Human Factors Engineering for Healthcare applications: stakes, benefits and barriers

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Human Factors Engineering

- HFE is a “technology concerned with the analysis and optimization of the relationship between people and their activities, by the integration of human sciences and engineering in systematic applications, in consideration for cognitive aspects and socio-technical working contexts” PC Cacciabue

- “By this definition, Human Factors extends the concept of ergonomics, as the science of humans at work, beyond the workplace and behavioral performance to the cognitive and social aspects involved in human activity”.
Human Factors Engineering for healthcare (IT) applications

• **Goal**: optimization of the relationship between healthcare professionals and their working activities (healthcare work)

• **Mean**: systematic integration of human sciences and engineering in the medical informatics projects

• **Scope**: analysis, understanding and improvement of the work situation including cognitive and social aspects of the healthcare professionals activity
Human Factors Engineering Lifecycle

- First challenge: integrate HFE methods in Medical Informatics projects

- Projects:
  - Initiated by an institution (hospital): acquire – install a new Clinical Information System
  - Initiated by a Company: re-engineering of their product, design of a new product
Project lifecycle
Hospital: new CIS

Goals, Expected benefits (quality, safety, ROI)

Users needs
Requirements

Call for proposal
(Specification)

Choice of a product

Configuration
Pilot sites

Dissemination
Project lifecycle
Hospital: new CIS

- Goals, Expected benefits (quality, safety, ROI)
- Users needs
  - Requirements
- Call for proposal (Specification)
- Choice of a product
- Configuration
  - Pilot sites
- Dissemination

Human Factors Engineering lifecycle

- Understand the project (goals)
Goals, Expected benefits (quality, safety, ROI)

Users needs Requirements

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Choice of a product

Configuration Pilot sites

Dissemination

Understand the project (goals)

Description, Analysis and Model of the current work situation
- Context of use
- users (tasks and activity)
- Usability assessment of systems

Project lifecycle
Hospital: new CIS

Human Factors Engineering lifecycle
**Project lifecycle**

Hospital: new CIS

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**Human Factors Engineering lifecycle**

- Understand the project (goals)
- **Description, Analysis and Model of the current work situation**
  - Context of use
  - users (tasks and activity)
  - Usability assessment of systems
- Model of the current work situation
  - diagnosed problems
**Project lifecycle: New CIS**

- Goals, Expected benefits (quality, safety, ROI)
- Users needs, Requirements
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- Choice of a product
- Configuration, Pilot sites
- Dissemination

**Human Factors Engineering lifecycle**

- Understand the project (goals)
- **Description, Analysis and Model of the current work situation**
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  - Users (tasks and activity)
  - Usability assessment of systems
- **Model of the current work situation diagnosed problems**
- **COOPERATIVE DESIGN**
- **Model of the re-engineered work situation**
  - Organizational & Usability goals
**Project lifecycle:** Hospital: new CIS

- **Goals, Expected benefits** (quality, safety, ROI)
- **Users needs Requirements**
- **Call for proposal** (Specification)
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- **Configuration**
- **Pilot sites**
- **Dissemination**

**Human Factors Engineering lifecycle**

1. **Understand the project (goals)**
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   - Context of use
   - Users (tasks and activity)
   - Usability assessment of systems
3. **Model of the current work situation**
   - Diagnosed problems
4. **COOPERATIVE DESIGN**
5. **Model of the re-engineered work situation**
   - Organizational & Usability goals
6. **Iterative evaluation**
7. **Human factors problems - Recommendations**
**Project lifecycle: new CIS**

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8. Survey – Evaluation of impact
Project lifecycle
System engineering

Goals, Expected benefits (ROI, diffusion, quality)

Users needs
Requirements

Specification
Development of a concept

Implementation of the concept

Release
Human Factors Engineering lifecycle

- Understand the project (goals)
  
- Description, Analysis and Model of the current work situation
  - Context of use
  - Users (tasks and activity)
  - Usability assessment of systems

- Model of the current work situation diagnosed problems (HCI)

Project lifecycle System engineering

- Goals, Expected benefits (ROI, diffusion, quality)

- Users needs

- Requirements

- Specification

- Development of a concept

- Implementation of the concept

- Release
Human Factors Engineering lifecycle

Understand the project (goals)

Description, Analysis and Model of the current work situation
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- Usability assessment of systems

Model of the current work situation diagnosed problems

COOPERATIVE DESIGN

Model of the re-engineered HCI Usability goals

Iterative evaluation

Usability problems - Recommendations

Project lifecycle System engineering

Goals, Expected benefits (ROI, diffusion, quality)

Users needs

Requirements

Specification Development of a concept

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**Human Factors Engineering lifecycle**

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**Project lifecycle**

- Hospital: new CIS
  - Goals, Expected benefits (quality, safety, ROI)
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  - Call for proposal (Specification)
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  - Configuration Pilot sites
  - Dissemination

**System engineering**

- Goals, Expected benefits (ROI, diffusion, quality)
- Users needs
- Requirements
- Specification Development of a concept
- Implementation of the concept
- Release

**Iterative evaluation**

- Usability problems - Recommendations

**Survey – Evaluation of impact**

**Synchronize timelines and agendas**
Understand the project (goals)

Model of the current work situation
- Context of use
- users (tasks and activity)
- Usability assessment of systems

Model of the re-engineered work situation
Organizational & Usability goals

COOPERATIVE DESIGN

Iterative evaluation
Usability problems - Recommendations

Survey – Evaluation of impact

Goals, Expected benefits (ROI, diffusion, quality)

User needs
Requirements

Call for proposal (Specification)

Choice of a product

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Dissemination

Project lifecycle
Hospital: new CIS

Human Factors Engineering lifecycle

Project lifecycle
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COOPERATIVE DESIGN

Goals, Expected benefits (quality, safety, ROI)

Users needs
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Goals, Expected benefits (ROI, diffusion, quality)

Users needs
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Specification Development of a concept
Implementation of the concept
Release

Hospital: new CIS

Human Factors – Medical Informatics Lille 24 May 2006
The HFE engineering toolbox

• Theories, conceptual frameworks, models, methods, techniques, devices …

• From various fields: cognitive psychology, cognitive ergonomics, cognitive engineering, usability, ethnology, sociology, software engineering …
COGNITIVE
psychology, ergonomics, engineering

• Theories and models
  – Decision making, process control, human error,

• Methodologies, frameworks
  – Cognitive Task Analysis (CTA); activity analysis,

• Methods
  – Interviews, questionnaires, protocol analysis, documents analysis, audio/video-recorded observations, …
Usability

• Methods:
  – Usability inspection: heuristic evaluation, cognitive walkthrough
  – Usability tests
  – Focus groups

• Techniques, devices
  – Usability labs
Software engineering

- Modelling languages and methods:
  - UML
  - SADT
  - Petri nets
  - GOMS
  - KLM
Examples of results obtained with medication CPOE projects
The projects

• Medication ordering, [dispensing], and administration process
  – Several applications (Medasys DxCare, SIB Génois)

• Hospital setting, survey of the therapeutic process during the patient’s stay:
  – Several hospitals:
    • Academic hospitals (CHU Lille, Georges Pompidou Paris)
    • General Hospitals (Denain, Bayeux)
Description, Analysis and Model of the current work situation
Field observations

• What are the actual tasks performed by the physician, the nurse, the pharmacist?
• In which order?
• How do they synchronize their work?
• Who is actually in charge of the survey and control of the tasks? Of the medication process?
Field observations

• Many different organizations exist
  – In different hospitals
  – Within the same hospital, in the different departments

• Modeling of ONE of the existing organization,

• Use of the models to support the design of the future organization
Scenario: the nurse accompanies the physician on his medical rounds
Search for information
<table>
<thead>
<tr>
<th>PHYSICIAN</th>
<th>NURSE</th>
<th>PHARMACIST</th>
</tr>
</thead>
</table>
| Search for information | patient’s medical information | Patient’s medical information

*Distributed: documents, patients interview, clinical data, other professionals knowledge*
Search for information

patient’s medical information

Gather information

Gather information
Search for information

patient’s medical information

Gather information

Provide information (summarize patient’s case)

Provide information (summarize the patient’s case)
PHYSICIAN

Search for information

Make a decision (explain the decision)

NURSE

patient’s medical information

Gather information

Provide information (summarize patient’s case)

PHARMACIST

Make a decision (explain the decision)
Search for information

Make a decision (explain the decision)

Document the orders

patient’s medical information

Gather information

Provide information (summarize patient’s case)

Document the orders
Search for information
Make a decision (explain the decision)
Document the orders
Sign the orders

patient’s medical information

Gather information
Provide information (summarize patient’s case)
Document the orders (under physician’s dictation)

Sign the orders
PHYSICIAN

- Search for information
- Make a decision (explain the decision)
- Document the orders
- Sign the orders

NURSE

Patient’s medical information

- Gather information
- Provide information (summarize patient’s case)
- Document the orders (under physician’s dictation)

PHARMACIST

List of medication orders
**PHYSICIAN**

- Search for information
- Make a decision (explain the decision)
- Document the orders
- Sign the orders

**NURSE**

- patient’s medical information
- Gather information
- Provide information (summarize patient’s case)
- Document the orders (under physician’s dictation)

**PHARMACIST**

Send the orders to the pharmacy (nominative dispensing)
Physician

- Search for information
- Make a decision (explain the decision)
- Document the orders
- Sign the orders
- List of medication orders

Nurse

- Patient’s medical information
- Gather information
- Provide information (summarize patient’s case)
- Document the orders (under physician’s dictation)

Pharmacist

- Order the drugs from the pharmacy (global dispensing)
- Send the orders to the pharmacy (nominative dispensing)

Order the drugs from the pharmacy (global dispensing)
**PHYSICIAN**

- Search for information
- Make a decision (explain the decision)
- Document the orders
- Sign the orders

**NURSE**

- Gather information
- Provide information (summarize patient’s case)
- Document the orders (under physician’s dictation)

**PHARMACIST**

- Retrieve nominative orders
- Order the drugs from the pharmacy (global dispensing)
- Send the orders to the pharmacy (nominative dispensing)
PHYSICIAN
Search for information
Make a decision (explain the decision)
Document the orders
Sign the orders

NURSE
Patient’s medical information
Gather information
Provide information (summarize patient’s case)
Document the orders (under physician’s dictation)

PHARMACIST
List of medication orders
Order the drugs from the pharmacy (global dispensing)
Send the orders to the pharmacy (nominative dispensing)

Deliver the medication for designated patients
Retrieve nominative orders
Analyze
Prepare
Deliver the medications for designated patients
Physician:
- Search for information
- Make a decision (explain the decision)
- Document the orders
- Sign the orders

Nurse:
- Gather information
- Provide information (summarize patient’s case)
- Document the orders (under physician’s dictation)

Pharmacist:
- Retrieve global orders
- Retrieve nominative orders
  - Analyze
  - Prepare
  - Deliver the medications for designated patients

Patient’s medical information:
- Gather information
- Provide information (summarize patient’s case)

List of medication orders:
- Order the drugs from the pharmacy (global dispensing)
- Send the orders to the pharmacy (nominative dispensing)
PHYSICIAN

Search for information

Make a decision (explain the decision)

Document the orders

Sign the orders

NURSE

patient’s medical information

Gather information

Provide information (summarize patient’s case)

Document the orders (under physician’s dictation)

List of medication orders

Order the drugs from the pharmacy (global dispensing)

Send the orders to the pharmacy (nominative dispensing)

PHARMACIST

Deliver the medications

Retrieve global orders

prepare

Deliver the medications

Retrieve nominative orders

Analyze

prepare

Deliver the medications for designated patients
**PHYSICIAN**
- Search for information
- Make a decision (explain the decision)
- Document the orders
- Sign the orders

**NURSE**
- Gather information
- Provide information (summarize patient’s case)
- Document the orders (under physician’s dictation)

**PHARMACIST**
- Retrieve nominative medications

**List of medication orders**
- Order the drugs from the pharmacy (global dispensing)
- Send the orders to the pharmacy (nominative dispensing)

**Retrieve global orders**
- Prepare
- Deliver the medications

**Retrieve nominative orders**
- Analyze
- Prepare
- Deliver the medications for designated patients

**Patient’s medical information**
Search for information → Make a decision (explain the decision) → Document the orders → Sign the orders

PHYSICIAN

patient’s medical information

Gather information → Provide information (summarize patient’s case) → Document the orders (under physician’s dictation)

PHARMACIST

Retrieve medications (global orders) → Retrieve nominative medications

NURSE

List of medication orders

Order the drugs from the pharmacy (global dispensing) → Send the orders to the pharmacy (nominative dispensing)

PHARMACIST

Retrieve global orders → prepare → Deliver the medications

Retrieve nominative orders → Analyze → prepare → Deliver the medications for designated patients
**PHYSICIAN**
- Search for information
- Make a decision (explain the decision)
- Document the orders
- Sign the orders

**NURSE**
- Gather information
- Provide information (summarize patient’s case)
- Document the orders (under physician’s dictation)

**PHARMACIST**
- Gather information
- Retrieve global orders
- Retrieve nominative orders
- Analyze
- Prepare
- Deliver the medications
- Deliver the medications for designated patients

**List of orders**
- Retrieve medications (global orders)
- Retrieve nominative medications
- Gather information

**Patient’s medical information**
Physician:
- Search for information
- Make a decision (explain the decision)
- Document the orders
- Sign the orders

Nurse:
- Gather information
- Provide information (summarize patient’s case)
- Document the orders (under physician’s dictation)

List of medication orders:
- Order the drugs from the pharmacy (global dispensing)
- Send the orders to the pharmacy (nominative dispensing)

Pharmacist:
- Retrieve global orders
- Retrieve nominative orders
- Analyze
- Prepare
- Deliver the medications
- Deliver the medications for designated patients

List of orders:
- Retrieve medications (global orders)
- Retrieve nominative medications

Gather information
Prepare administration
Search for information

Make a decision (explain the decision)

Document the orders

Sign the orders

List of medication orders

Order the drugs from the pharmacy (global dispensing)

Send the orders to the pharmacy (nominative dispensing)

List of orders

Gather information

Provide information (summarize patient’s case)

Gather information

Document the orders (under physician’s dictation)

Document the orders (under physician’s dictation)

Retrieve global orders

Retrieve nominative orders

Retrieve medicaments (global orders)

Retrieve nominative medicaments

Prepare administration

Administer / document administration

Analyze

Deliver the medications

Deliver the medications for designated patients
Who (which role) participates in each step of the process?
Who has the most complete knowledge about the medication process for each patient of the ward?
Who is in the best position for the survey (& control?) of this process?
• UML modeling of a possible organization with a medication CPOE system (ordering, dispensing, administration)
Scenario:
• the nurse does not accompany the physician on his medical rounds: he is alone with his computer (mobile laptop, CPOE available at bedside)
• nominative dispensing
Search for Information
Display patient’s Medical information

Search for Information

Make a decision

Make a decision
Display patient’s Medical information

Display Order Entry Screen

Search for Information

Make a decision

Enter the orders

Enter the orders
APPLICATION

Display patient’s Medical information

Display Order Entry Screen

PHYSICIAN

Search for Information

Make a decision

Enter the orders

Validate the orders

NURSE

PHARMACIST

Validate the orders
APPLICATION
- Display patient’s Medical information
- Display Order Entry Screen
- Save the order

PHYSICIAN
- Search for Information
  - Make a decision
  - Enter the orders
  - Validate the orders
- Update orders for pharmacist

PHARMACIST

NURSE

Update orders for pharmacist
APPLICATION

- Display patient’s Medical information
- Display Order Entry Screen
- Save the order
- Update orders for pharmacist
- Update the Nurse’s Medication Administration Record (MAR)

PHYSICIAN

- Search for Information
- Make a decision
- Enter the orders
- Validate the orders

NURSE

PHARMACIST

- Display the nominative orders
Display patient’s Medical information
Display Order Entry Screen
Save the order

Search for Information
Make a decision
Enter the orders
Validate the orders

Analyze the orders content

Update orders for pharmacist
Update the Nurse’s Medication Administration Record (MAR)

Display the nominative orders
Analyze the orders content
Send medication to the ward
Display patient’s Medical information

Display Order Entry Screen

Save the order

Update orders for pharmacist

Update the Nurse’s Medication Administration Record (MAR)

Search for Information

Make a decision

Enter the orders

Validate the orders

Retrieve medications

Analyze the orders content

Prepare nominative dispensing

Display the nominative orders

Send medication to the ward

Retrieve medications (nominative doses)
Prepare the meds for administration
Administer the meds / Document administration

Display patient’s Medical information

Display Order Entry Screen

Save the order

Update the Nurse’s Medication Administration Record (MAR)

Display the MAR

Search for Information

Make a decision

Enter the orders

Validate the orders

Update orders for pharmacist

APPLICATION

PHYSICIAN

NURSE

PHARMACIST
APPLICATION

Display patient’s Medical information

Display Order Entry Screen

Save the order

Update orders for pharmacist

Update the Nurse’s Medication Administration Record (MAR)

Display the MAR

Update the MAR

PHYSICIAN

Search for Information

Make a decision

Enter the orders

Validate the orders

Gather Information

Prepare the meds for administration

Administer the meds / Document administration

NURSE

Retrieve medications

Medications (nominative doses)

Gather Information

Prepare the meds for administration

Administer the meds / Document administration

Send medication to the ward

PHARMACIST

Display the nominative orders

Analyze the orders content

Prepare nominative dispensing

Display the MAR
- Increased role of the pharmacist for the control of prescriptions and dispensing
- Application in charge of the control of communication between professionals and of the synchronization of their tasks
- Reduced role of the nurse, reduced knowledge (physician’s intention?)
Recommendations

• Installing a medication CPOE system has an impact on the work situation. It is important to choose to model and design the future organization.

• This design must address explicitly the question of survey and control of the medication process.

• The organization must support the cooperative work and the synchronization of the tasks of the healthcare professionals.
Consequences for the design of the future work situation

• Focus on the first part of the process (medical decision, medication ordering)

• Example of an organizational design & solution (Denain Hospital)

• Requirements for the re-engineering of Human Computer Interface (physician)
<table>
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<tbody>
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<td>Display patient’s Medical information</td>
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<td>Provide information (summarize patient’s case)</td>
<td>Analyze the orders content</td>
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<tr>
<td>Save the order</td>
<td>Enter the orders</td>
<td>Validate the orders</td>
<td>Prepare unit dose dispensing</td>
</tr>
<tr>
<td>Update the Nurse’s Medication Administration Record (MAR)</td>
<td>Update orders for pharmacist</td>
<td>Check the orders entered by the physician</td>
<td>Send medication to the ward</td>
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Recommendations for the CPOE systems
Recommendations for the CPOE systems

- The system must support properly the decision making phase: good overview of the patient’s medical information and of the current treatments

  ➞ Important re-engineering

- Should support the synchronization of tasks and the collaborative planning of the care process

  ➞ Deep re-engineering, new models inspired from CSCW systems
Conclusion
Toward Utopia land

- HFE technology is systematically integrated in both sides of the projects (organizational / system re-engineering)
Toward Utopia land

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• HFE experts are called in as soon as possible, very early in the projects
Toward Utopia land

- HFE technology is systematically integrated in both sides of the projects (organizational / system re-engineering)
- HFE experts are called in as soon as possible, very early in the projects
- The future work situation (organization and system) is explicitly designed and chosen
Toward Utopia land

• HFE technology is systematically integrated in both sides of the projects (organizational / system re-engineering)
• HFE experts are called in as soon as possible, very early in the projects
• The future work situation (organization and system) is explicitly designed and chosen
• Safety concerns are integrated in the design (control of the process, barriers to errors)
• ......
Thank you for your attention

Questions?