Using a Low-Cost Simulation Approach for Assessing the Impact of a Medication Administration System on Workflow

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## Background: A Continuum of Studies and Settings

<table>
<thead>
<tr>
<th>Laboratory</th>
<th>Naturalistic</th>
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<tr>
<td>- Fixed usability lab</td>
<td>- Study in the real setting</td>
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<td>- Experimental tasks</td>
<td>E.g. in hospital room, Real operating room</td>
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<td>- “think aloud”</td>
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<td>- Cognitive task analysis</td>
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<tr>
<td>- Clinical simulations</td>
<td>E.g. “simulated” doctor-patient interviews (using EHR)</td>
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Background: A Continuum of System Evaluation Across the SDLC

1. Planning (needs analysis)
   - workflow analysis
   - job analysis
   - analysis of decision making
   - interviews

2. Analysis (requirements)
   - interviews
   - questionnaires
   - focus groups
   - video analysis
   - cognitive task analysis

3. Design
   - usability testing
   - usability inspection
   - design walkthroughs

4. Implementation (programming)
   - usability testing
   - code inspections
   - software unit testing

5. Support (maintenance)
   - summative evaluations

Application of usability testing (and related methods) across the SDLC
Low-Cost (Rapid) Simulation Approach to Usability Testing

• Can be applied across the entire continuum of settings (from artificial to simulation to naturalistic recording)
• Can be applied across the entire continuum of stages in the SDLC
• If conducted in real environment (with real users) can lead to high level of fidelity (and can recording in place can even be left on to do naturalistic recording – not possible in fixed usability or simulation lab)
• Is very low in cost (equipment is customized to site, but typically in the cost range of a few thousand dollars)
Equipment for Conducting Rapid Low-Cost Usability Tests and Simulations

- Video camera to record user physical actions
- Microphone to record user verbalizations
- Screen cam to record user facial expressions
- Recording of computer/PDA screens to CD using screen capture software e.g. Hypercam
Clinical Simulations in Health Informatics

• Extends use of usability testing in healthcare to realistic settings and tasks (and real users)

• Extends work by Kushniruk & Patel on use of “standardized patient” used in medical education
  – to include study of users, e.g. doctors or nurses, while using a real clinical system

• Can extend to full video and audio recording
Analyzing Clinical Workflow Using Simulations

• Approach can be used to simulate clinical activity and to identify:
  – Errors induced by use of technology
  – Effects (intended and unintended on clinician workflow)
  – Effects on workflow

• Operationally workflow refers to:
  • How tasks are structured
  • Who performs them
  • What their relative order is
  • How they are synchronized
  • How information flows to support the tasks and how tasks are being tracked
Overall Approach

• Involves a combination of methods
• We use for design or re-design of systems based on
  – Video based usability analyses
  – Discussion with users about design issues right after user of system (contextualized)
• What can be done to improve design in terms of system customization? (this situation is now quite common in health informatics)
Step 1: Identify the User-Technology Level to Simulate

Multiple Users Interacting with Each Other and the System to Carry Out Multiple Tasks as part of the Organization

User Interacting Individually with the System and their Environment to Carry Out a Work Task

User Interacting With the System in Isolation
Step 2: Develop an Ecologically Valid Simulation

Environment → Tasks → Users

Ecological Validity

Replication of the Work Environment

Representative Findings – verified by health professionals
Step 3: Select a Testing Environment

- Exist on a continuum from low to high fidelity

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<th>Low Fidelity</th>
<th>High Fidelity</th>
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<td>e.g. reading case studies and responding to them (e.g. entering into a system while “thinking aloud”)</td>
<td>e.g. tasks carried out in real environments</td>
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Important for the environment to:
- replicate the conditions present in real environments
- place individuals in environments and situations that are similar to the "real world” (Kushniruk et. al., 2006)
Step 4: Select User Tasks

- Subjects should be asked to perform selected clinical tasks
- Tasks may involve more than one clinician
- Tasks that are simulated should range from the:
  - Simple - complex
  - Routine - atypical
  - Non-urgent - urgent
  - Controlled - uncontrolled environments
Step 5: Select User(s)

- Representative of the clinicians that are expected to work with the system and/or device
- Users should be selected based on a targeted user profile:
  - level of clinical expertise
  - level of computer expertise
  - nature of clinical practice
Step 6: Select Simulation Recording Approach

• Video and audio recording of subjects performing tasks
Case Study: Video Based User Analysis of a Medication Administration System

- Simulation and real setting
- Prototype medication administration system developed
- Environment:
  - hospital room
  - patient (or mannequin) lying in bed
  - medication administration system
  - medication cart
  - bar code scanner
  - RFID bracelets

- Application
  - administer medication

- Subjects/Users:
  - 5 nurses, 11 physicians
Video Recording of Workflow Using System Prototype
FIRST ORDER:
00:14.3 SEARCH FOR PATIENT ON COMPUTER
00:45.7 VIEW ORDER LIST
00:51.9 SELECT ORDER
00:55:3 VERIFICATION SCREEN APPEARS

MOVES OVER TO PATIENT
00:59:6 TALKING TO PATIENT S. “Nice to meet you. Is your name Toridai, right? I will now give you an IV drip”
01:09.5 SCAN PATIENT ID (FROM WRIST)

MOVES BACK TO COMPUTER
01:25:2 VIEW EXECUTION INFORMATION

MOVES OVER TO PATIENT AND SETS BAG

SECOND ORDER:
02:24.6 SEARCH FOR PATIENT ON COMPUTER
Findings from Video Analysis - Old Versus New Workflow

- Moves the bulk of medication administration activities from the medication room to the bedside
- Move from Parallel to Serial Processing
- Increases complexity of work under certain conditions (e.g. increased number of medications, urgency and interruption) leading to error
- Can predict (and plan around) those conditions
Post Task Interaction with Users (Conducted in the Setting)

• Cued recall and semi-structured discussion about interaction with system for potential changes to design (from user’s perspective)

• Objective:
  – To combine assessment of design issues obtained from video analysis and simulation

  AND

  – User-based insights (obtained directly from post-task interaction and discussion with end users) on needed improvements and refinements to system design
Discussion with User regarding Design (post video recording)

E: Do you find any difficulty with handling the technology?

S: In today’s operation there were no problems. But in real situations involving the scanner, sometimes the scanner doesn’t respond to the barcode. Also sometimes the cord of the scanner is too short to reach the patient.

E: Do you feel there needs to be changes made to the system?

S: In general, I want a more simplified system for the verification process. The more patients there are, the more difficult the verification would become. Sometimes in the emergency we have to skip this procedure due to its time-taking process and someone might need urgent help, but with this system I don’t think I’d be able to do that …
Combining Data from Different Perspectives

- Triangulation on specific design features to modify system to make it usable
- Based on both video observation and coding of (a) simulation and (b) naturalistic video recording
- In this study, the results of the different analyses methods were found to be consistent
- However, from previous studies, users do not always know what they do – need evidence from multiple perspectives
- Therefore user comments and inputs were considered carefully in light of detailed video analysis to make system usable and safe enough for release
Advantages of Simulation Approach

- Replicatable
- Not prone to recall bias
- Collects rich data
- Avoids the use of patients and health professionals in the evaluation of systems in “live” environments
  - Users do not become uncomfortable or stressed
- Can be used to make decisions regarding system selection
- Allows one to make changes to the process
- Can be used to help identify problems in a process in order to improve and standardize the process
Conclusions

• Low-cost approach can be applied to conduct high fidelity simulation testing of health information systems
• Approach can be use to detect both unintended and intended effects of systems before they are implemented on a widespread scale
• Such methods are badly needed to ensure system safety, effectiveness and efficiency (as in other industries such as aviation)