EHR Usability: Current Status & Future Directions

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2013 WISH Closing Keynote
EHR Usability:

The Emotional Stages

Some time in the past...

We are here...

Some time in the future...

http://smallbiztrends.com/2012/11/4-quick-usability-wins-for-your-website.html

http://cabarettheatreblog.files.wordpress.com/2012/02/emotionless_spock_by_elfqueen1969-d2yx7rp.png

http://searchengineland.com/does-this-website-usability-fairy-tale-have-a-happy-ending-86440
Outline

• Why Usability?
  – The business case
  – The safety and productivity challenges

• TURF – A Unified Framework of EHR Usability
  – Usefulness
  – Usableness
  – Satisfaction
  – Using TURF for design

• The Future of EHR Usability
Outline

• Why Usability?
  – *The business case*
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• The Future of EHR Usability
August 10, 2011

Wall Street

Exxon Mobil: $331 Billion

Apple: $337 Billion

Apple became the biggest company in market value
August 10, 2011

Wall Street

Usability is More Valuable than Oil!

Apple became the biggest company in market value
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Decrease of Productivity

• An outpatient CPOE increased encounter time per patient by 2.12 minutes
  – from 9.8 to 12. (Overhage, 1997)

• An inpatient CPOE increased the time spent on patient order entry
  – from 2.1% to 9% workday. (Shu, 2001)

• An outpatient EMR reduced patient volume
  – from 5/hour to 4/hour
  – and stayed at 4/hour after four years of use
AHLTA

- $4 billion to develop; much more to maintain
- Large user base
  - 412 medical clinics
  - 414 dental clinics
  - 65 military hospitals
  - in US and bases across the world
- Poor usability of AHLTA is one of the “Top Three Reasons” for physicians leaving military services
- Now considering replacement options for AHLTA
BUT...

- In other studies, if a physician was given the choice to go back to paper, none wanted to do it.

- They hate the system they love.
<table>
<thead>
<tr>
<th>Description</th>
<th>Example</th>
<th>Potential Risk/Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truncation error</td>
<td>Drop down fields too narrow to allow the user to view the entire entry</td>
<td>Wrong dosage</td>
</tr>
</tbody>
</table>

Unit:
- Select -
- Kilogram
- Kilogram per Sq
- Kilograms per D
- Kilograms per Cu
- Kilograms per Un
- Kilograms per Mi
- Kilograms per Sq
- Kilograms/Millim
- Kit
- Liter
- Liters per Day
- Liters per Minute
- Lozenge
What does a Normal Growth Chart Look Like?

David Bricks
Growth Chart with (CHF) Congestive Heart Failure

David Bricks
Growth Chart

constitutinal
growth issue
(growth issues
caused by
 genetic
mutation
or syndromes)

David Bricks
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EHR Usability
TURF Framework for EHR Usability

- **Intrinsic Complexity**
- **Extrinsic Difficulty**
- **Electronic Health Record**
- **Functions**
- **Users**
- **Representations**
- **Tasks**
- **Usable**
- **Satisfying**
- **Useful**

System Usability
TURF Framework for EHR Usability

- Functions
- Users
- Representations
- Tasks
- Usable
- Satisfying
- Useful
- Electronic Health Record
- Intrinsic Complexity
- Extrinsic Difficulty
- Users
- System Usability

Factors:
- Social/Team factors
- Time factors
- Organizational factors
- Cultural factors
- Physical/Spatial factors
- Historical factors
Dr. Townshend prescribes 90 day supply of Metformin 500 mg tablets by mouth twice daily to patient John Doe who is a pre-diabetic patient with a glucose level of 110.
Dr. Townshend prescribes 90 day supply of Metformin 500 mg tablets by mouth twice daily to patient John Doe who is a pre-diabetic patient with a glucose level of 110.
**TURF - A Unified Framework of EHR Usability**

- **An Acronym for**
  - Task, User, Representation, & Function

- **A Theory for**
  - defining, describing, explaining, and predicting usability

- **A Method for**
  - evaluating and measuring usability
  - designing usability
  - categorizing usability and safety problems

- **A Software Tool for**
  - (partially) automating usability evaluation
  - conducting user testing
  - generating evidence-based designs
  - conducting usability and patient safety analytics

What is Usability?

- Under TURF, usability is defined as how:
  - useful,
  - usable,
  - satisfying

A system is for the intended users to accomplish goals in the work domain by performing certain sequences of tasks.
# Usability Dimensions & Measures

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Descriptions</th>
<th>Representative Measures</th>
</tr>
</thead>
</table>
| **Useful** | A system is useful if it supports the work domain where the users accomplish the goals for their work, independent of how the system is implemented | • Percentage of domain functions in the EHR vs. all domain functions in the work domain  
• Percentage of domain functions over all functions (domain and non-domain) in the EHR |
| **Usable** | A system is usable if it is easy to learn, easy to use, and error-tolerant. | • Learnability  
  - Number of trials to reach a certain performance level  
  - Number of items that need to be memorized  
  - Number of sequences of steps that need to be memorized  
• Efficiency  
  - Time on task  
  - Task steps  
  - Task Success  
  - Mental effort  
• Error Prevention and Recovery  
  - Error occurrence rate  
  - Error recovery rate |
| **Satisfying** | A system is satisfying to use if the users have good subjective impression of how useful, usable, and likable the system is | • Various ratings through survey, interview, and other instruments |

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Usefulness

- How well the system supports the work domain where the users accomplish the goals for their work, independent of how the system is implemented.

- Measures:
  - Domain Function vs. Overhead Function
  - System Complexity
What is a Function?

- **Domain Function**
  - Order a medication

- **Overhead Function**
  - After click “Submit”, select “Continue” among “Continue”, “Save”, “Undo”, and “Delete” to close dosage popup; then click “Exit” to close Med popup; then click “Exit” to close Order popup; then click “Summary” tab to see list of medication orders submitted

- **Missing Function**
  - Check drug-drug interaction
Functions in Different Models

Designer model
- In the system
- Not wanted by users
- Not used in activities

User model
- In the system
- Wanted by users
- Not used in activities

Activity model
- In the system
- Not wanted by users
- Used in activities

Not in the system
- Not wanted by users
- Used in activities

Wanted by users
- Not used in activities
An Electronic Dental Record System
Measuring Usefulness: Domain Function Saturation

Domain Function Saturation = \frac{\text{#Domain Functions in EHR}}{\text{#Domain Functions in Entire Work Domain}}

A Small EDR System

\[ \frac{37}{80} = 46\% \]

(From Chen, 2008)
Measuring Usefulness: Overhead Function

Overhead in EHR = Domain Functions in EHR + Overhead Functions in EHR

CPOE 1
- Domain Functions in EHR: 58%
- Overhead Functions in EHR: 42%

CPOE 2
- Domain Functions in EHR: 64%
- Overhead Functions in EHR: 36%
Measuring Usefulness: System Complexity

- Number of levels in the hierarchy
- Branching: Number of immediate nodes
- Popularity of nodes
System Hierarchy
Branching

Average Number of Immediate Nodes Per Level

Number of Levels
Popularity of Nodes
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Usableness

- How easy is the system for users to learn, use, and resist errors

- Measures
  - Learnability
  - Efficiency
  - Effectiveness
  - Error
Learnability

- Memorability
- Predictability
- Change in task performance (time, error, memory)
Efficiency

- Task time
- Task Steps
- Mental effort
- Usability violations
- Workflow efficiency
1. In this table, we have task times of three versions of rEHRs.
Task Time and Usability Violation
Mental Workload

- CPOE
- ePrescribing
- Clinical Summary
- Smoking Status
- Problem List
- Growth Chart
- BMI
- Vital signs
- Demographics

Physical vs. Mental Workload
Effectiveness

- Task completion rate
- Path deviation
Optimal path can be loaded. Current task can be automatically matched to optimal path.
Error

- Error rate
- Error detection rate
- Error recovery rate
- Error usability violations
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Satisfaction

- User’s subjective impression of how useful, usable, and likable the system is

- Likert scale type of evaluations
  - System Usability Scale (SUS)
1. Below is original answer scores of system usability surveys of rEHR version 1 given by 3 users. Select the data and click “SUS Score” button to convert answer score to SUS score.

2. Select “SUS Score” column and calculate mean of all the SUS scores.

3. Average SUS score of rEHR version 1 is 50.
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TURF in Action: Redesigning EHR

- OpenVista: Open Source EHR
- NIST Use Case §170.302(e)
- Maintain active medication allergy list
  - Add allergy; Modify allergy; Review allergy

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TURF in Action: Redesigning EHR

TURF in Action: Redesigning EHR

- 81% reduction in Overhead Functions
- 89% increase in Domain Functions

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Functions that are useful and essential for the work
Functions

-- Useful

Overhead functions that increase complexity by adding distractions
Functions

-- Useful

Missing useful functions that cause frustration
Functions -- Useful

User Interface -- Usable

Clumsy user interface that increases task difficulty
Functions

-- Useful

User Interface

-- Usable

Overhead workflow that is not essential for the work
User Interface
-- Usable

Functions
-- Useful

Prescriptions

- Select -
Kilogram
Kilogram per Sq
Kilogram per D
Kilogram per C
Kilogram per U
Kilogram per M
Kilogram per S
Kilogram per Mill
Kit
Liter
Liters per Day
Liters per Min
Lozenge
Functions

-- Useful
Ideal Usability

(1) All and only useful functions are included

(2) User interface is invisible

(3) Clinical workflow is never touched
You already knew how to use it.

You are not even aware that you are using it.

You cannot use it.
(1) Face recognition checks patients in at door

(2) Patient records retrieved automatically

(3) While walking into exam room, 
   *Weight*: pressure sensitive floor
   *Height*: video
   *Temperature*: skin scan
   *Heart rate*: skin scan
   Then,
   *Blood pressure*: wifi, automatic

(4) Using speech recognition and NLP: notes, orders, prescriptions, etc., all captured and organized into EHR automatically

(5) All the doctor has to do with the CHART is just to review and sign (by finger print)
So how to...

and make Mr. Spock smile,

forget about this,

Like this...

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X Prize Foundation

Qualcomm Tricorder X Prize

- $20 million Star Trek-like Health Device
Turf is an integrated toolkit for usability evaluation, testing, measurement and design of electronic health record systems.

Turf has been developed by the SHARPC research group dedicated to addressing the usability and workflow challenges of Health Information Technology.
TURF Video Demo

http://www.youtube.com/watch?v=c-XncyPKLzc&feature=share&list=UU7aOOaRylFTY83yXVBugQ1g