :

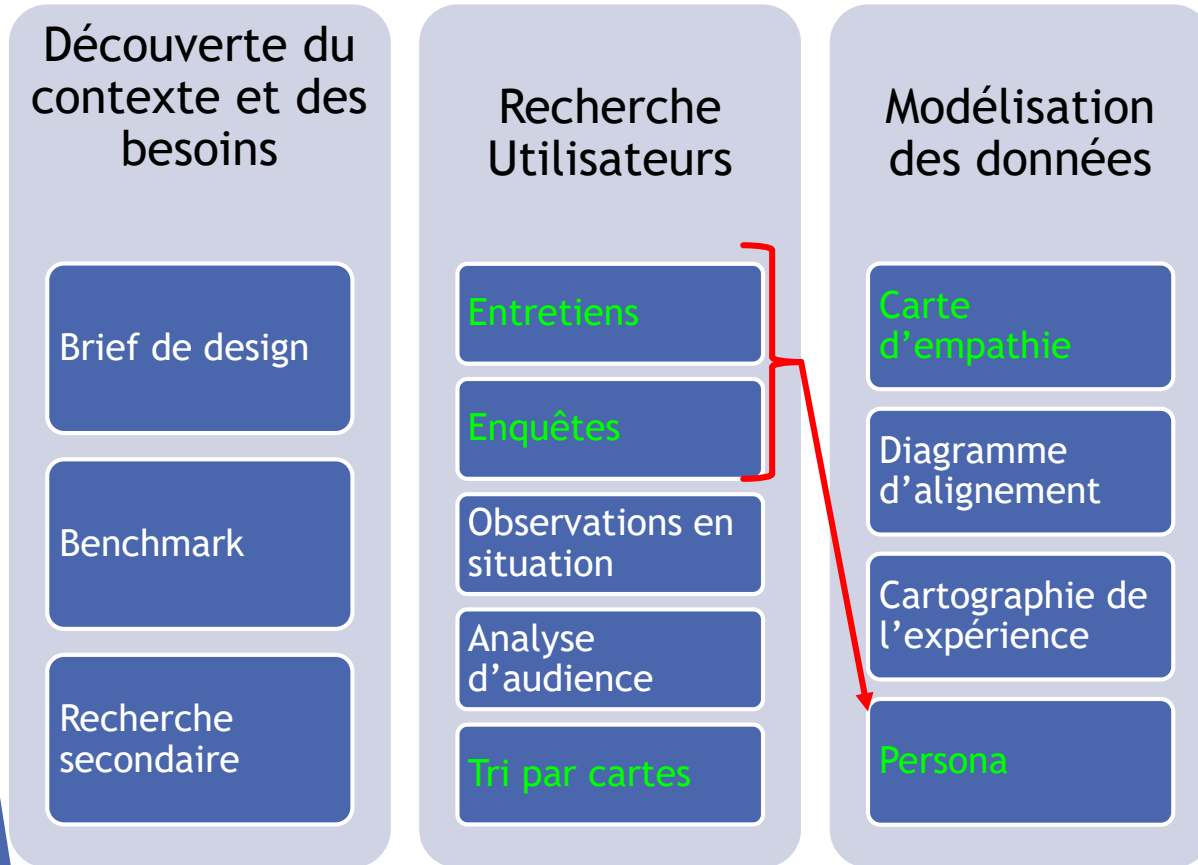
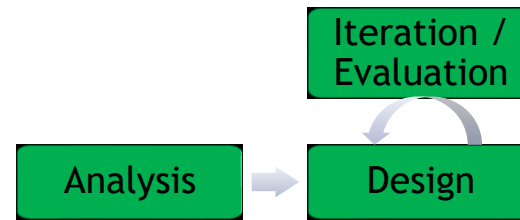
- Modéliser la **structuration** des connaissances chez l'humain



Src :Le design interactif, B. Drouillard - DUNOD

Src : [Usaddict](#)

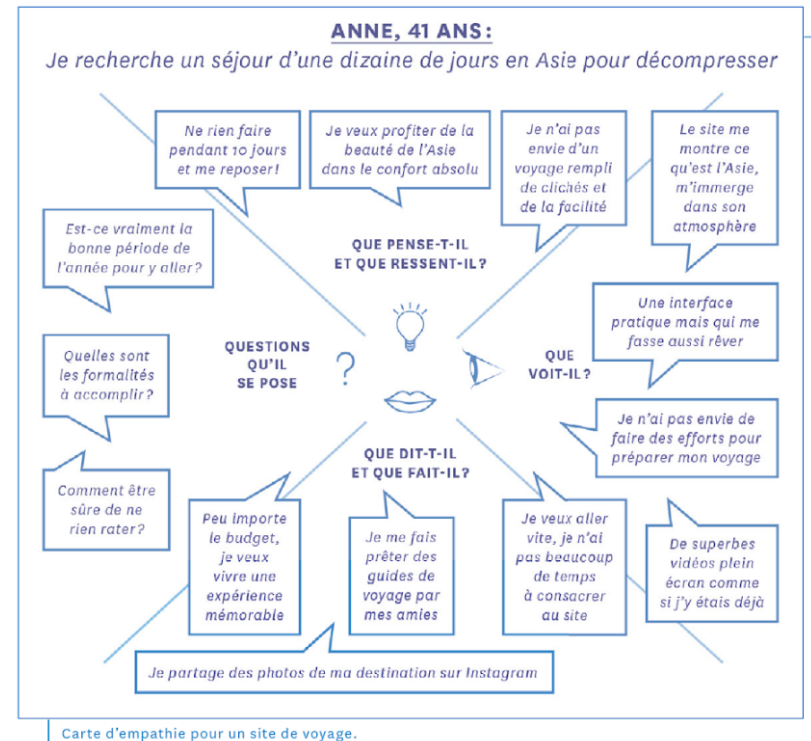
# About the UCD phases



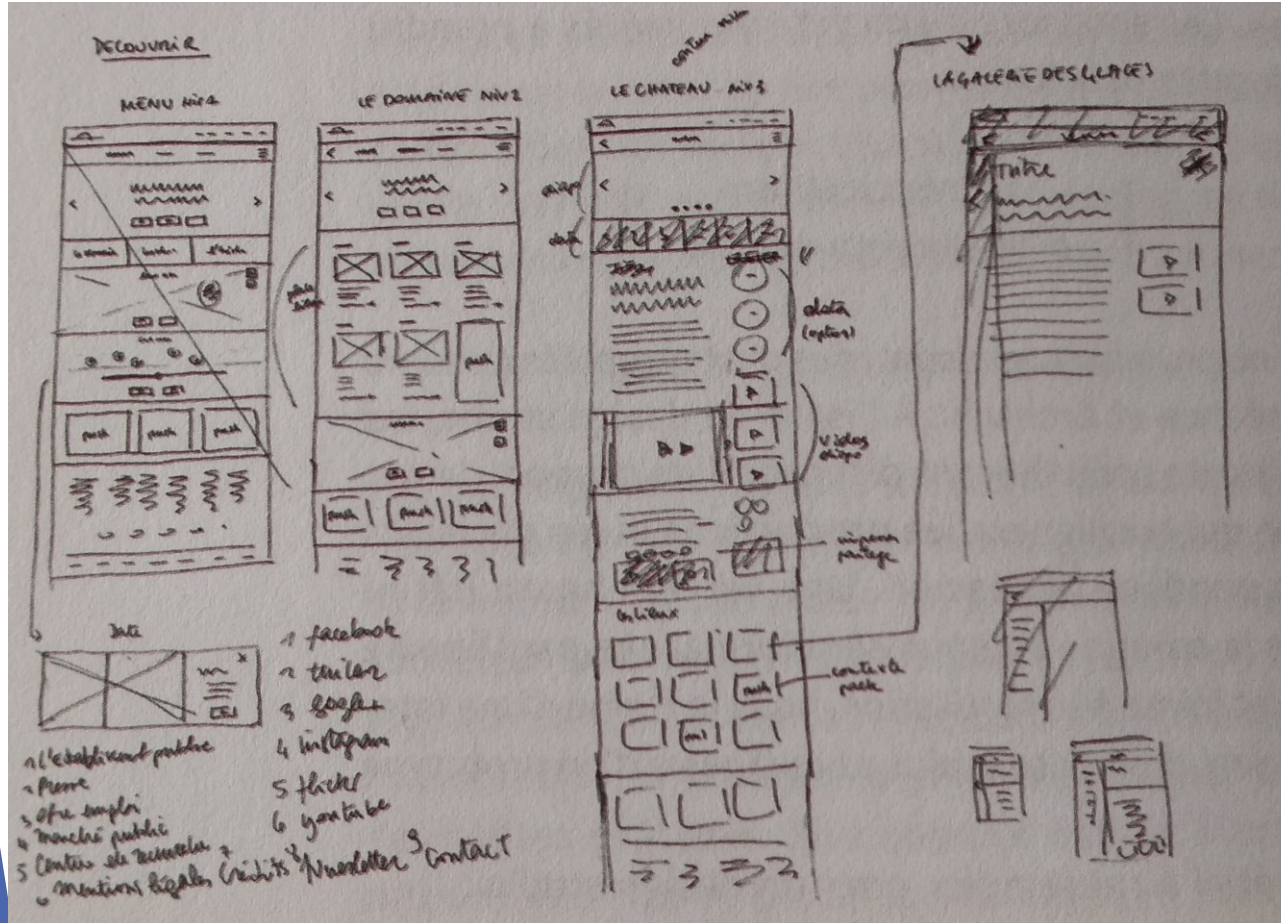
Src: Le design interactif, B. Drouillard - DUNOD



Src : [ComExplorer](#)



# About the UCD phases

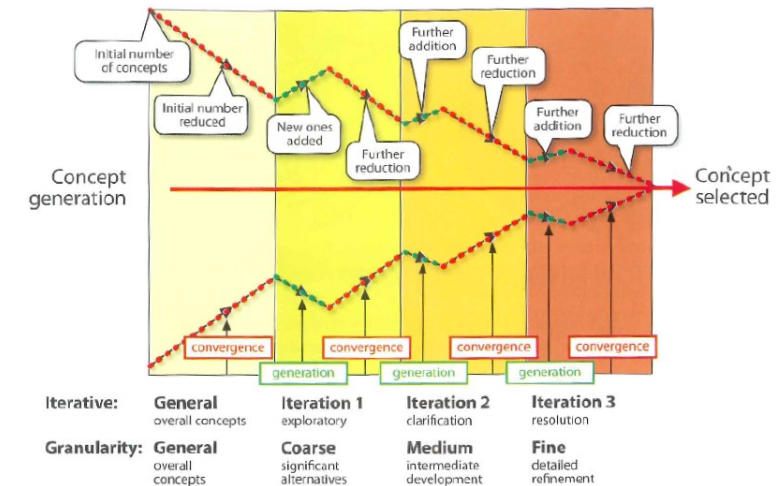


Idéation et exploration de solutions

Design studio

Crayonnés et maquettes

Moodboard



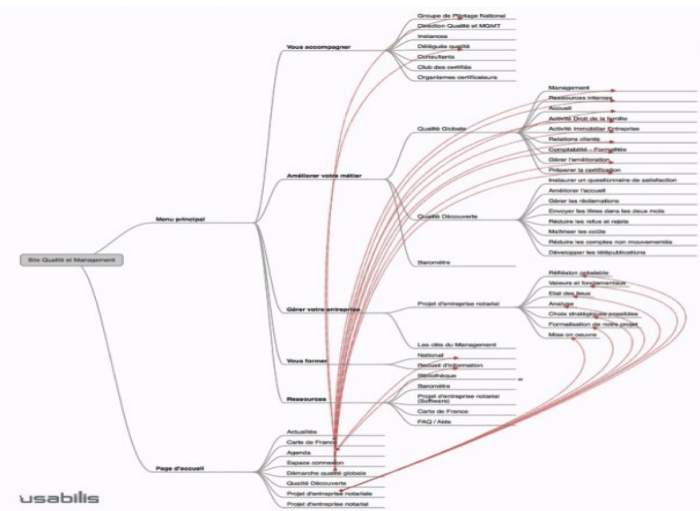


# About the UCD phases

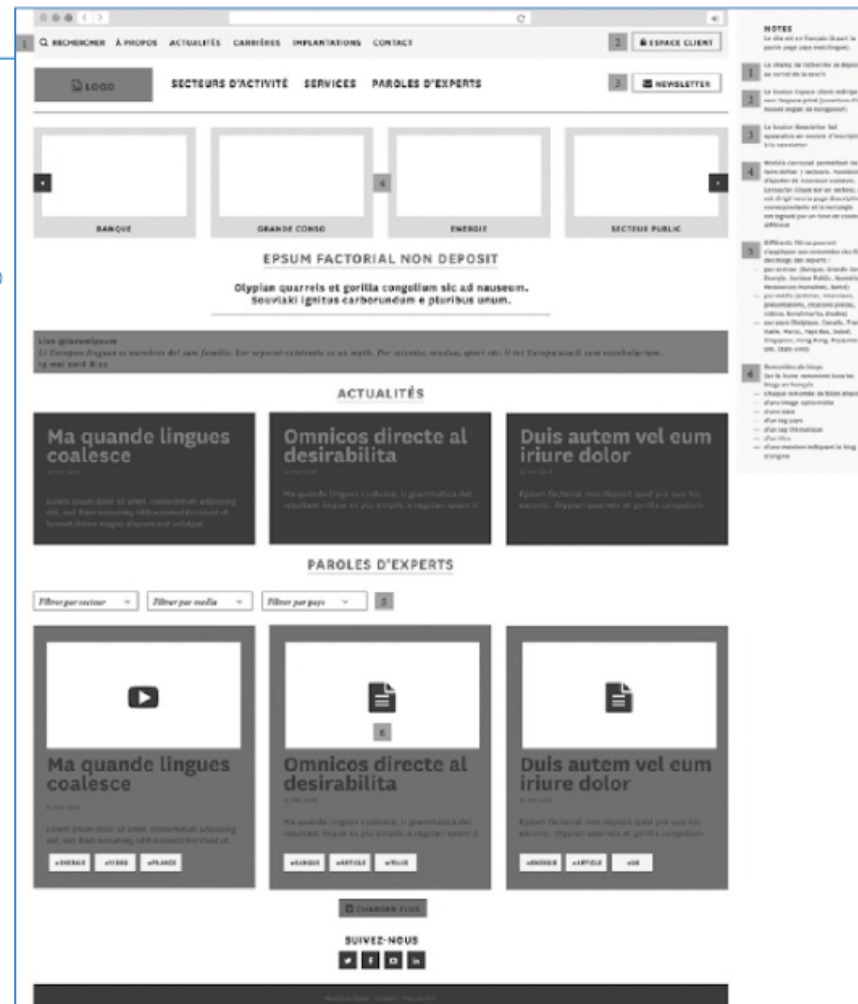
Analysis

Design

Iteration / Evaluation



@designers interactifs\*



Interface filaire annotée.

Formalisation de l'interface

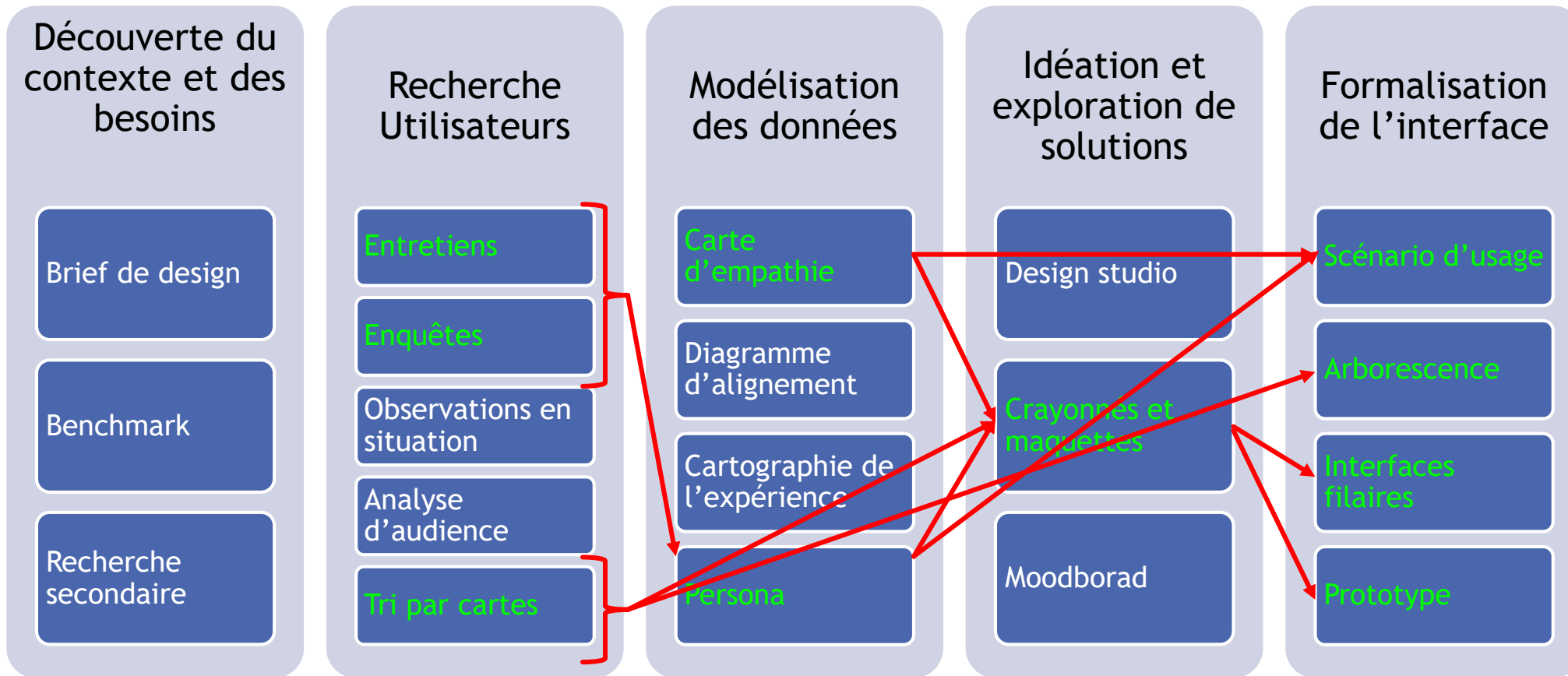
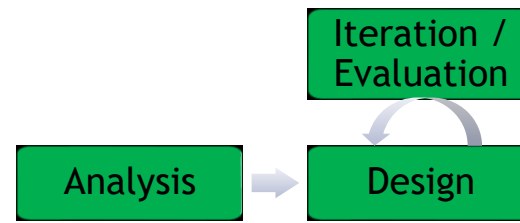
Scénario d'usage

Arborescence

Interfaces filaires

Prototype

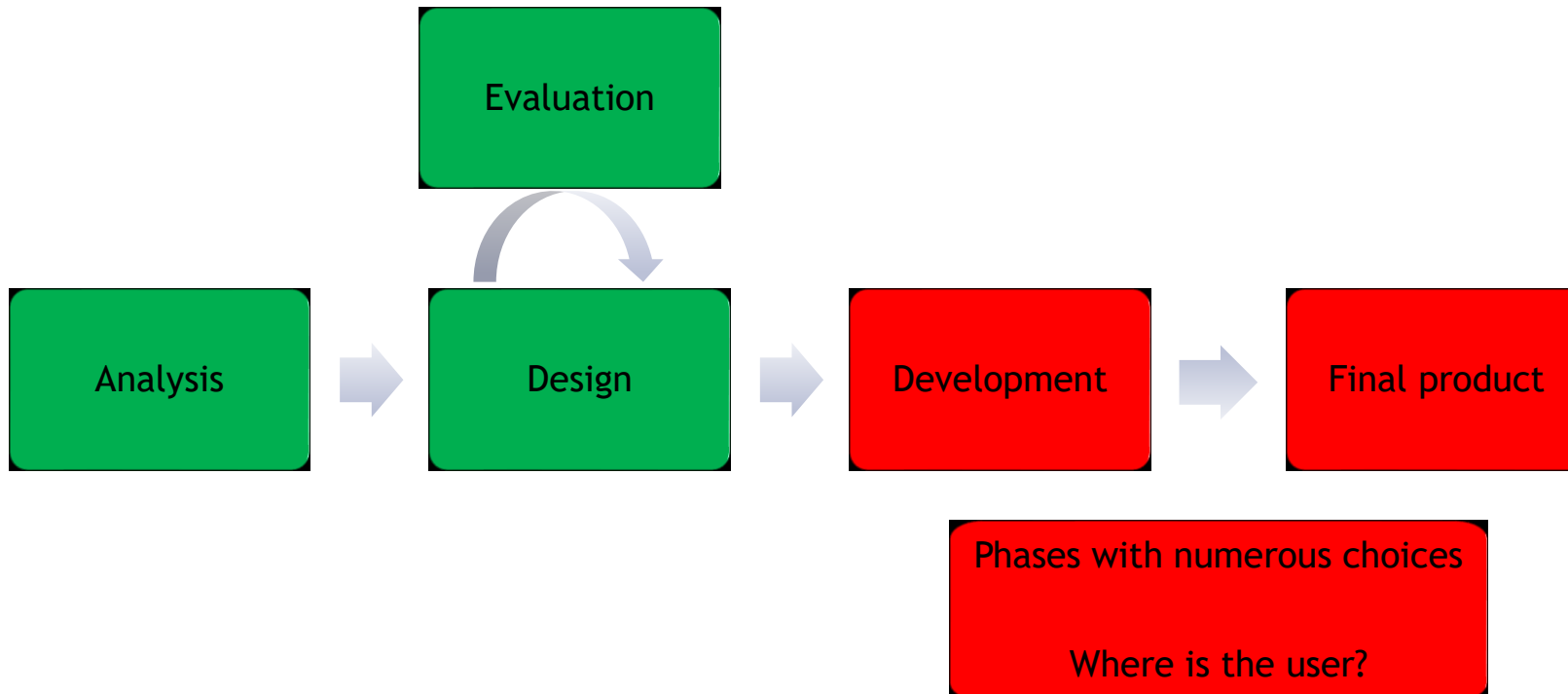
# About the UCD phases



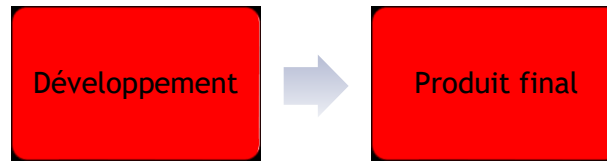
Src : Le design interactif, B. Drouillard - DUNOD

# UCD – Beyond the 3 phases?

- **Deficiency** of the iterative process with his **3 phases**



How to manage



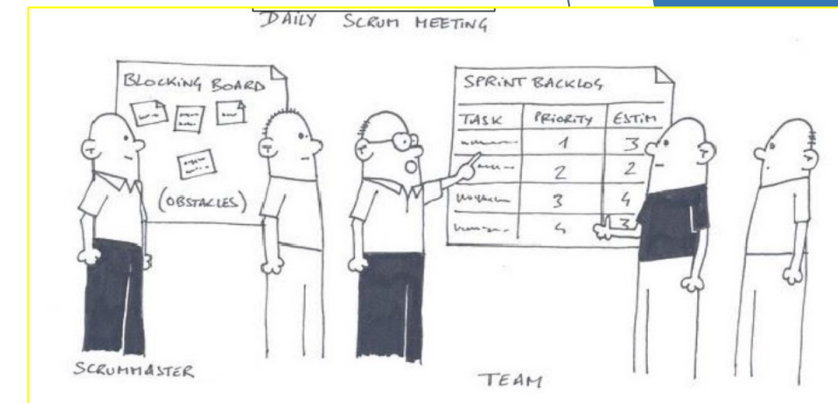
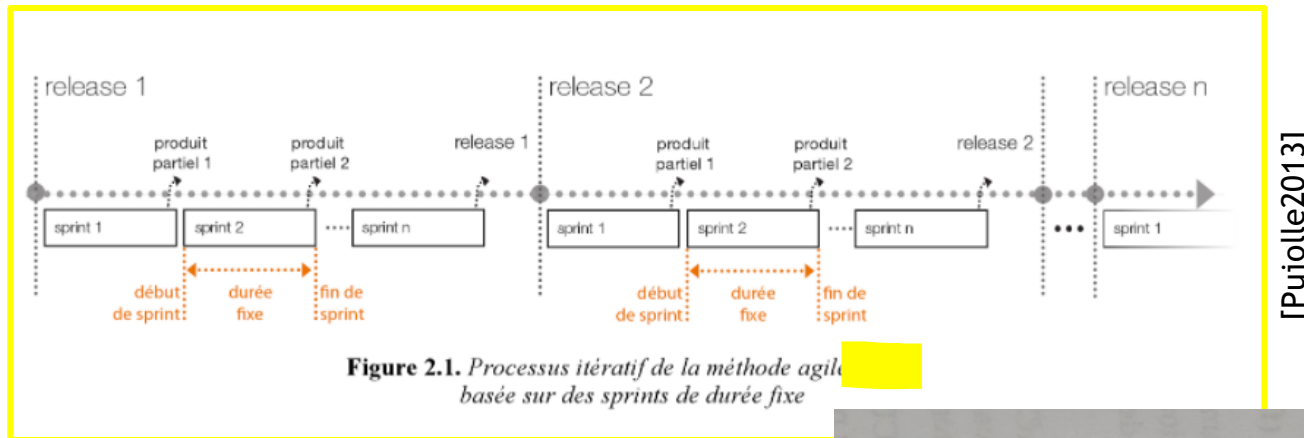
by integrating the users

- ▶ **Agile User Centered (AUC)** [Pujolle2013]
  - ▶ Consideration of users and uses during all phases of the project
    - ▶ The diversity of users (accessibility context)
    - ▶ The diversity of uses (mobility context)

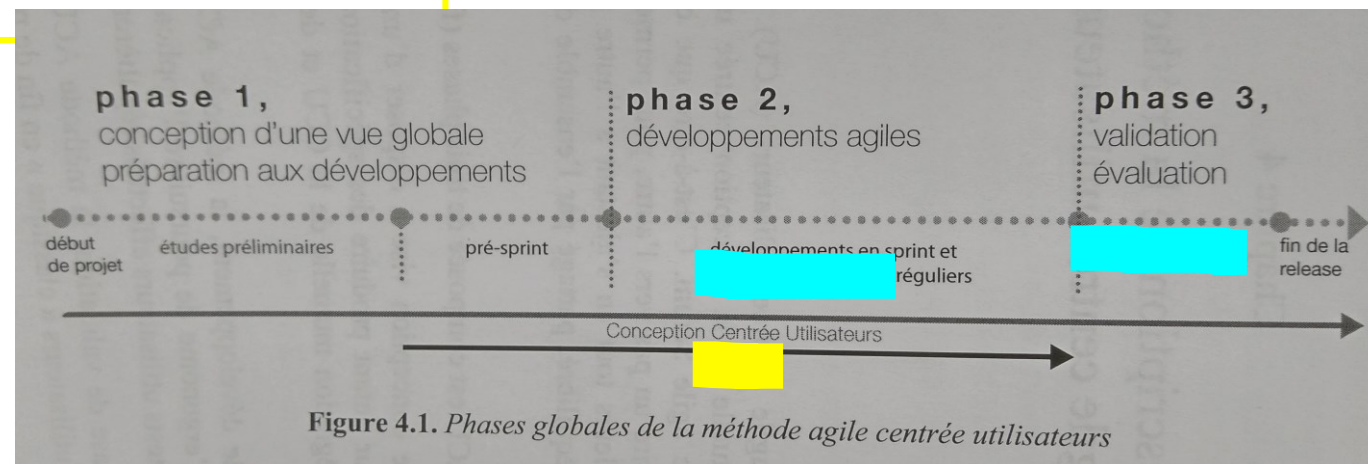


# Agile User Centered (AUC) [Pujolle2013]

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



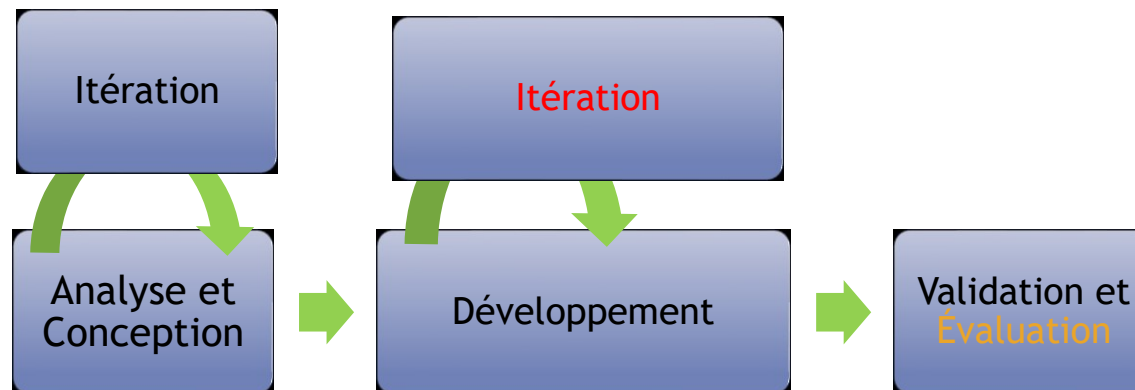
Src : <https://fr.slideshare.net/veltanletharius/scrum-9758730>



[Pujolle2013]

# ACU – Agile & UCD methods

- ▶ Mutual integration :
  - ▶ Phase 1 adjustment:
    - ▶ Objective: obtain a global view of the product ⇒ testing et evaluations of the prototypes
  - ▶ Phase 2 adjustment:
    - ▶ Objective: integration of user mini-tests on 'incomplete' products ⇒ end of sprint
  - ▶ Maintenance of phase 3:
    - ▶ Objective: "classic" user tests



# ACU – Agile & UCD methods

- ▶ Phase 2 adjustment:
  - ▶ Objective: **integration of user mini-tests on 'incomplete' products ⇒ end of sprint**
  - ▶ Adding an artifact:
    - ▶ List of ergonomic recommendations or adjustments, resulting from a user mini-test

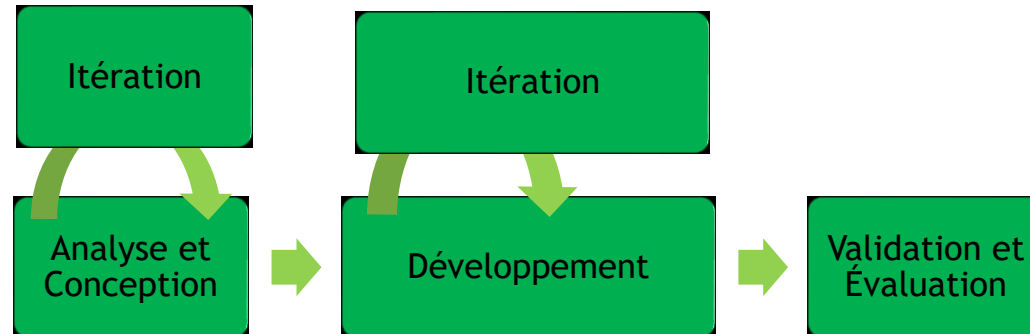
| Liste des recommandations |            |                          |          |
|---------------------------|------------|--------------------------|----------|
| Recommandations           |            | Etat des recommandations |          |
| en attente<br>à discuter  | à intégrer | intégrées                | validées |
|                           |            |                          |          |
|                           |            |                          |          |

[Pujolle2013]

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

# Conclusion UCD

- ▶ Tout projet peut être conduit avec une approche de CCU :
  - ▶ Atelier de co-conception,
  - ▶ Rémunération des testeurs
  - ▶ Enquêtes diffusées par internet, ...
- ▶ Ne pas tricher, vous ne pouvez pas être parti pris
  - ▶ utilisateur – concepteur possible mais utilisateur particulier !!!



# 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]

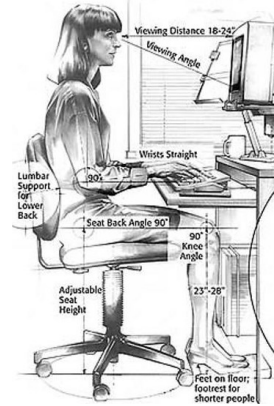
- Design of a system that is:
  - ergonomic (user-friendly)
  - usability (utilisabilité)
  - useful (utilité, usefulness/utility)
- Based on:
  - Acceptability
  - User experience (UX)
  - Affordance (facilité/perception)

How to measure these elements?

- Towards measures of usability
- Towards acceptance models

# Reminder: Ergonomics – different types

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



# De la psychologie cognitive à l'ergonomie cognitive

## ► Généralités :

### ► Psychologie cognitive :

- Étudier et comprendre les processus cognitifs humains

### ► Ergonomie cognitive :

- Appliquer ces notions de psycho. cognitive à l'amélioration des interfaces, et des interactions humains/interfaces

## ► Focus sur l'ergonomie cognitive :

### ► Définition :

- Composante appliquée de la psychologie cognitive ergonomique ayant pour but de comprendre comment s'élaborent les comportements intellectuels complexes dans une situation de travail

### ► Principes :

- Étude des situations de travail mental par application des méthodes, concepts, et modèles des psychologues cognitifs



# Intervention ergonomique – Une double analyse

## 1. Analyse de la tâche

### ► Tâche prescrite :

- Ce qui doit être fait => but à atteindre
- Dans un environnement donné
- Séquence de sous-tâches / actions / opérations de l'utilisateur

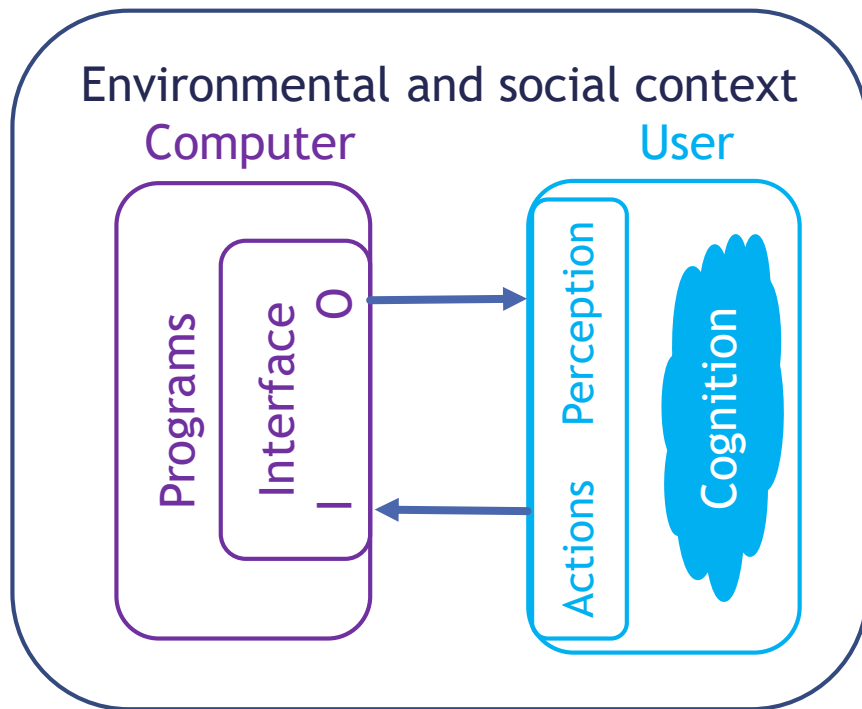
Privilégiée par les concepteurs au détriment des utilisateurs

## 2. Analyse de l'activité cognitive correspondante

### ► Tâche réalisée :

- Ce qui est fait réellement => processus et représentations mobilisées par l'utilisateur pour réaliser les sous-tâches
- Analyse des données comportementales (*i.e.* traces de l'activité mentale) similaire aux méthodes de psycho. cognitive expérimentale
- Dédution des causes potentielles d'un comportement par inférence (analyse stat.) sur les données

# Intervention ergonomique – Schématisation [Baccino2013]



- ▶ Information theory [Shannon1949]
  - ▶ Two information processing systems
    1. **Computer/Interface**
    2. **User**
  - ▶ 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<sup>1</sup>, analysis of mental activity (ergonomics)

# Intervention ergonomique – Modèle du processeur humain

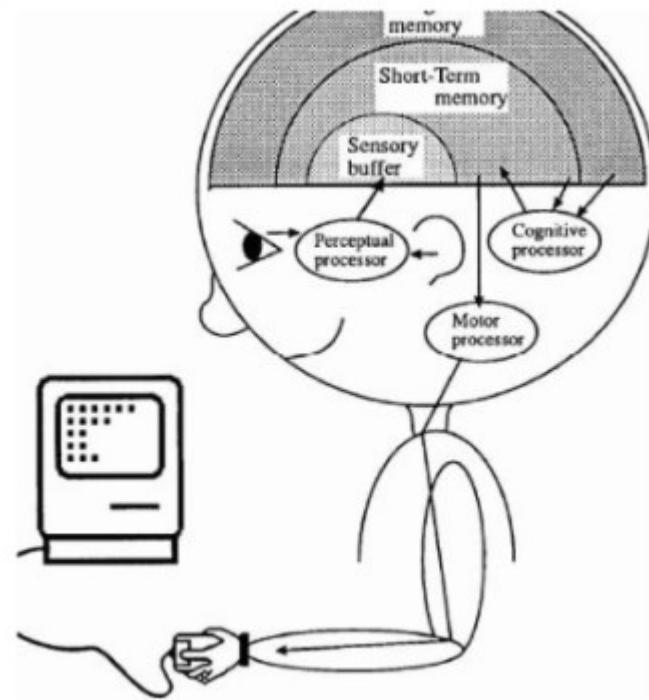
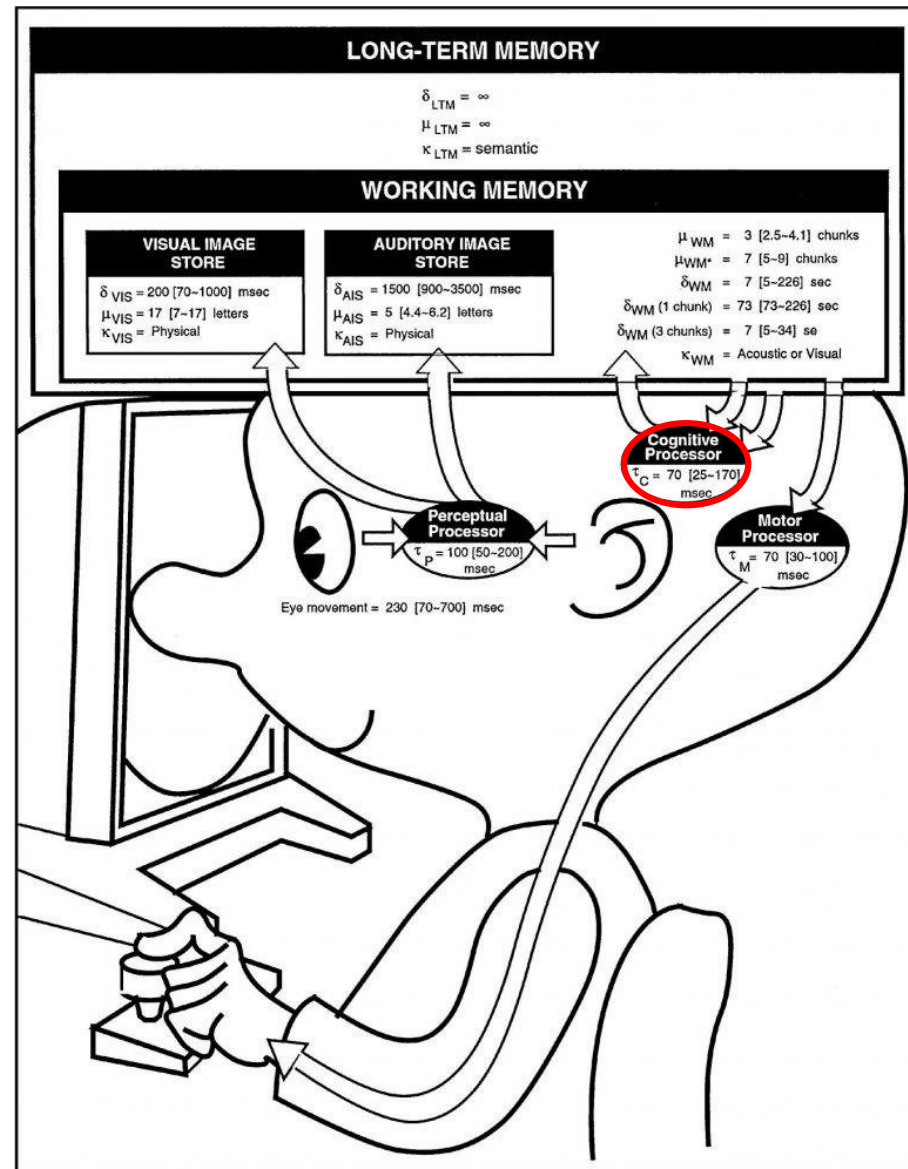


Figure A.1 Modèle du processeur humain [Card 83].

- ▶ Processeur Humain [Card 83]
  - ▶ Représentation de l'être humain en phase de traitement des connaissances
- ▶ L'individu est un système
  - ▶ Prenant en entrée des données les stimuli perceptifs,
  - ▶ Effectuant des traitements et
  - ▶ Produisant des sorties, les actions

## Intervention ergonomique – Modèle du processeur humain



Src: [Card et al., 1986]

# Ergonomie cognitive des interactions HM/HO

## ► Objectifs :

- **Décrire et expliquer** les interactions entre un H et un système informatique afin d'**améliorer** le bien-être des utilisateurs et l'efficacité globale des systèmes,

## ► Leviers :

### 1. **L'utilisabilité :**

- Niveau de facilité avec lequel un utilisateur emploie un produit informatique pour réaliser une tâche précise,
- **Norme ISO 9241 :**
  - Paramètre non statique => évolution / type d'utilisateur / contexte d'usage
  - Nécessité de prise en compte de ces paramètres pour l'évaluation (d'une interface)

### 2. **L'interface :**

- Moyen (physique ou cognitif) par lequel l'Humain peut utiliser un outil
- Trois types d'interfaces :
  - **Interfaces linguistiques** : interactions sous forme écrite ou orale (ex : ligne de commande, menu, ...)
  - **Interfaces directes** : WIMP, interaction directe par pointage d'objets graphiques (ex : bureau Windows)
  - **Interfaces intelligentes** : sujet de recherche actif, interfaces adaptatives au comportement de l'utilisateur (ex : réalité augmentée, ...)

# Usability - definition

- ▶ Norme ISO 9241 :
  - ▶ «Un produit est dit utilisable lorsqu'il peut être utilisé avec **efficacité**, **efficience** et **satisfaction** par des utilisateurs donnés, cherchant à atteindre des objectifs donnés, dans un contexte d'utilisation donné.»
    - ▶ **Efficacité**: l'utilisateur doit réussir à faire ce qu'il veut faire
    - ▶ **Efficience**: il doit pouvoir le faire rapidement et avec le moins d'erreurs possible
    - ▶ **Satisfaction**: caractéristiques esthétiques, apprenabilité, confort
- ▶ [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:**

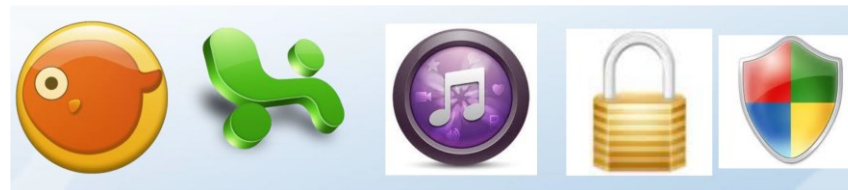
- ▶ set of **quantitative measures** on human behavior, extracted from an **heuristic evaluation** or from **User experiments/tests**

# 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.

# Critères de Bastien & Scapin

- ▶ Guidage
- ▶ Charge de travail
- ▶ Contrôle explicite
- ▶ Adaptabilité / Flexibilité
- ▶ Gestion des erreurs
- ▶ Homogénéité/Cohérence
- ▶ Signifiante des codes et dénominations
- ▶ Compatibilité



# Guidage

- ▶ **Objectif** : faciliter l'utilisation du système et son apprentissage
- ▶ Créer des *feed-back* et *feed-forward* pour :
  - ▶ réduire la charge cognitive
  - ▶ prévenir des situations d'erreur
  - ▶ rassurer (ex : progression d'une opération)
- ▶ **Perception humaine du temps de réponse** :
  - ▶  $t < 0.1$  sec : perçu comme instantané
  - ▶  $t < 1$  sec : le délai est perçu, mais ne perturbe pas l'utilisateur
  - ▶  $t > 10$  secondes : l'utilisateur va vouloir faire autre chose en attendant
  - ▶ **Pour les longs délais** : changement de curseur, barre de progression, ...

# Guidage - Recommandations

- ▶ **Incitation** (*feed-forward*)
  - ▶ griser les commandes non disponibles
  - ▶ fournir la liste et le format de saisie des données attendues
  - ▶ donner des valeurs par défaut « intelligentes »
- ▶ **Retour utilisateur** (*feed-back*)
  - ▶ toute action utilisateur => changement de présentation de l'interface
  - ▶ indiquer les modes de fonctionnement du système
  - ▶ signaler les traitements longs par un message d'attente
  - ▶ toujours faire apparaître les saisies de l'utilisateur
  - ▶ rendre visibles les traitements réalisés par le système



[contactez-nous](#)

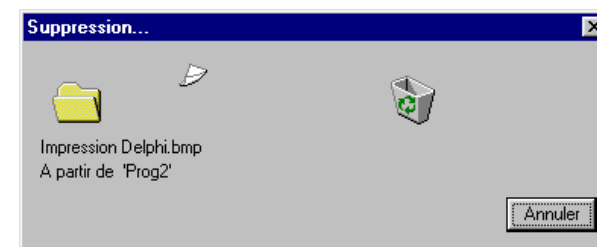
|                  |                   |                          |                             |      |               |           |
|------------------|-------------------|--------------------------|-----------------------------|------|---------------|-----------|
| Produits         | Commandes & Stats | Marketing                | Pages                       | Blog | Configuration | Apparence |
| Livraison        | Paiement          | Commandes & Factures     | Gérer son ailemap           |      |               |           |
| Devises et taxes | Nom de domaine    | Personnaliser les textes | Services & options          |      |               |           |
| Stocks           | Ads & Partage     |                          | Scripte & services externes |      |               |           |

☒ Utiliser l'adresse IP suivante :

Adresse IP :

Masque de sous-réseau :

Passerelle par défaut :



# Guidage - Recommandations

## ► Groupement / distinction (design graphique)

- Regrouper les informations de même type par un même format ou une même position
- Mettre en évidence les informations différentes par une présentation distincte

## ► Lisibilité (typographie)

- Utiliser une police droite
- Utiliser du contraste : lettres sombres sur fond clair

| Erreurs à l'exécution                                      | Options de syntaxe                                        |
|------------------------------------------------------------|-----------------------------------------------------------|
| <input type="checkbox"/> Vérification <u>L</u> imites      | <input type="checkbox"/> Chaînes-var <u>s</u> trictes     |
| <input type="checkbox"/> Vérification <u>P</u> ile         | <input type="checkbox"/> Eval. booléenne <u>c</u> omplète |
| <input type="checkbox"/> Vérification <u>E</u> /S          | <input checked="" type="checkbox"/> Syntaxe étendue       |
| <input type="checkbox"/> <u>V</u> érification Débordements | <input type="checkbox"/> Opérateur @ <u>t</u> ypé         |
|                                                            | <input type="checkbox"/> Paramètres <u>o</u> uverts       |

# Charge de travail

- Principe : Ensemble des moyens visant à réduire la charge perceptive et mnésique de l'utilisateur

The screenshot displays a web-based interface for a university's digital work environment, titled "Mon environnement numérique de travail". The interface is organized into several sections:

- Navigation Bar:** Located at the top, it includes links for "Mon bureau", "Mes outils", "Intranet", "Recherche", "Formation - Insertion pro.", "Bibliothèques", "Vie de l'établissement", "Élections 2017", and "Assistance".
- Left Sidebar:** Contains a "PERSONNALISER" dropdown and a list of links under the "Université" heading: "Intranet du personnel", "Intranet des étudiants", "Bibliothèques - documentation", and "Vie culturelle". Below this is a section for "Actualités de Suptice" with a link to "Annonces suptice".
- Main Content Area:** Titled "Annonces Rennes 1", it displays a list of announcements. The first announcement is about a sports event: "Le sport ? En 2018, je m'y (re)jette !". Other announcements include information about a conference, thesis submissions, and energy consumption.
- Right Sidebar:** Contains three main sections:
  - Messagerie:** Includes a link to "Accéder à ma boîte aux lettres" and a list of links: "Documentation à l'usage du webmail" and "En cas de problème créer un ticket".
  - Agenda:** Includes a link to "Accéder à mon agenda" and a list of links: "Documentation à l'usage de l'agenda" and "En cas de problème créer un ticket".
  - Espaces documents:** Includes a section for "Mon emploi du temps UR1" with a link to "Mon emploi du temps" and a calendar view.



# Charge de travail - Recommandations

**Lancer**

**Lancement de l'application de gestion des notes**

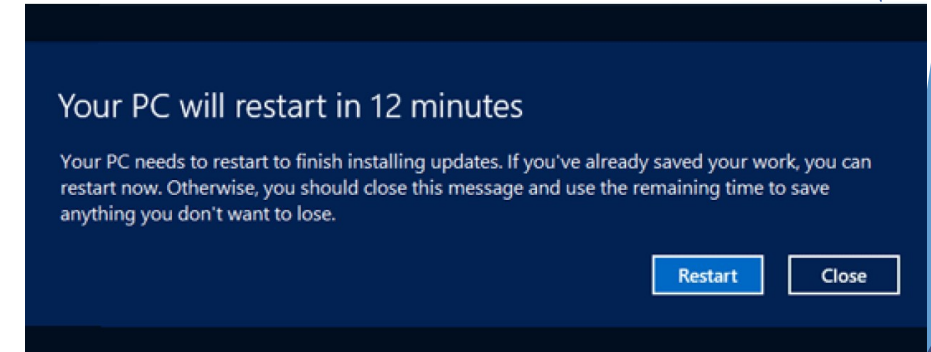
- ▶ N'afficher que les informations pertinentes
- ▶ Réduire le nombre d'actions élémentaires
  - ▶ minimiser les saisies/lectures
  - ▶ éviter les textes trop verbeux
- ▶ Faire les traitements automatiques
  - ▶ pas de saisie d'informations déductibles (i.e. calculs, report d'information, ...)

# Charge de travail - Recommandations

- ▶ Présenter uniquement les **informations nécessaires**
  - ▶ *less is more* : limiter le nombre de widgets et de fenêtres qui introduisent des manipulations supplémentaires
  - ▶ Cacher ou supprimer les informations non essentielles
  - ▶ Utiliser si possible l'ordre naturel des choses
- ▶ Préférer :
  - ▶ Les **manipulations directes** aux saisies de commandes ou d'arguments
    - ▶ *point and click instead of remember and type*
  - ▶ Un **petit nombre de commandes génériques**
    - ▶ *Reconnaître* est plus facile que *se souvenir*

# Contrôle explicite - Recommandations

- ▶ **Définition** : prise en compte par le système des actions des utilisateurs, et contrôle des utilisateurs sur le traitement de leurs actions
- ▶ Actions explicites
- ▶ Contrôle utilisateur : retour arrière

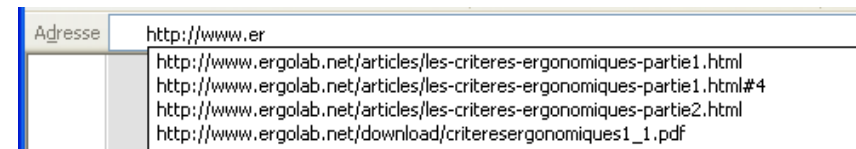


# Flexibilité

- ▶ **Objectif :** prendre en compte la diversité des utilisateurs et des situations
- ▶ **Exemples :**
  - ▶ paramétrages : préférences, options, tableaux de bord
  - ▶ prendre en compte les niveaux différents d'expertise
    - ▶ 1<sup>ère</sup> utilisation, utilisations occasionnelles, utilisations répétées
  - ▶ correction d'orthographe
  - ▶ représentation multiple des concepts
    - ▶ associer plusieurs objets de présentation à un concept donné
    - ▶ variations sur une forme de base unique
  - ▶ possibilité de résoudre un problème de plusieurs manières
    - ▶ Clic droit + « supprimer » / glisser-déposer
  - ▶ respect du rythme de l'utilisateur
  - ▶ éviter d'imposer un ordre pour les entrées d'informations

# Flexibilité - Recommandations

- ▶ **Permettre :**
  - ▶ l'activation des commandes au clavier ou à la souris
  - ▶ Le **paramétrage** du logiciel **par l'utilisateur** selon ses préférences
  - ▶ Fournir un moyen rapide d'accéder aux commandes des menus
- ▶ **Adaptativité :** **personnalisation dynamique** sans action explicite de l'utilisateur
- ▶ Les utilisateurs expérimentés doivent pouvoir se servir rapidement des opérations les plus courantes
- ▶ Solutions :
  - ▶ icônes
  - ▶ abbréviations (Ctrl-s)
  - ▶ mnémoniques (Alt-f-e)
  - ▶ touches spéciales (Xerox Star: move, copy, properties...)
  - ▶ complétion automatique, frappe anticipée (*type ahead*)
  - ▶ mécanismes de navigation, historiques
  - ▶ *redo*



# Homogénéité

- ▶ Concerne la cohérence globale de l'interface
  - ▶ interne : à l'intérieur d'une application
  - ▶ externe : entre les applications, avec la métaphore du système
- ▶ **Principe** : un système qui a l'air familier est perçu comme simple à utiliser
- ▶ **Intérêt** : faciliter l'apprentissage et l'utilisation
- ▶ **Risque** : freiner ou bloquer l'évolution (inertie des standards)

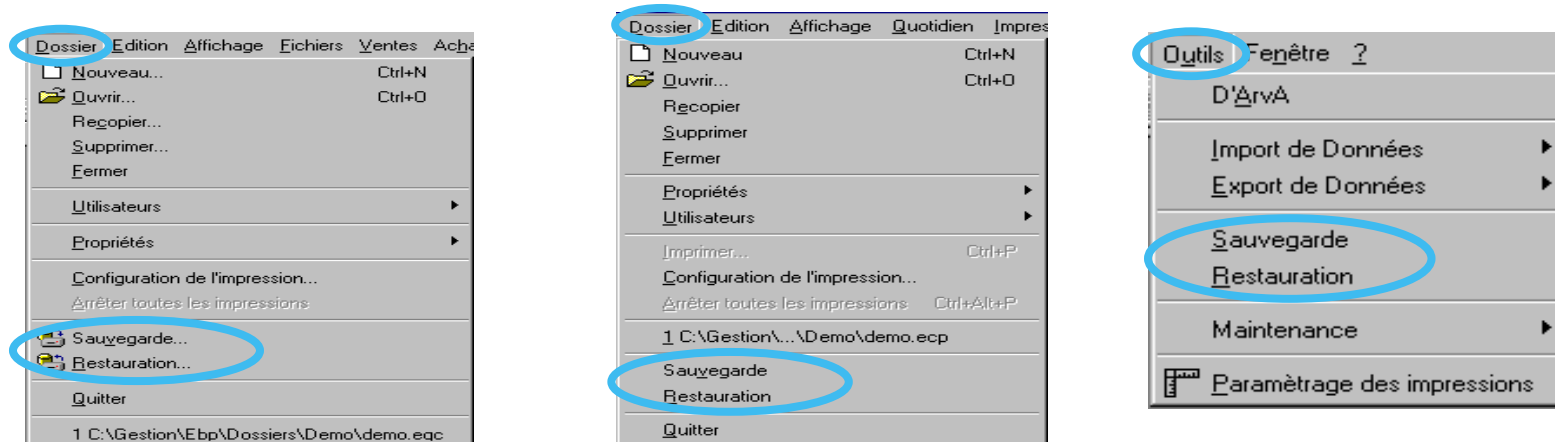
# Homogénéité - Recommandation

## ► Schéma directeur :

- les fenêtres doivent suivre le même schéma d'agencement
- Ex. : boîte de recherche en haut à droite

## ► Sémantique constante :

- des boutons de la souris, du vocabulaire désignant les commandes du logiciel
- Ex. : ouvrir / copier-coller / préférences / ...



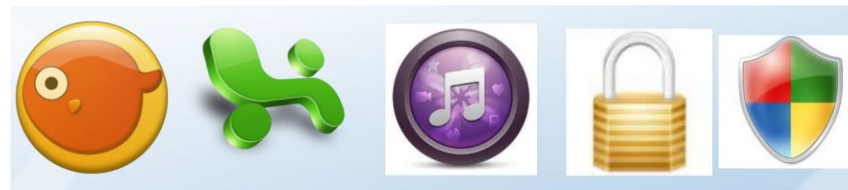
# Compatibilité

- ▶ **Définition :** Capacité du système à s'intégrer dans l'activité des utilisateurs
- ▶ **Principes :**
  - ▶ Utilisation du langage de l'utilisateur
  - ▶ Présentation cohérente des informations / aux autres supports de travail
    - ▶ ex. : version électronique d'un formulaire papier
  - ▶ Compatibilité entre la tâche de l'utilisateur et son accès aux commandes
    - ▶ exemple : commandes fréquentes au premier niveau des menus



# Critères de Bastien & Scapin

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- ▶ Signifiante des codes et dénominations
- ▶ Compatibilité



# 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:**
  - ▶ **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. 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 measurements
3. Conduct the user tests
  - Selection of users
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, ...
  - ▶ **Ordered values:** items sort, ...
  - ▶ **Quantitative values:** time, %, number of X, ...

|                              | 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's decision on how and when to use new IT.**
  - ▶ Understand how various interventions can influence the known determinants of IT adoption and use.

- ▶ One main model in the literature:

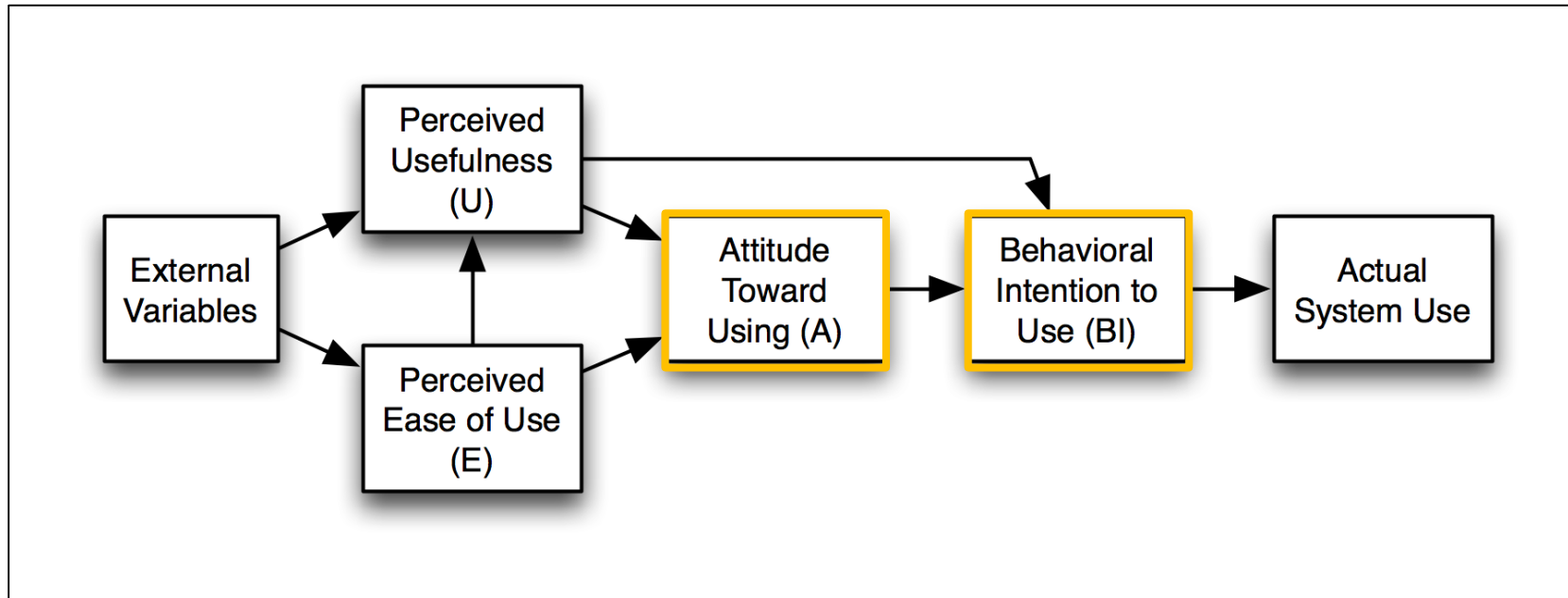
- ▶ From: **TAM** - **T**echnology **A**cceptance **M**odel [Davis1989, Bagozzi1992]
  - ▶ to its improvement & generalization: **UTAUT** - **U**nified **T**heory of **A**cceptance and **U**se of **T**echnology (UTAUT) [Venkatesh2003]

# 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.

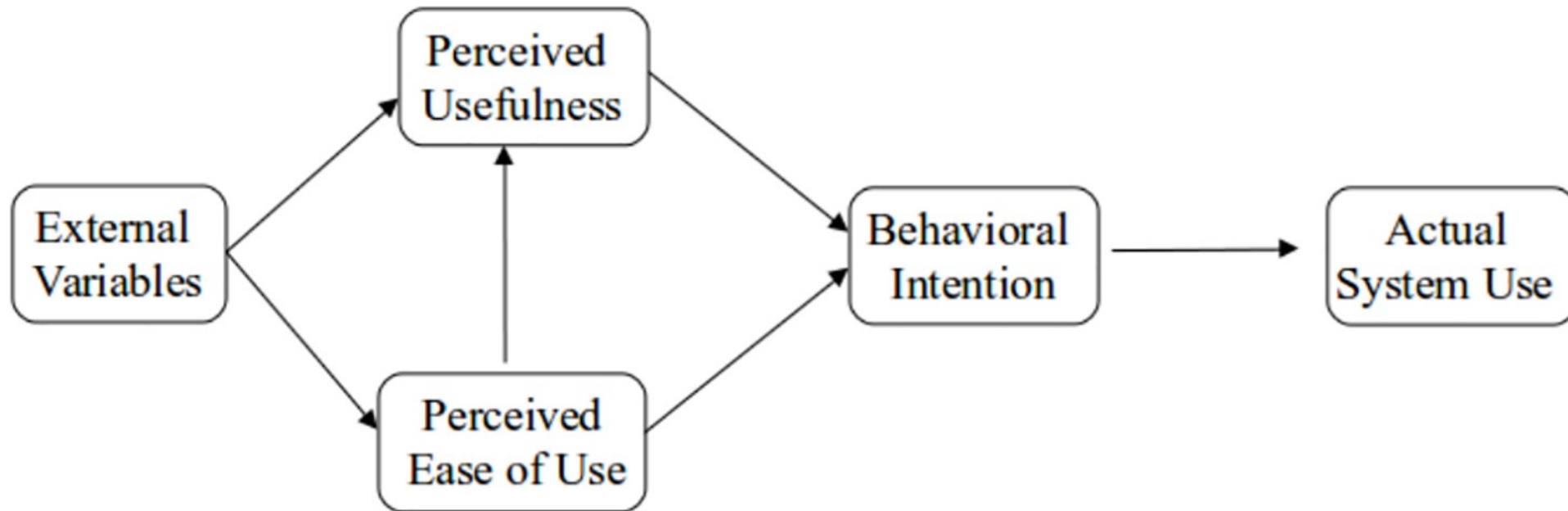


# User acceptance model – TAM



[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]

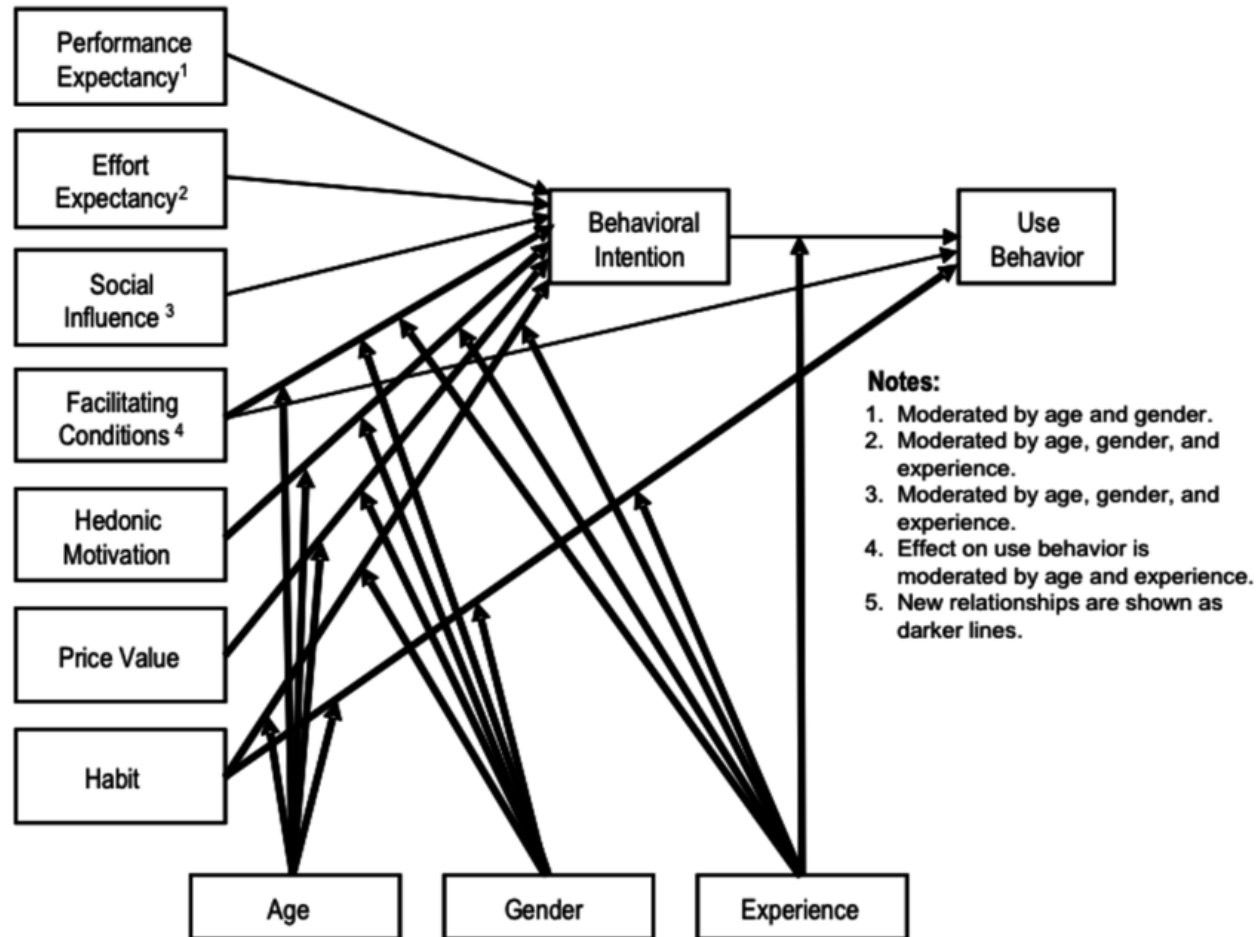
► Aims to explain:

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]

# Critics of User acceptance model

- ▶ Towards models extension (while retaining the bases of **Theory of Reasoned Action**), since:
  - ▶ End-use measurement is often too succinct:
    - ▶ how to predict the time of use or the frequency of use, in a long-term over a period?
  - ▶ Equivalent importance between:
    - ▶ the level of expectation, commitment and behavioral intention [Maruping et al. (2017)];
    - ▶ characteristics of a specific task and individual behavioral intention in the event of compulsory use, (cf. TTF: suitable for the task / technology);

# Critics of User acceptance model

- ▶ Go beyond acceptance models:
  - ▶ Beyond the intention of use, consider the consent to use (obligation of use versus actual wish)
  - ▶ Consider also the theory of the diffusion of innovations in addition to the theory of reasoned action, how to fuse these 2 theories?
- ▶ Consider the possible usefulness in contexts different from the current one:
  - ▶ Ex: adoption and rejection according to the health context of telework, distance education, etc.

# Data analysis

- ▶ Essential task

Based on

## 1. 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

## 2. Data Exploration:

- ▶ For **data structuration** before any stat analysis
- ▶ To highlight clusters, but also to adjust measurement scales

# Data analysis – Example [Baccino2013]

| User | Expertise<br>(0 novice ; 1 expert) | Comfort<br>(1- very difficult ; 5 - very easy) | Executing<br>time (s) | #visited<br>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**

- 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

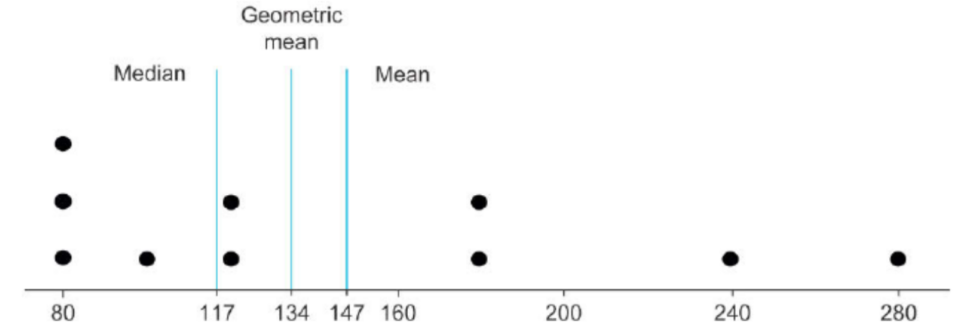
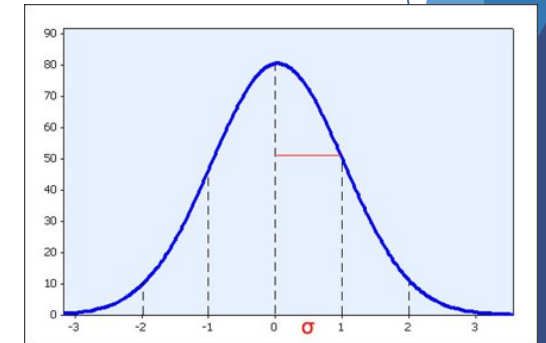


FIGURE A.2 Difference in "average" point estimates



# 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               |

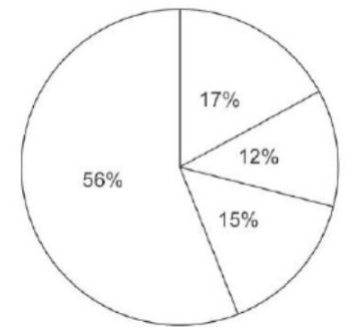
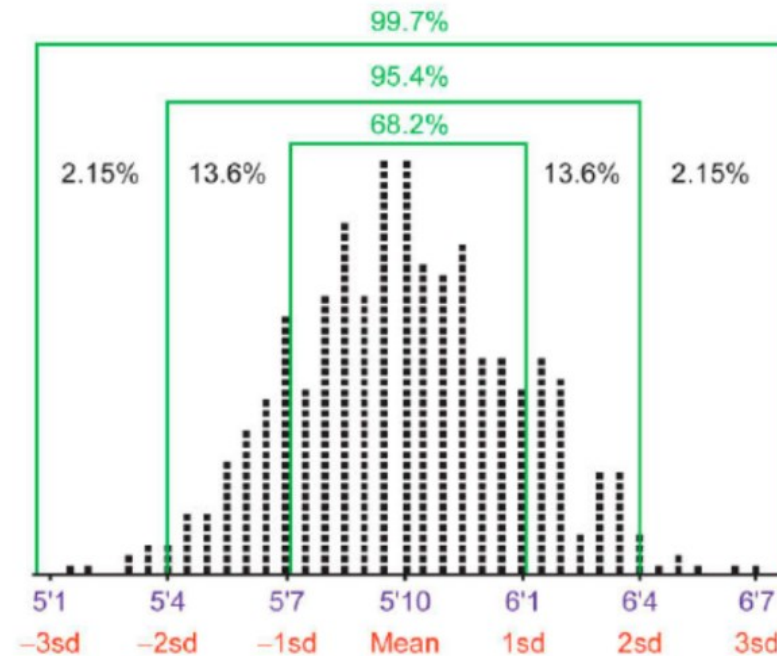
# Descriptive statistic - Graphical sum up

- ▶ 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:

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

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

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

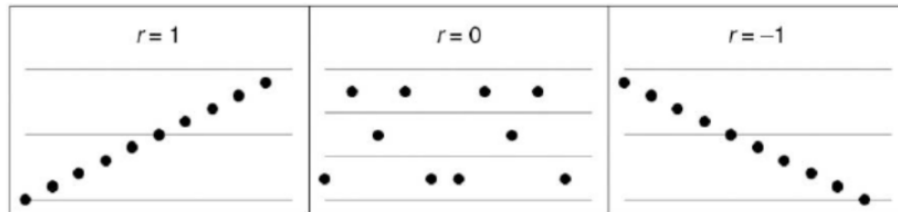


FIGURE 10.1 Scatterplots of various relationships between variables

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

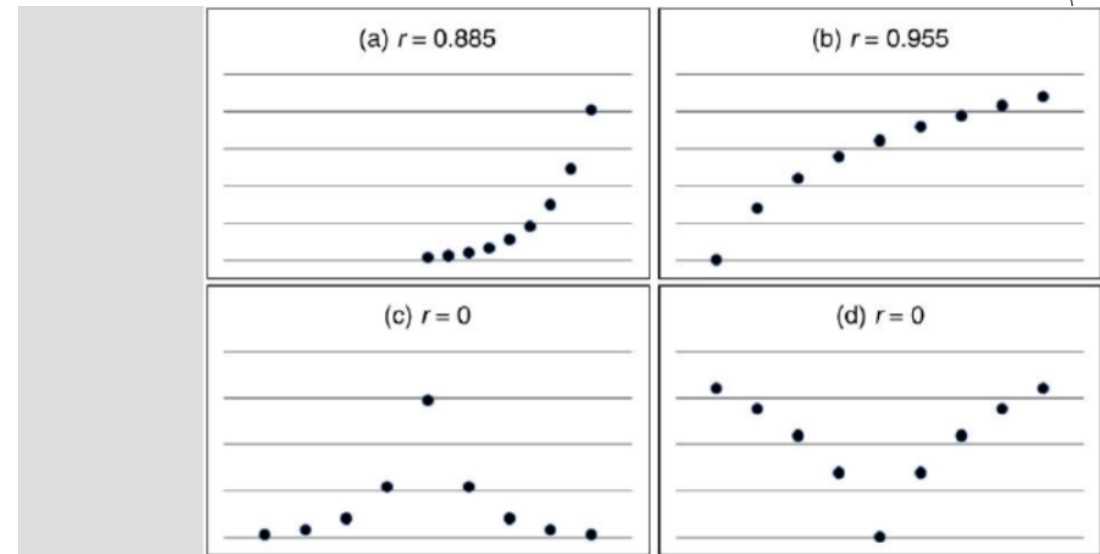


FIGURE 10.3 Graphs of nonlinear patterns



# 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:

$$\hat{y} = b_0 + b_1x + e$$

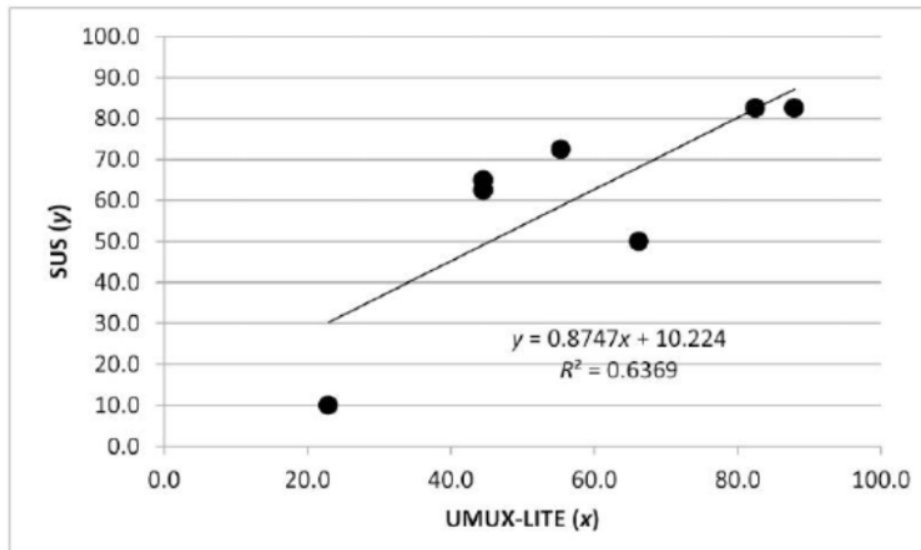


FIGURE 10.4 A least-squares regression line

# 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<br>(var numériques)             | Ech. Indépendant | T. De Student                      | ANOVA                              |
|                                               | Ech. Dépendant   | T. De Student                      | ANOVA                              |
| Non paramétriques<br>(var ordinales)          | Ech. Indépendant | Test de Mann<br>Whithney           | ANOVA<br>de Kruskal-Wallis         |
|                                               | Ech. Dépendant   | Test de Wilcoxon                   | ANOVA<br>de Friedman               |
| Tableaux de<br>contingence<br>(Var nominales) | Ech. Indépendant | Chi <sup>2</sup> de<br>contingence | Chi <sup>2</sup> de<br>contingence |
|                                               | Ech. Dépendant   | Chi <sup>2</sup> 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

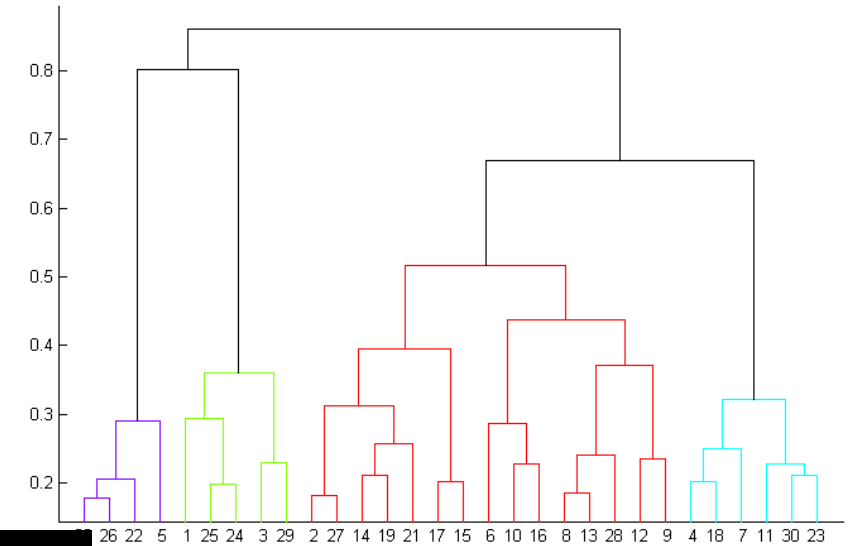
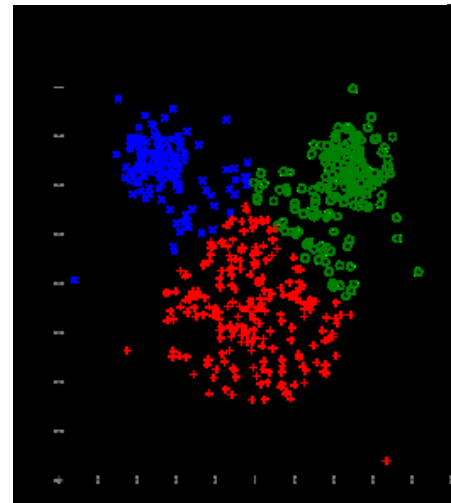
- ▶ Reliability analysis of a scale
- ▶ Principle:
  - ▶ Used when behavior is difficult to observe
  - ▶ Correlation computation (alpha de Cronbach):
    - ▶ to extract the data consistency
    - ▶ Between metrics and variances of observed answers for each question
  - ▶ **Reliability**: how the measure (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](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

**Eric ANQUETIL**

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

INSA

UMR IRISA

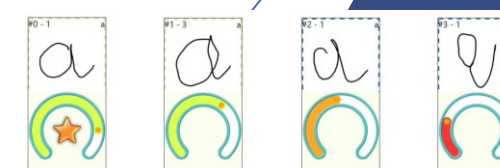
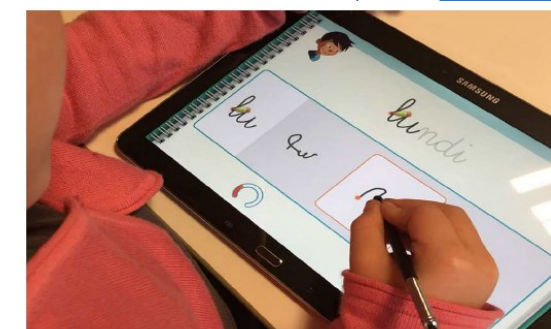
Région  
BRETAGNE

Learn&Go

académie  
Rennes  
Éducation  
nationale  
Ministère de l'Éducation  
Nationale  
République Française

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LOUSTIC



(a) (b) (c) (d)

# Objectifs

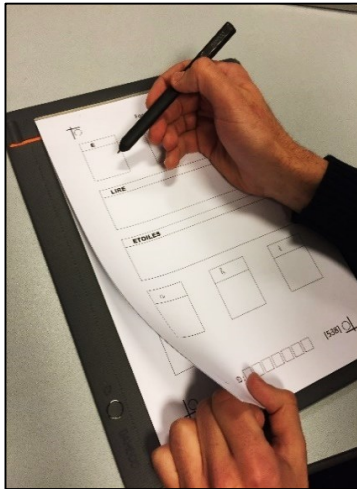
- ✓ Il s'agit d'objectiver l'efficacité d'un entraînement Kaligo d'une durée de 4 mois par comparaison à un entraînement traditionnel réalisé en classe par les enseignants. Nous supposons que l'IA de Kaligo (guidage + feedback) constitue une plus-value pour l'apprentissage de l'écriture manuscrite en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



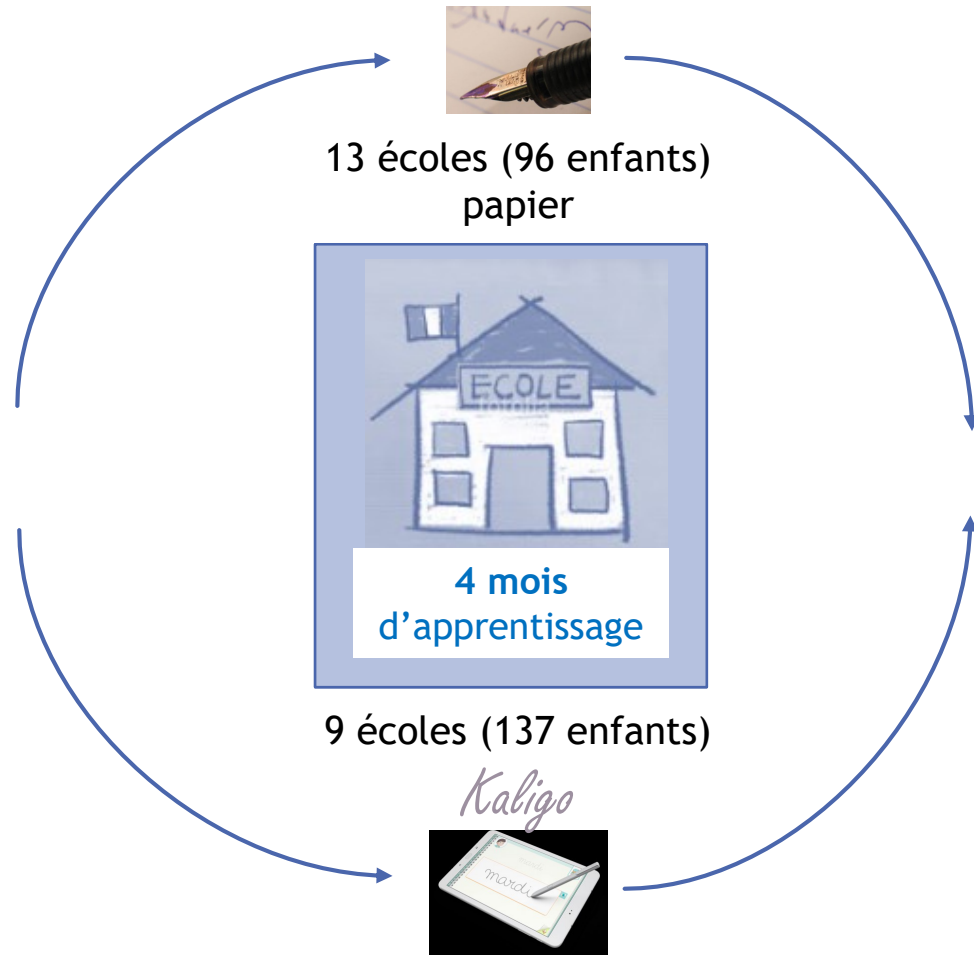
# Etude d'impact: Protocol expérimental



233 enfants  
22 écoles  
(Grande section)



Evaluation initiale sur  
papier  
avec capture numérique

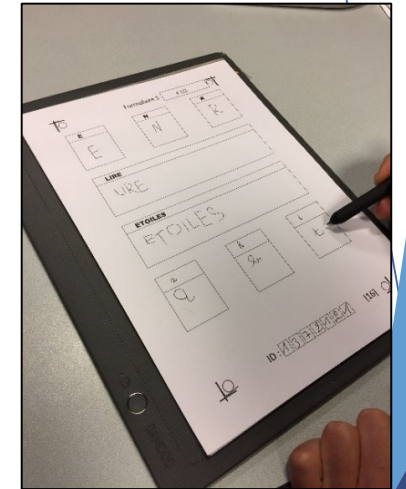


13 écoles (96 enfants)  
papier



9 écoles (137 enfants)

*Kaligo*

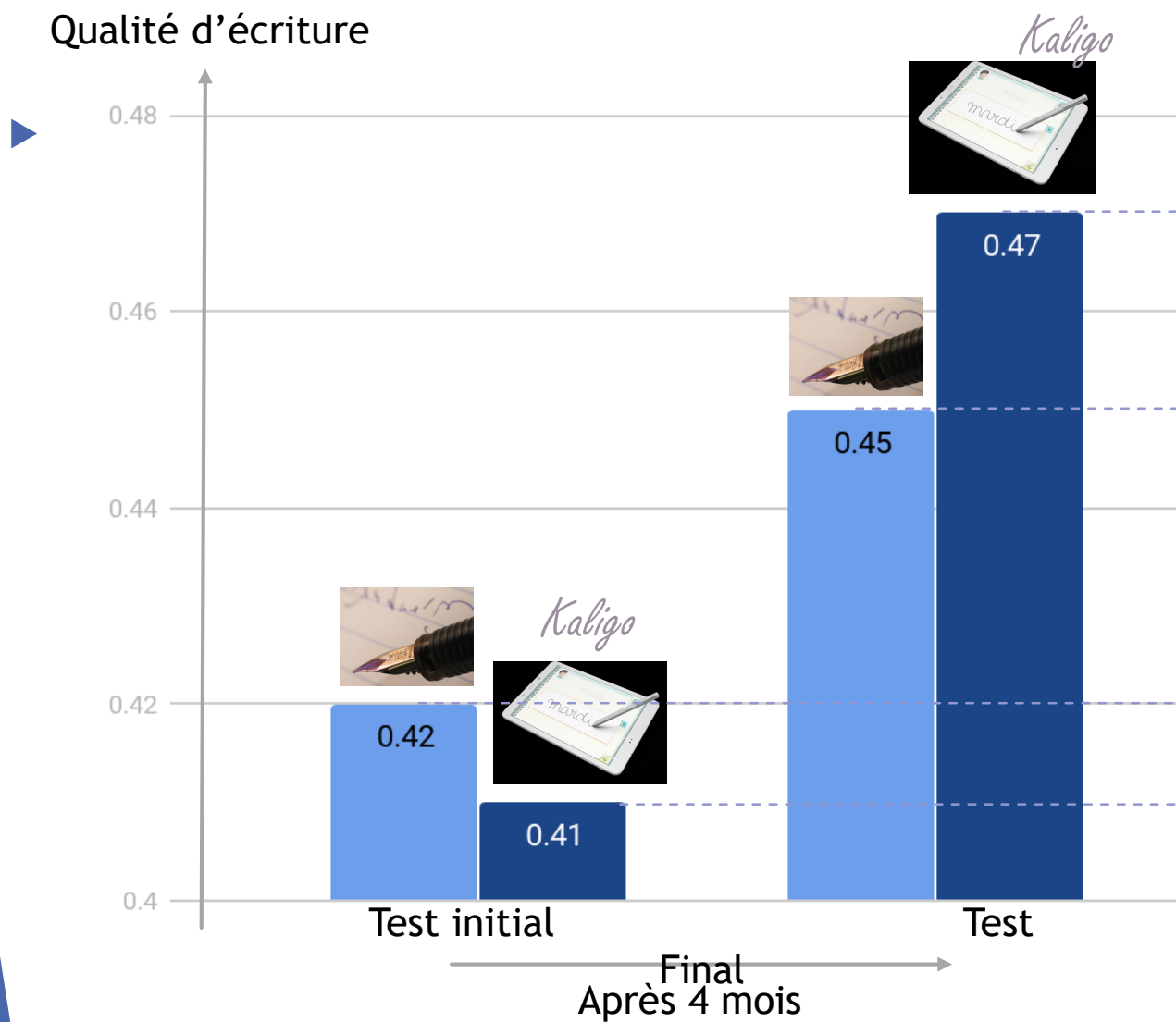


Evaluation finale sur papier  
avec capture numérique

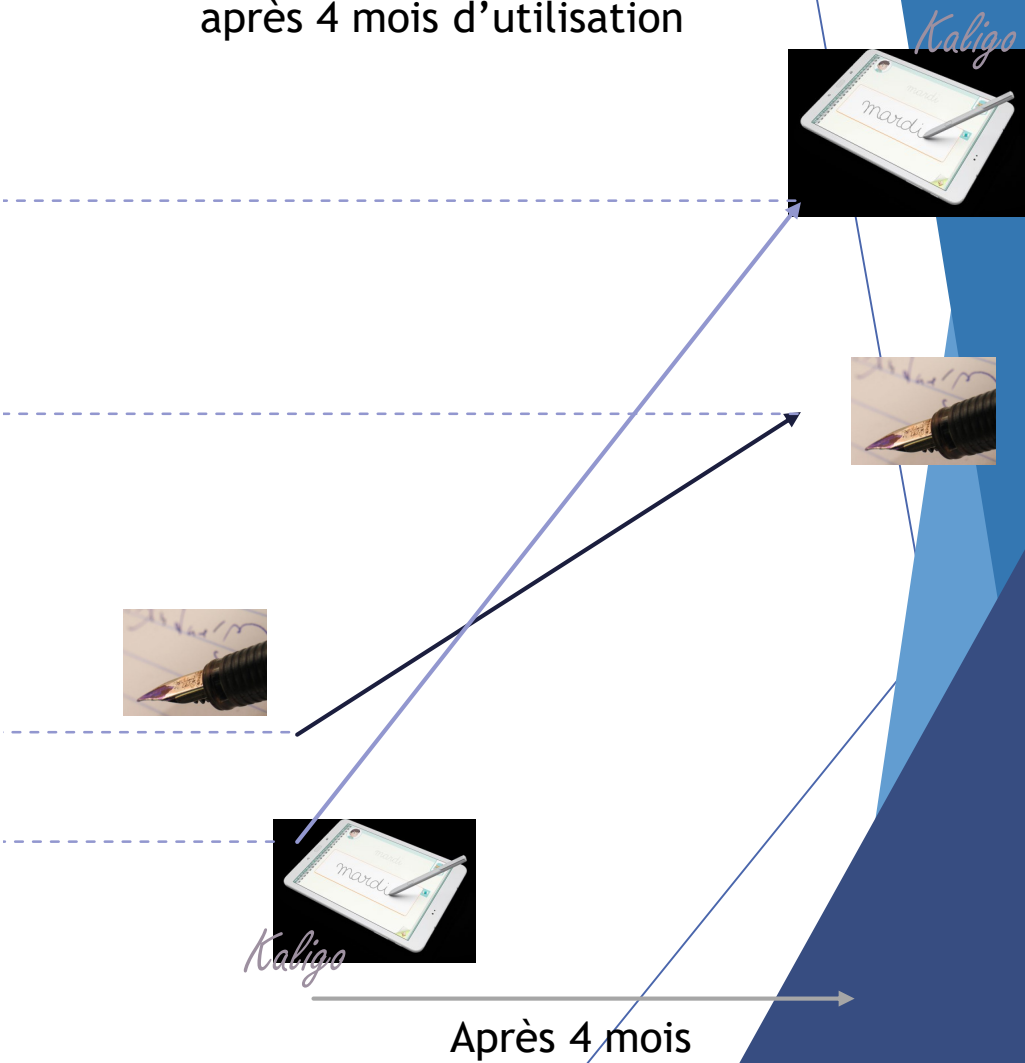
# TESTS et MESURES

- 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)

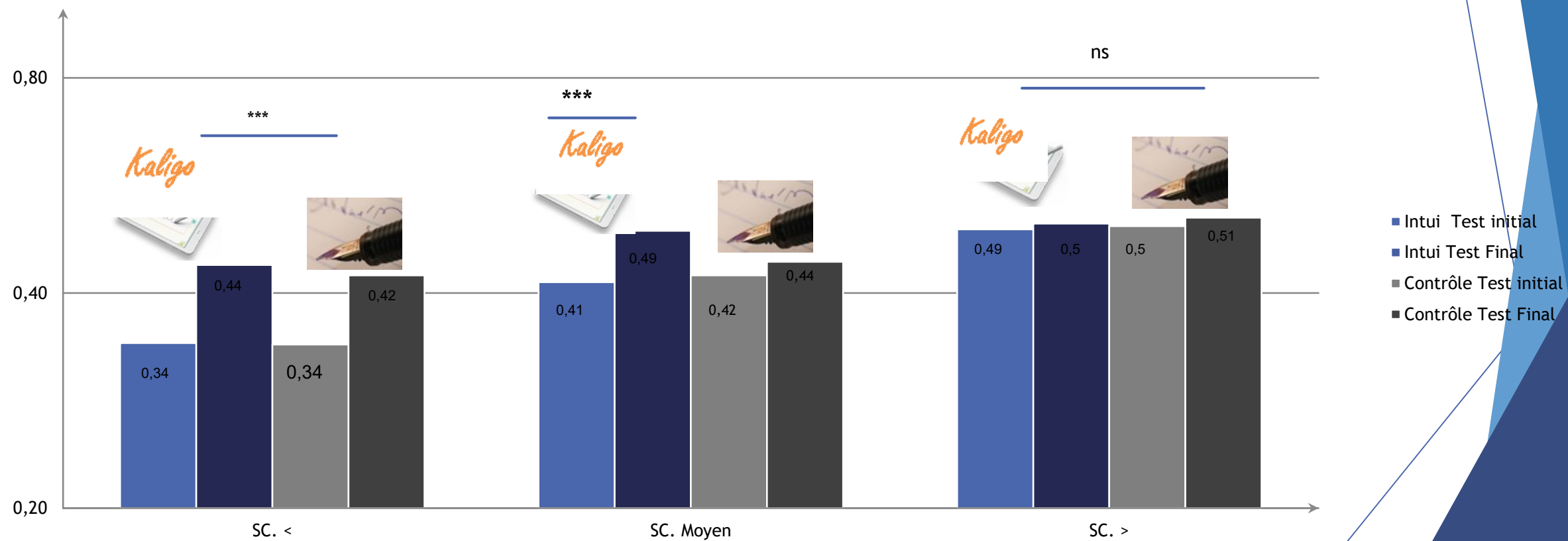
# Etude d'impact: Premiers résultats



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

