Workshop on Designing & Conducting User Studies

20 August 2015 - Curitiba, Brazil
### Overview of the day

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<td>Kristien Ooms</td>
<td>Amy Griffin</td>
</tr>
<tr>
<td>University of Ghent</td>
<td>University of New South Wales-Canberra</td>
</tr>
<tr>
<td>ICA Commission on Use and User Issues</td>
<td>ICA Commission on Cognitive Visualization</td>
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<tr>
<td>Methods and techniques of use, user and usability research in geo-information processing and dissemination.</td>
<td>Designing your user study or experiment.</td>
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<table>
<thead>
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<th>Module 3</th>
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<td>Zbyněk Štěrba</td>
<td>Kristien Ooms</td>
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<td>University of Ghent</td>
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<td>ICA Commission on Cognitive Visualization</td>
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<tr>
<td>Hypothesis – a tool to conduct to cartographic user research</td>
<td>When and how to apply Eye Tracking</td>
</tr>
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</table>
ICA Commission on Use and User issues

David Forrest
Corné van Elzakker
David Schobesberger
Alex Pucher
Kristien Ooms
Rob Roth
Artemis Skarlatidou
Alena Vondráková

Together Everyone Achieves More
ICA Commission on Use and User Issues

• Small commission ‘core’
  – website, bibliography, facilitation of the organization of workshops / seminars and all relationships with ICA

• Corresponding Commission members
  – Mailing list of > 125 people
  – Through website
  – Mainly from science, many PhD candidates

• Goals:
  – Inform > Share & exchange > Facilitate

• Through:
  – Workshops & Congresses
  – Website & Publications
ICA Commission on Use and User Issues

• 20 August 2015 in Curitiba, Brazil- Joint Commission workshop
  – *Designing and Conducting User Studies*
  – ICA Commission on Cognitive Visualization - Use and User Issues

• 21 August 2015 in Curitiba, Brazil- Joint Commission workshop
  – *Envisioning the Future of Cartographic Research*
  – ICA Commission on Cognitive Visualization – Geovisualization - Use and User Issues - Map Design

• 23 – 29 August 2015, Rio de Janeiro, Brazil
  – Several **sessions** on Use and User Issues
  – **Business meeting**: Thursday 25th August!!!
ICA Commission on Use and User Issues

Website

– www.univie.ac.at/icacomuse
– (annotated) online bibliography

Planned:

online overview & FAQ
→ usability methods and techniques
→ aspects of experiment design
→ tips for analysis
→ why/when one would use the techniques
ICA Commission on
Use, Users, and Usability Issues

Proposed new Terms of Reference 2015-2019

**exchange** of knowledge, news, and information on use, users, and usability in cartography, geo-information processing, and related fields.

**bibliography** on use, user, and usability research in cartography and related fields. **TOPICS:**
- use of emerging mapping technologies
- methods and techniques for evaluating products
- use case studies with print, web-based, and mobile maps
- map-based user interfaces (UI) and user experience (UX) design
- studies of user abilities and differences therein
- user-centred design and usability engineering

**review paper** from bibliographical database
→ includes a **final research agenda** on map use, users, and usability for Cartography.

**online overview & FAQ**
→ usability methods and techniques
→ aspects of experiment design
→ tips for analysis
→ why/when one would use the techniques (replaces planned book publication)

→ gather and communicate original scientific contributions
→ training workshops for non-specialists on use, user, and usability issues in Cartography and related fields
→ participate in and contribute to workshops and seminars organized in other disciplines (e.g. Computer Science, Geography, GIScience)
→ involve & support young (PhD) researchers
→ researchers from different cultural environments
→ promote scientific research
→ resulting training materials
→ commission's website!

→ special journal issue with sibling ICA Commissions
ICA Commission on Use, Users, and Usability Issues

Proposed new Terms of Reference 2015-2019

**special sessions** on map use, users, and usability
- at future ICA conferences
- at other regional conferences on cartography and related topics.
- gather and communicate original scientific contributions

**training workshops** for **non-specialists** on use, user, and usability issues in Cartography and related fields
- resulting training materials → commission’s website!

**special journal issue** with sibling ICA Commissions

participate in and contribute to **workshops** and **seminars** organized in
- **other disciplines** (e.g. Computer Science, Geography, GIScience)
- by other ICA Commissions

**Involve & support**
- **young (PhD) researchers**
- researchers from **different cultural environments**
Workshop on Designing & Conducting User Studies

Module 1:
Methods and techniques of use, user and usability research in geo-information processing and dissemination.
Overview

• Content of the module:

“The first module will introduce you to use, user & usability research in geo-information processing and dissemination. Reasons for doing such research are to understand and explain how GI tools work for their users and to design more usable tools. In this first module, the focus will be on the latter. The concept of User Centered Design will be presented and an overview will be given of the most commonly applied research techniques, along with tips & tricks on how and when to use them. Experiences will be shared in interactive sessions.”
Know your user

• Who are you?
  – What is your background?
  – Have you ever done user research?
  – What are your expectations of this workshop?
  – What do you hope to learn from this workshop?
  – Do you have specific questions?
This module...

- *use,*
- *user &*
- *usability research*
- *in geo-information processing*
- *and dissemination*
- *???
Map use research

More holistic, functional map use research

e.g. use of cycling maps, investigated by Dutch project group
Types of map use research

Perceptual and cognitive research

Flannery, 1971
Nowadays ...

• Technological developments:
  – integration
    → *in the geodata collection*
    → *in geoinformation production processes*

• Map users became also map producers
  *(and collectors of map data > crowd sourcing / VGI)*

• Not only maps
  → also other ways of geospatial data dissemination
  → *therefore*....
Not only *MAP* use issues ...

But also use and user issues related to, e.g.:

- Data and databases
- Other output formats
- Software and information systems
- Hardware
- Interfaces

From map use research to *use, user & usability research* in geo-information processing and dissemination.....
Aspects of usability (ISO 9241-11)

**Guidance on Usability:**
“the extent to which a product can be used by specified users to achieve specified goals with **effectiveness**, **efficiency** and **satisfaction** in a specified context of use”

**Effectiveness:**
the accuracy and completeness with which specified users can achieve specified goals in particular environments

**Efficiency:**
the resources expended in relation to the accuracy and completeness of goals achieved

**Satisfaction:**
the comfort and acceptability of the work system to its users and other people affected by its use
Not only usability ...

In our workshop we are dealing with:

- **uses** (tasks, questions, purposes, applications, etc.)
- **users** (human beings)
- **usability**

...and particularly with:

**methods and techniques** of doing use, user and usability research
Not only usability...

Morville, 2004
http://semanticstudios.com/publications/semantics/000029.php
Not only usability ...

- **Useful** > able to be used for a practical purpose > are our geoinformation products and systems useful? (~ effective)
- **Usable** > relative ease of use
- **Desirable** > emotional desirability (tempers efficiency)
- **Findable** > users should be able to find what they need
- **Accessible** > geoinformation, tools and systems should also be accessible to people with disabilities (more than 10% of the population)
- **Credible** > do users trust and believe the geoinformation products and tools they see or have to work with?
- **Valuable** > value should be delivered to the sponsors, the mission must be advanced (~ satisfaction & effectiveness)

Morville, 2004
http://semanticstudios.com/publications/semantics/000029.php
The 3 U’s

- *usability-utility tradeoff*

→ distinction between
- interfaces for **experts**
  - great utility
  - difficult to learn and use
- **general-use** interfaces
  - transparently usable
  - require little or no learning to use
  - support only a small set of user tasks
User Centered Design

What is UCD?
- Origin: software engineering
  - Product development: waterfall model
  - Involve user in all stages of design process
The UCD life cycle

Analyse Requirements

Business User

Organisational

Use contexts

Characteristics

Stakeholder

Tasks

Preferences

Evaluate Designs

Testing with representative users

Design satisfies requirements

Produce Design Solutions

Conceptual Design & Prototype

Interim Designs & Prototypes

Final Design & Prototype

Identify the need for user-centred design

input

Testing with representative users

Design satisfies requirements

Business User

Organisational

Stakeholder

Use contexts

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Identify the need for user-centred design

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Testing with representative users

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Stakeholder

Use contexts

Characteristics

Tasks

Preferences

Identify the need for user-centred design

input

Testing with representative users

Design satisfies requirements
The UCD life cycle

Requirement analysis!!!
The UCD life cycle

Usability evaluation

Evaluate Designs
Testing with representative users

Design satisfies requirements

Iterative process

Produce Design Solutions
Conceptual Design & Prototype
Interim Designs & Prototypes
Final Design & Prototype
10 “elements” of the usability engineering lifecycle

1. **Know the User**: Complete a **needs assessment** (also called a task analysis or work domain analysis) with target users to establish user profiles and use case scenarios;

2. **Competitive Analysis**: Critically compare existing interfaces supporting similar use cases to determine how the proposed interface can fill unmet needs;

3. **Setting Goals**: Use insight from the needs assessment and competitive analysis to formalize a requirements document of **proposed functionality** to guide design and development;

4. **Participatory Design**: Recruit a **representative set of target users** to participate in the conceptual **design** of the interface;
10 “elements” of the usability engineering lifecycle

5. **Coordinated Design**: Coordinate design across the project team to develop a consistent product identity (i.e., look and feel);

6. **Guidelines and Heuristic Analysis**: Recruit experts during design and development to evaluate the interface according to guidelines (generalized insights generated from the scientific investigation of digital interfaces) and heuristics (well-accepted, overarching design principles drawn from experience);

7. **Prototyping**: Create static or interactive mockups of the interface; an early, partially-functional prototype is referred to as an alpha release while a fully-functional, but unstable prototype is referred to as a beta release;
10 “elements” of the usability engineering lifecycle

8. **Empirical Testing**: Recruit a *representative set of target users* to *evaluate* the utility and usability of numerous prototypes during their evolution; formative evaluation describes the feedback solicited in the early to intermediate stages of the project on the alpha and beta releases, while summative evaluation is conducted on the full release of the interface to determine if the usability and utility goals have been achieved;

9. **Iterative Design**: Revise the interface based on feedback from guidelines/heuristic analysis and empirical testing;

10. **Collect Feedback from Field Use**: Acquire feedback about the interface *after* it is *transitioned* into the field to inform future product releases.
The UCD life cycle

#1: Work Domain Analysis

#2: Conceptual Development

#3: Prototyping

#4 Interaction & Usability Studies

#5: Implementation

#6: Debugging

user participation/input at each stage
Many user research methods & techniques

- Interviews
- Product analysis
- Literature / document studies
- Observation
- Brainstorming
- Surveys / questionnaires
- Thinking aloud
- Eye-tracking
- Heuristic evaluation
- Personas
- Scenario development
- Screen logging
- Snapshot studies
- Focus groups
- Stakeholder meetings
- Participatory design
- Retrospection
- Card sorting
- Task analysis
- Diary / notekeeping (empathy probes)
- Introspection
- Usability inspections
- Performance testing
- User satisfaction measurement
- Expert evaluation
Many user research methods & techniques

How many users?

Time frame?

Stage of development?

Visual analyses?

Requirement phase?

Prototype?

End users: age?

Manpower?

Money?

Statistical analyses?

End users: expertise?

End users: gender?

Research Questions?
Important aspects of usability research

• Distinction between methods & techniques of data collection and data analysis

• Keep in mind that not all methods can be applied in all stages of the UCD

• Distinction between qualitative and quantitative research

• Working with experts or with (representatives of) “real” end-users

• Is it a within- or between user study?

• Doing research in the proper context (field-based vs. laboratory based research)
Important aspects of usability research

**Method** = User Centered Design

(of geospatial data processing and dissemination systems)

**Techniques** *e.g.*:

**Qualitative**

- Focus groups
- Interviews
- Observation
- Thinking aloud
- Questionnaires
- Screen logging
- Eye tracking
- Performance analysis

**Quantitative**

- Analyse requirements
- Produce design solutions
- Conceptual design & prototypes
- Final design & prototypes

Identify the need for user-centred design

Business & User

- Organisational characteristics
- Stakeholder characteristics
- Characteristics
- Stakeholder preferences
- Use contexts
- Tasks

Evaluate designs

Testing with representative users

Design satisfies requirements

Business & User

Interim designs & prototypes

Final design & prototypes

Conceptual design & prototypes
Quantitative

• produces general insights
• insights are superficial
• identify significant differences
• may not explain differences
• harder to design
• easier to analyze

Qualitative

• produces specific insights
• insights are deep
• explain significant differences
• may not identify differences
• easier to design
• harder to analyze
• sample size dictated by central limit theorem \((n>30\) minimum); 

• participants often **need not** be **experts**; experts even may provide spurious results 

• determine if a **between** or **within** subjects design is most appropriate
• materials are *simplified* map designs

• materials represent your experimental *blocks*

• *control*: visual variables, map types, map pattern, interface functions, viewing conditions, etc.

• *vary*: 1-2 (max) of these aspects most related to your research questions
Example: Bivariate Mapping
Elmer, 2012
Participants: QUANTITATIVE

Materials: QUANTITATIVE

Separable

<table>
<thead>
<tr>
<th>Shaded Cartogram</th>
<th>Rectangle Map</th>
<th>Bar Chart</th>
<th>Value By Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>Height</td>
<td>Height</td>
<td>Transparency</td>
</tr>
<tr>
<td>Value</td>
<td>Width</td>
<td>Height</td>
<td>Hue</td>
</tr>
</tbody>
</table>

Integral

<table>
<thead>
<tr>
<th>Choropleth w/ Graduated Symbols</th>
<th>Bivariate Choropleth</th>
<th>Spoke Glyph</th>
<th>Shaded Texture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>Value</td>
<td>Orientation</td>
<td>Value</td>
</tr>
<tr>
<td>Value</td>
<td>Hue/Sat</td>
<td>Orientation</td>
<td>Texture</td>
</tr>
</tbody>
</table>

Configural

Asymmetrical

8 blocks

Elmer, 2012

Procedure: QUANTITATIVE

Analysis: QUANTITATIVE
• questions represent your *trials* and are *simplified* map reading tasks

• the order of blocks, and trials within blocks, should be *randomized* across participants to combat learning effects

• include an opening *biographic survey*, a *training block* of questions, and an *exit survey*

• design to last ~*15 minutes*; fatigue starts at ~*30 minutes*
• interpretation of results based on **statistics** applied to the collected numerical data

• **metrics**: accuracy/correctness, response time, difficulty, confidence

• report both **descriptive** and **inferential** statistics
Participants: QUANTITATIVE

Materials: QUANTITATIVE

Procedure: QUANTITATIVE

Analysis: QUANTITATIVE

Elmer, 2012
### Table 4.8

<table>
<thead>
<tr>
<th>Map Type</th>
<th>Axis</th>
<th>Median RT (Elementary)</th>
<th>Median RT (General)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Choropleth w/ Graduated Symbols</td>
<td>+</td>
<td>19.00</td>
<td>28.96</td>
<td>7.22E-005</td>
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<tr>
<td>Bivariate Choropleth</td>
<td>Y</td>
<td>19.83</td>
<td>33.88</td>
<td>6.56E-005</td>
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<tr>
<td>Shaded Texture</td>
<td>X</td>
<td>31.92</td>
<td>18.71</td>
<td>1.70E-005</td>
</tr>
<tr>
<td>Spoke Glyph</td>
<td>Y</td>
<td>27.83</td>
<td>47.67</td>
<td>1.13E-005</td>
</tr>
<tr>
<td>Spoke Glyph</td>
<td>+</td>
<td>19.79</td>
<td>47.13</td>
<td>1.93E-009</td>
</tr>
<tr>
<td>Spoke Glyph</td>
<td>-</td>
<td>34.46</td>
<td>53.58</td>
<td>0.000149</td>
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<tr>
<td>Bar Chart</td>
<td>-</td>
<td>31.50</td>
<td>59.08</td>
<td>1.35E-007</td>
</tr>
</tbody>
</table>

**Table 4.8.** Combinations of map type/task wherein the General level differed from the Elementary level at ± 25%.

Elmer, 2012
• sample size dictated by diversity of opinions/experiences regarding the research topic (n<20 for cartography)

• participants often need to be experts; minimally, they require a wealth of experience on the research topic

• participants should be sampled purposefully across applications domains, areas of interest, etc., to ensure breadth
• physical materials may **not** be **necessary**, given the research questions

• materials that are included are **real** map designs (working or complete)

• participants may provide their **own materials** (example maps, datasets, etc.) to stimulate discussion
• determine if you are using a structured, semi-structured, or unstructured approach

• the order of questions is purposeful; topics include key questions and probes

• include an opening biographic survey and closing open-ended question ("is there anything else you wish to share?")

• design to last ~60 minutes; fatigue sets in after ~90 minutes
**semi-structured:** key & probe questions

<table>
<thead>
<tr>
<th>Section 4: Cartographic Empowerment</th>
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<tr>
<td>11</td>
</tr>
<tr>
<td>11a</td>
</tr>
<tr>
<td>11b</td>
</tr>
<tr>
<td>11c</td>
</tr>
</tbody>
</table>

Sack, 2013
• interpretation of results based on qualitative data analysis (QDA) on interview transcripts

• **coding scheme:** a priori or ad-hoc; train two independent coders for reliability (required for cartography)

• **metrics:** frequency, extensiveness, diversity, intensiveness

• report both **descriptive** statistics of codes and **synopsis** of participant quotations
Participants: QUALITATIVE

Materials: QUALITATIVE

Procedure: QUALITATIVE

Analysis: QUALITATIVE

coding scheme

<table>
<thead>
<tr>
<th>Category</th>
<th>Value</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ecological</td>
<td>biological</td>
<td>the place provides for a variety of plants, animals, and other organisms</td>
</tr>
<tr>
<td></td>
<td>diversity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>wildlife</td>
<td>the place provides habitat for animals, including game</td>
</tr>
<tr>
<td></td>
<td>wilderness</td>
<td>the place is wild</td>
</tr>
<tr>
<td></td>
<td>life</td>
<td></td>
</tr>
<tr>
<td></td>
<td>sustaining</td>
<td>the place produces, preserves, cleans, and/or renews air, soil, and water</td>
</tr>
<tr>
<td>sociocultural</td>
<td>aesthetic</td>
<td>the place provides pleasant or beautiful scenery</td>
</tr>
<tr>
<td></td>
<td>therapeutic</td>
<td>the place makes people feel better, physically or mentally</td>
</tr>
<tr>
<td></td>
<td>recreation</td>
<td>the place provides opportunities for fun and/or relaxation</td>
</tr>
<tr>
<td></td>
<td>historic</td>
<td>the place has natural and human history embedded in it</td>
</tr>
<tr>
<td></td>
<td>scientific</td>
<td>the place provides opportunities for scientific study</td>
</tr>
<tr>
<td></td>
<td>cultural</td>
<td>the place is important to particular wisdom, traditions, and ways of life</td>
</tr>
<tr>
<td></td>
<td>spiritual</td>
<td>the place is sacred or provides a place of religious worship</td>
</tr>
<tr>
<td></td>
<td>intrinsic</td>
<td>the place has value simply because it exists</td>
</tr>
<tr>
<td>economic</td>
<td>subsistence</td>
<td>the place provides food and materials necessary to sustain people’s lives</td>
</tr>
<tr>
<td></td>
<td>economic</td>
<td>the place provides opportunities for jobs and/or income</td>
</tr>
</tbody>
</table>

Sack, 2013
Why We Mix our Methods

- **efficiency**: use of convergent methods to arrive at conclusions more quickly/cheaply

- **effectiveness**: combat insight saturation and overcome method limitations by approaching the same question in different ways

- **reliability**: triangulate insight across methods to improve confidence in findings

- **validity**: ensure insights remain ‘true’ across all possible use and user contexts

- **significance**: tackle multiple, interrelated research questions in a single project

- **stupidity**: because we forget things the first time around
Important aspects of usability research

Requirements Analysis
- Focus groups
- Brainstorm sessions
- Interviews
- Surveys & questionnaires
- Stakeholder meetings
- Literature review
- Card sorting
- ...

Evaluate early design
- Paper prototype
- Storyboarding
- Heuristic evaluation
- Automated evaluation
- Wizard of Oz
- Thinking aloud
- Eye tracking
- Card sorting
- Cognitive walkthrough
- ....

Evaluate elaborate design
- Performance testing
- User satisfaction
- Heuristic evaluation
- Cognitive walkthrough
- Functional prototyping
- Critical incidents
- Logging user interactions
- ....

User feedback
- Questionnaires
- User satisfaction
- Logging user interactions
- Observations
- Diary keeping
- ...

...
Important aspects of usability research

• Involving (representatives of) “real” users:
  – Surveys & questionnaires
  – Interviews
  – Focus groups / stakeholder meetings
  – Observation: logging user activities (including tracking, video, screen logging)
  – Eye-movement tracking
  – Thinking aloud
  – Participatory design

• Involving experts (not the users themselves):
  – Heuristic evaluation / usability inspection
  – Cognitive walkthrough

• Theory based
  – Automated evaluation
  – Scenario-based design
  – Secondary sources
## Important aspects of usability research

<table>
<thead>
<tr>
<th>Method</th>
<th>Similar or Related Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Expert-based</strong></td>
<td></td>
</tr>
<tr>
<td>heuristic evaluation</td>
<td>rules of thumb</td>
</tr>
<tr>
<td>conformity inspection</td>
<td>feature inspection, consistency inspection, standards inspection, guideline checklist</td>
</tr>
<tr>
<td>cognitive walkthroughs</td>
<td>pluralistic walkthroughs, prototyping, storyboarding, Wizard of Oz</td>
</tr>
<tr>
<td>scenario-based design</td>
<td>personas, scenarios of use, use case, context of use, theatre</td>
</tr>
<tr>
<td>secondary sources</td>
<td>content analysis, competitive analysis</td>
</tr>
<tr>
<td><strong>Theory-based</strong></td>
<td></td>
</tr>
<tr>
<td>automated evaluation</td>
<td>automated interaction logs, unmoderated user-based methods</td>
</tr>
<tr>
<td>participant observation</td>
<td>ethnographies, field observation, MILCs, journal/diary sessions, screenshot captures</td>
</tr>
<tr>
<td>surveys</td>
<td>questionnaires, entry/exit surveys, blind voting, cognitive workload assessment</td>
</tr>
<tr>
<td>interviews</td>
<td>structured interviews, semi-structured interviews, unstructured interviews, contextual inquiry</td>
</tr>
<tr>
<td>focus groups</td>
<td>supportive evaluation</td>
</tr>
<tr>
<td><strong>User-based</strong></td>
<td></td>
</tr>
<tr>
<td>Delphi</td>
<td></td>
</tr>
<tr>
<td>card sorting</td>
<td>Q methodology, concept mapping, afinity diagramming, brainstorming</td>
</tr>
<tr>
<td>talk/think aloud</td>
<td>verbal protocol analysis, co-discovery study</td>
</tr>
<tr>
<td>interaction study</td>
<td>performance measurement, controlled experiments</td>
</tr>
</tbody>
</table>
Important aspects of usability research

Cognitive Walkthroughs
A cognitive walkthrough is the most ‘hands-on’ of the expert-based methods, as the expert must assume the role of the user and complete a set of tasks in the anticipated way that the user would perform them.

1. Expert-based Methods

Expert-based methods solicit input and feedback about a cartographic interface from consultants with training and experience in cartographic interface design and evaluation.

Conformity Assessment
Conformity assessment requires experts to determine if the interface passes a set of requirements, such as a pre-determined feature list, design standards and conventions, or in-house specifications.

Good when there are multiple components of an interface requiring the same look/feel, when diVerent teams of designers are working on diVerent components of the application, when there are established design standards and conventions, when a work domain analysis has been completed.

Poor when the evaluation goal is to brainstorm potential usability issues rather than ensure the interface meets certain requirements, when the project consists of only several people working together closely, when there is little or no precedent on how a novel interface should look and behave.

Tip for Cartography: While there are few cartographic interface design standards, the Open Geospatial Consortium (OGC) has developed several guidelines and standards for the use and dissemination of geographic information.

Good when the characteristics/behaviors of the targeted end users are well understood, when the expert has a great deal of experience working with users, when there is not enough time to study users firsthand, when the tasks included in the walkthrough represent real-world work objectives well, when multiple steps must be completed in order to use the interface, when only paper mockups are available.

Poor when experts are not familiar with the user group, when the tasks are ill-defined, open-ended, or have multiple solutions, when the research design is not informed by a study with users.

Tip for Cartography: It may be best to include experts and users together (i.e., a pluralistic walkthrough), as interactive map use often is exploratory and open-ended, making it difficult for experts to predict suboptimal interaction strategies on their own.

Heuristic Evaluation
Heuristic evaluation requires experts to summarize potential usability and utility issues with an interface according to a pre-determined set of heuristics, or well-accepted cartographic interface design principles.

Good when input/feedback is needed quickly, when only a small set of experts are available, when used for several rounds of expert evaluation, when designers/developers are interested in uncovering a broad range of interface issues.

Poor when expert consultants are unavailable or expensive, when the experts are part of the project team, when targeting a specific kind of interface problem, when one or more of the heuristics is not relevant to the goals of interface evaluation, when there is excessive subjectivity in interpreting the heuristics.

Tip for Cartography: It is important that the experts performing the heuristic evaluation have experience in both Interactive Cartography and Usability Engineering; such restrictions may prohibitively narrow the pool of available experts.
Important aspects of usability research

Scenario-based Design

Scenario-based design makes the expected uses of an interface explicit through the description of a scenario, or story consisting of a problem setting, the interfaces available in the setting, and personas of the expected users of the interfaces.

Good when: A work domain analysis cannot be completed due to limited resources or poor user accessibility, when actual use scenarios are well known or validated through user studies, when the interface needs to support a diverse set of users or objectives, when expert- or user-based studies relying on tasks are conducted at later stages in design/development, when the project team is large.

Poor when: Little is known about the users, when the scenarios are not validated with user-based studies, when the scenarios are overly simplistic or include only a subset of the complete set of potential users or objectives, when an interface is in the final stages of development.

Tip for Cartography: Background knowledge in Geography is important for good scenario-based design, as the designers/developers need to understand the geographic phenomena represented in the interactive phenomena when drafting the hypothetical scenario.

(2) Theory-based Methods

Theory-based methods require the interface designers and developers to evaluate the cartographic interface themselves by applying theoretical frameworks and guidelines established through scientific research.

Automated Evaluation

With automated evaluation, usability and utility measures are generated programmatically by applying specialized computer algorithms.

Good when: The goal is to improve and stabilize source code, when long-term interface support is needed after deployment, when the fully-featured interface serves a large user community, when resources are limited to complete multiple rounds of user-based studies.

Poor when: The interface is unique or novel, when the usability measures for a specific type of application are poorly established, when the interface is simple and includes only several features.

Tip for Cartography: When the cartographic interface is designed for use by a diverse set of users, automated evaluation can be used to initiate changes in the interface according to past use; simple examples of such adaptive interfaces include ranking of items by 'most viewed' or adjusting default tool parameters according to the most frequent selections.

Secondary Sources

A secondary source is any piece of information not collected by the party using the information, and includes text documents, maps/images, and software applications.

Good when: The designers/developers know little about the application domain, when a user-based work domain analysis cannot be completed, at the formative stage of design and development, when there are a large number of competing applications that implement similar functionality, when there were multiple previous versions of the interface.

Poor when: The interface is designed to support a wide variety of application domains, when the interface is the first of its kind and has few extant parallels for comparison, when a robust work domain analysis already was completed, when at the final stages of development.

Tip for Cartography: Secondary sources are useful for understanding what types of questions or tasks should be included in future user-based studies (particularly for an initial work domain analysis).
Important aspects of usability research

**Participant Observation**
In participant observation, evaluators watch users interact with the interface during their daily work in order to generate an ethnography, or comprehensive narrative of the way in which the interface is used in practice.

*Good when* evaluators have excellent access to users, when evaluators want to build a strong connection with a particular set of users, when information is needed about how users currently work, when the project is large with design/development spanning multiple years, when the interface or a previous version of the interface already is in use.

*Poor when* access to users is limited, when users are diverse in their characteristics or application domain, when users are dispersed geographically, when feedback is needed quickly, when the interface is simple or supports few tasks.

*Tip for Cartography:* Participant observation may not be an efficient use of resources, as cartographic interfaces are often a single step in a larger workflow that includes many non-cartographic applications.

**Surveys**
The survey method requires participants to respond to a series of pre-determined, typically structured questions with no investigator interaction.

*Good when* input is required from a large number of diverse users, when characteristics of the targeted audience are not fully known, when the investigators cannot be present physically to administer the evaluation, when the participants have very little time to provide feedback.

**Interviews**
An interview is a purposeful conversation between the evaluator and user in which the user answers a series of structured and unstructured questions.

*Good when* the user needs and expectations are poorly known, when the software supports a small number of highly-specialized users or stakeholders, when transitioning an interface to a new application domain.

**Focus Groups**
The focus group is the multi-person equivalent to the interview, where a group of targeted end users (3-10) discuss topics posed by a session moderator.

*Good when* the user needs and expectations are poorly known, when investigators have access to a large number of users and stakeholders (more than required for interviews, but much less than required for surveys), when the focus of summative evaluation is user satisfaction, when the investigators do not have time to complete interviews.

*Poor when* important design decisions are based solely upon the results, when the investigators are unfamiliar with the user objectives or expectations and therefore do not know what questions to ask, when access to end users is limited, when users are asked to recall experiences or usage strategies from a significant amount of time prior to taking the survey.

*Tip for Cartography:* Surveys for cartographic interface evaluation should include questions specific to both cartographic representation (i.e., the design of the maps themselves) and cartographic interaction.

*Poor when* the participants are not representative of the target users, when the user group is diverse, when investigators have limited time to perform the evaluation and analyze the results.

*Tip for Cartography:* The interviews may benefit from having users provide map examples from discussion during the interviews or from having participants demonstrate their software to clarify the interview discussion.

**3) User-based Methods**
User-based methods solicit input and feedback about a cartographic interface from a representative sample of targeted end users; administration of user-based methods is fundamental to a user-centered design approach and the only way to ensure success of the cartographic interface.

*Good when* access to users is limited, when users are diverse in their characteristics or application domain, when users are dispersed geographically, when feedback is needed quickly, when the interface is simple or supports few tasks.

*Tip for Cartography:* Focus groups may benefit from including a mixture of map mapmakers and map users in each session.
Important aspects of usability research

**Delphi**
The Delphi method is a distributed approach to focus groups that collects multiple rounds of anonymous feedback, with moderator summaries distributed between rounds.

*Good when* the interfaces and the problems they support are extremely complex, when the users are geographically dispersed or the feedback needs to be collected online, when the superiors of one or more users also are included in the group communication.

*Poor when* the feedback is required quickly, when there is not a team member available to moderate the sessions, when users have little personal investment in the tool (as there may be a high drop out rate over rounds).

*Tip for Cartography:* It may be useful to anchor the discussion threads to an interactive map using asynchronous/diVerent-place geocollaboration and geodeliberation techniques.

**Card Sorting**
Card sorting is an activity in which participants group a given set of items, or cards, according to their similarity.

*Good when* there are a large set of functions included in the interface (between 30-200) or these functions include a large set of parameters, when the optimal categorization or structure is not currently known, when an existing categorization resulted in usability issues and needs to be revised, when the interface requires a large amount of navigation among multiple pages or menus.

*Poor when* the set of items is small (less than 30) or extremely large (200+), when the goal is to refine a single feature in the interface, when users can customize the layout/organization of the interface.

*Tip for Cartography:* The card sorting technique is particularly promising for hierarchically grouping feature types and associated map symbols in an expandable, interactive legend.

**Talk-Aloud & Think Aloud**
In this method, users are guided through a series of benchmark tasks by a session moderator and instructed to describe verbally either what they are doing (talk aloud) or what they are thinking (think aloud).

*Good when* evaluators are interested in identifying a broad range of usability issues, when feedback is required quickly on only the most important problems, when project resources are limited, when there are multiple ways to complete the same objective.

*Poor when* the tasks the interface should support are poorly known, when the participants are not representative of the target audience, when each task requires a large amount of time to complete, when evaluators are more interested in utility than usability, when participants are already familiar with the interface.

*Tip for Cartography:* Because most people interact with maps in an unstructured way, it is important that the task protocol includes both close-ended, simple tasks with a 'right answer' as well as open-ended, exploratory tasks that may lead to divergent solutions.

**User-based Methods**
User-based methods solicit input and feedback about a cartographic interface from a representative sample of targeted end users; administration of user-based methods is fundamental to a user-centered design approach and the only way to ensure success of the cartographic interface.

*Good when* the project spans multiple years and includes iterative rounds of interaction studies, when the kind of interface evaluated has an established optimal score in the applied performance measures, when evaluators are interested both in expanding the understanding of interactive cartography broadly as well as improving the cartographic interface specifically.

*Poor when* user objectives are not known, when time and resources are lacking to collect and analyze the copious interaction logs, when the performance measures poorly support the evaluation goals, when evaluators are interested in capturing subjective satisfaction.

*Tip for Cartography:* In addition to the interaction log, information about the user’s eye movements also can be captured during an interaction study.

**Interaction Study**
Interaction studies require users to complete a set of benchmark tasks with the interface in a controlled setting while their interactions are captured in an interaction log.
Learning from each other...

- Input from audience
  - Who did user research?
  - Describe background
  - Decisions you had to make (select technique, find participants,...)
  - Issues you encountered
  - ....

[Comic of a usability test going wrong]

*Bug Bash by Hans Bjordahl*
Important aspects of usability research

How many users?!

• Depending on technique
  – Data = Qualitative or Quantitative?

Qualitative analyses on...
  Focus Groups  Observations  Thinking aloud
  \( n \geq 5 \) participants...

Statistical analyses on....
  Performance measurements  Questionnaires  Eye tracking
  \( n \rightarrow \alpha, SD, z, \dot{x},... \)

• How many user groups?
  – Evaluate user characteristics (between user)
    • Multiple groups, different characteristics
  – Evaluate different products (within user)
    • Multiple groups, same characteristics
Important aspects of usability research

• **Use contexts**: e.g. map use environment
  – hard copy maps:
    • as wall map, on the desk top, in the field, ....
  – screen maps:
    • on the desk top, on handheld mobile devices
    • stand-alone or network application
      (e.g. Internet)
    • hard- and software available, interfaces
    • use at one place or distributed collaboration ....
Important aspects of usability research

• New user environments
  – World Wide Web
    *Web maps, WMS, distributed GIS, GDI’s*
  – Mobile & wireless devices
    *Smartphones, PDA’s, Pocket PC’s ... with location aware applications (LBS)*
      – small screens
      – low resolution
      – few colours
      – small data files
Some Tips & Tricks…

• Always realize WHY you are doing what you are doing with geographical information in your studies or future work

• Always know for WHOM you are doing what you are doing

• Never take for granted that the geographic information or geographic data product or service you have designed or generated is usable for everyone

• Follow user-centered design approaches and investigate the usability
Some Tips & Tricks...

• Take the time to work out (and document) every step of the **research sequence**:
  – Formulate clear **objectives**
  – Formulate clear **research questions**
  – Only after that: decide on **methods and techniques** of user research with which you will probably find answers to your research questions
  – **Execute** user research
  – **Analyze** the data and answer your questions
  – **Validate** your research method / technique
Some Tips & Tricks...

- Provide incentives / do not force
- Ask permission / seek informed consent
- Do not waste subject’s time (test set-up)
- Maintain privacy / confidentiality (no names in reports, permission for pictures / videos in publications)
- Do not expose subjects to risks /potential harms
- Sound reporting on test persons / methods
- Laws regulating use of human subjects
Thank you for your attention!

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