Ambient Learning Displays
Distributed Mixed Reality Information Mash-ups to support Ubiquitous Learning

Dirk Börner

Promotor: Prof. Dr. Marcus Specht
Supervisor: Dr. Marco Kalz
Background

• Mobile Technologies + Ubiquitous Connectivity + Pervasive Functionality are changing the conditions for lifelong and non-formal learning

• Rethinking the relationship of environment, technology, and learning to build a bridge between different contexts and situations learners are operating in
Background

• Mobile Technologies + Ubiquitous Connectivity + Pervasive Functionality are changing the conditions for lifelong and non-formal learning

• Rethinking the relationship of environment, technology, and learning to build a bridge between different contexts and situations learners are operating in

Interdisciplinary approach to explore the potentials of mobile and pervasive technologies to support ubiquitous learning in authentic situations
Background

[http://www.ruderfinn.com/rfrelate/intent/mobile/intent-index.html]
Research Focus
Ubiquitous Learning

Learning Environments → Mobile Technologies Pervasive Functionality → Ubiquitous Learning Environments

Permanency
Accessibility
Adaptability
Situatedness
Immediacy
Interactivity

[Ogata & Yano, 2004]
Research Focus
Ubiquitous Learning

Learning Environments → Mobile Technologies Pervasive Functionality → Ubiquitous Learning Environments

- Information
  - Permanency
  - Accessibility
  - Adaptability

- Interaction
  - Immediacy
  - Interactivity

- Instruction
  - Situatedness

[Ogata & Yano, 2004]
Research Focus
Information, Interaction, Instruction

- Support and assist learners to enable them to navigate more efficiently through information and find the right information in any given situation
• Support and assist learners to enable them to navigate more efficiently through information and find the right information in any given situation.

• Move the information off the screen into the physical environment and make use of the entire physical environment as an interface.
- Support and assist learners to enable them to **navigate more efficiently** through information and **find the right information** in any given situation.

- Move the **information off the screen** into the physical environment and make use of the entire physical **environment as an interface**.

- **Support the learning process** in the physical environment where it is happening and enable learners to **construct knowledge as a personal, social, and environmental process**.
Research Questions

**Problem:** Ubiquitous learning is **not supported in its situatedness**, authentic context, and social dependencies. Although ubiquitous learning environments offer a variety of display and interaction modalities learners are confronted with **missing awareness indicators** reflecting the available learning support in their current environment.
Research Questions

**Problem:** Ubiquitous learning is not supported in its situatedness, authentic context, and social dependencies. Although ubiquitous learning environments offer a variety of display and interaction modalities learners are confronted with **missing awareness indicators** reflecting the available learning support in their current environment.

Which methods of interaction and information presentation can be used to create awareness in ubiquitous learning environments? How can these content be condensed to create meaningful mash-ups?

Which sensors, displays, and artefacts can be used and how must they be aggregated, filtered, and implemented in ubiquitous learning environments?

Which methods of interaction and information presentation can be used to create awareness in ubiquitous learning environments?

How are the awareness methods assimilated and perceived in ubiquitous learning environments and what are the implications for the design?

Does the utilization of contextualized digital content support and enhance the learning experience in ubiquitous learning environments and what are the effects?
Problem: Ubiquitous learning is not supported in its situatedness, authentic context, and social dependencies. Although ubiquitous learning environments offer a variety of display and interaction modalities learners are confronted with missing awareness indicators reflecting the available learning support in their current environment.

Which information is relevant for learners in authentic learning situations within ubiquitous learning environments and how can this information be obtained and aggregated?

How can ambient interaction modalities improve the availability and accessibility of this information within ubiquitous learning environments?

Is the improved availability and accessibility of relevant information an effective support in authentic learning situations?
Research Questions

**Problem:** Ubiquitous learning is **not supported in its situatedness**, authentic context, and social dependencies. Although ubiquitous learning environments offer a variety of display and interaction modalities learners are confronted with **missing awareness indicators** reflecting the available learning support in their current environment.

Which information is relevant for learners in authentic learning situations within ubiquitous learning environments and how can this information be obtained and aggregated?

**What are the learning effects of ambient information presentation in a situated learning context within ubiquitous learning environments?**

How can ambient interaction modalities improve the availability and accessibility of this information within ubiquitous learning environments?

Is the improved availability and accessibility of relevant information an effective support in authentic learning situations?
Research Objectives

Support learners in authentic learning situations within ubiquitous learning environments: establish the awareness for information relevant for situated learning, examine the personal, social, and environmental sense-making process facilitated through ambient information presentation, evaluate the situated learning support in authentic learning situations on its effectiveness for learning, especially to solve problems in context.

 Ambient Learning Displays
Research Objectives

Support learners in authentic learning situations within ubiquitous learning environments: establish the awareness for information relevant for situated learning, examine the personal, social, and environmental sense-making process facilitated through ambient information presentation, evaluate the situated learning support in authentic learning situations on its effectiveness for learning, especially to solve problems in context.

Ambient Learning Displays

Define functional requirements for a ubiquitous learning support framework: give suggestions and provide guidelines for the design and implementation of future ambient systems and applications for learning.
## Conceptual Framework

### Types of Awareness for Ubiquitous Learning

[Ogata, 2009]

<table>
<thead>
<tr>
<th>Awareness</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social</td>
<td>Who can help to solve the problem?</td>
</tr>
<tr>
<td></td>
<td>How can I interact with the peer(s)?</td>
</tr>
<tr>
<td>Task</td>
<td>Which task can I do?</td>
</tr>
<tr>
<td></td>
<td>How much time is required?</td>
</tr>
<tr>
<td>Concept</td>
<td>What kind of concepts is necessary to complete the task?</td>
</tr>
<tr>
<td></td>
<td>Do I need to revise any of my current ideas in light of this new information?</td>
</tr>
<tr>
<td>Workspace</td>
<td>What are they doing?</td>
</tr>
<tr>
<td></td>
<td>What have they already done?</td>
</tr>
<tr>
<td>Knowledge</td>
<td>Who is using, changing, or discussing the same knowledge?</td>
</tr>
<tr>
<td></td>
<td>What knowledge did they use, change, or discuss?</td>
</tr>
<tr>
<td>Context</td>
<td>What objects are available around them?</td>
</tr>
<tr>
<td></td>
<td>Where are they?</td>
</tr>
</tbody>
</table>
Conceptual Framework

Ambient Information Channels (AICHE)
[Specht, 2009]
Conceptual Framework

Design Dimensions of Ambient Systems

[Pousman and Stasko, 2006]
Conceptual Framework

Physical World (Real Environment)  Ubiquitous Learning Environment  Digital World (Virtual Environment)
Conceptual Framework

Ubiquitous Learning Environment

Awareness

- Workspace
- Social
- Task
- Knowledge
- Context
- Concept

Physical World
(Real Environment)

Digital World
(Virtual Environment)
Conceptual Framework

Ubiquitous Learning Environment

Awareness

Workspace | Social | Task | Knowledge | Context | Concept

Ambient Information Channels

Visual | Auditory | Haptic

Physical World
(Real Environment)

Digital World
(Virtual Environment)
Conceptual Framework

Ubiquitous Learning Environment

Awareness

Workspace

Social

Task

Knowledge

Context

Concept

Ambient Information Channels

Visual

Auditory

Haptic
Conceptual Framework

Ubiquitous Learning Environment

Awareness

Workspace

Social

Task

Knowledge

Context

Concept

Ambient Information Channels

Visual

Auditory

Haptic

Remember

Understand

Apply

Analyze

Evaluate

Create

Physical World
(Real Environment)

Digital World
(Virtual Environment)

Ambient Learning Displays
Research Design

Literature Review

- Expert Study
  - Concept Mapping
    - Educational Problems
  - Contextual Cluster
- Literature Review
  - Ambient Displays
    - Design Patterns
    - Evaluation
  - Characteristics
  - Mobile and Ubiquitous Learning
    - Educational Objectives
    - Scenarios
  - Learning Taxonomy
    - Information Awareness
    - Ambient Displays
- Learning Display
  - AICHE
Research Design

Literature Review
## Research Design

### Methodology

<table>
<thead>
<tr>
<th>Information Capacity</th>
<th>Representational Fidelity</th>
<th>Aesthetic Emphasis</th>
<th>Notification Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>indexical</td>
<td>high</td>
<td>demand attention</td>
</tr>
<tr>
<td>somewhat high</td>
<td>iconic</td>
<td>somewhat high</td>
<td>interrupt</td>
</tr>
<tr>
<td>medium</td>
<td>iconic (metaphors)</td>
<td>medium</td>
<td>make aware</td>
</tr>
<tr>
<td>somewhat low</td>
<td>symbolic</td>
<td>somewhat low</td>
<td>change blind</td>
</tr>
<tr>
<td>low</td>
<td>symbolic (abstract)</td>
<td>low</td>
<td>(ignore) user pull</td>
</tr>
</tbody>
</table>

- **Ambient Design Dimensions**
  - Cognitive Process Dimension
  - Remember
  - Understand
## Research Design

### Methodology

<table>
<thead>
<tr>
<th>Information Capacity</th>
<th>Representational Fidelity</th>
<th>Aesthetic Emphasis</th>
<th>Notification Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>indexical</td>
<td>high</td>
<td>demand attention</td>
</tr>
<tr>
<td>somewhat high</td>
<td>iconic</td>
<td>somewhat high</td>
<td>interrupt</td>
</tr>
<tr>
<td>medium</td>
<td>iconic (metaphors)</td>
<td>medium</td>
<td>make aware</td>
</tr>
<tr>
<td>somewhat low</td>
<td>symbolic</td>
<td>somewhat low</td>
<td>change blind</td>
</tr>
<tr>
<td>low</td>
<td>symbolic (abstract)</td>
<td>low</td>
<td>(ignore) user pull</td>
</tr>
</tbody>
</table>

- **Ambient Design Dimensions**
  - Apply
  - Analyze

- **Cognitive Process Dimension**
## Research Design

### Methodology

The table below illustrates the relationship between Information Capacity, Representational Fidelity, Aesthetic Emphasis, and Notification Level:

<table>
<thead>
<tr>
<th>Information Capacity</th>
<th>Representational Fidelity</th>
<th>Aesthetic Emphasis</th>
<th>Notification Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>indexical</td>
<td>high</td>
<td>demand attention</td>
</tr>
<tr>
<td>somewhat high</td>
<td>iconic</td>
<td>somewhat high</td>
<td>interrupt</td>
</tr>
<tr>
<td>medium</td>
<td>iconic (metaphors)</td>
<td>medium</td>
<td>make aware</td>
</tr>
<tr>
<td>somewhat low</td>
<td>symbolic</td>
<td>somewhat low</td>
<td>change blind</td>
</tr>
<tr>
<td>low</td>
<td>symbolic (abstract)</td>
<td>low</td>
<td>(ignore) user pull</td>
</tr>
</tbody>
</table>

### Cognitive Process Dimension

- Remember
- Understand
- Apply
- Analyze
- Evaluate
- Create

### Ambient Design Dimensions

- User pull
- Make aware
- Demand attention
- Change blind
- Interrupt
- Ignore
## Research Design Methodology

<table>
<thead>
<tr>
<th>Information Capacity</th>
<th>Representational Fidelity</th>
<th>Aesthetic Emphasis</th>
<th>Notification Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>indexical</td>
<td>high</td>
<td>demand attention</td>
</tr>
<tr>
<td>somewhat high</td>
<td>iconic</td>
<td>somewhat high</td>
<td>interrupt</td>
</tr>
<tr>
<td>medium</td>
<td>iconic (metaphors)</td>
<td>medium</td>
<td>make aware</td>
</tr>
<tr>
<td>somewhat low</td>
<td>symbolic</td>
<td>somewhat low</td>
<td>change blind</td>
</tr>
<tr>
<td>low</td>
<td>symbolic (abstract)</td>
<td>low</td>
<td>(ignore) user pull</td>
</tr>
</tbody>
</table>

**Ambient Design Dimensions**

- **Information Capacity**
  - high
  - somewhat high
  - medium
  - somewhat low
  - low

- **Representational Fidelity**
  - indexical
  - iconic
  - iconic (metaphors)
  - symbolic
  - symbolic (abstract)

- **Aesthetic Emphasis**
  - high
  - somewhat high
  - medium
  - somewhat low
  - low

- **Notification Level**
  - demand attention
  - interrupt
  - make aware
  - change blind
  - (ignore) user pull

**Cognitive Process Dimension**

- Evaluate
- Create

**Remember**

- Understand
- Apply
- Analyze
- Evaluate
- Create
## Research Design Methodology

<table>
<thead>
<tr>
<th>Information Capacity</th>
<th>Representational Fidelity</th>
<th>Aesthetic Emphasis</th>
<th>Notification Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>indexical</td>
<td>high</td>
<td>demand attention</td>
</tr>
<tr>
<td>somewhat high</td>
<td>iconic</td>
<td>somewhat high</td>
<td>interrupt</td>
</tr>
<tr>
<td>medium</td>
<td>iconic (metaphors)</td>
<td>medium</td>
<td>make aware</td>
</tr>
<tr>
<td>somewhat low</td>
<td>symbolic</td>
<td>somewhat low</td>
<td>change blind</td>
</tr>
<tr>
<td>low</td>
<td>symbolic (abstract)</td>
<td>low</td>
<td>(ignore) user pull</td>
</tr>
</tbody>
</table>

- **Remember**
- **Understand**
- **Apply**
- **Analyze**
- **Evaluate**
- **Create**
Research Design
Methodology

<table>
<thead>
<tr>
<th>Information Capacity</th>
<th>Representational Fidelity</th>
<th>Aesthetic Emphasis</th>
<th>Notification Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>indexical</td>
<td>high</td>
<td>demand attention</td>
</tr>
<tr>
<td>somewhat high</td>
<td>iconic</td>
<td>somewhat high</td>
<td>interrupt</td>
</tr>
<tr>
<td>medium</td>
<td>iconic (metaphors)</td>
<td>medium</td>
<td>make aware</td>
</tr>
<tr>
<td>somewhat low</td>
<td>symbolic</td>
<td>somewhat low</td>
<td>change blind</td>
</tr>
<tr>
<td>low</td>
<td>symbolic (abstract)</td>
<td>low</td>
<td>(ignore)</td>
</tr>
</tbody>
</table>

User pull

Ambient Design Dimensions

Cognitive Process Dimension

Evaluate
Create
<table>
<thead>
<tr>
<th>Information Capacity</th>
<th>Representational Fidelity</th>
<th>Aesthetic Emphasis</th>
<th>Notification Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>indexical</td>
<td>high</td>
<td>demand attention</td>
</tr>
<tr>
<td>somewhat high</td>
<td>iconic</td>
<td>somewhat high</td>
<td>interrupt</td>
</tr>
<tr>
<td>medium</td>
<td>iconic (metaphors)</td>
<td>medium</td>
<td>make aware</td>
</tr>
<tr>
<td>somewhat low</td>
<td>symbolic</td>
<td>somewhat low</td>
<td>change blind</td>
</tr>
<tr>
<td>low</td>
<td>symbolic (abstract)</td>
<td>low</td>
<td>(ignore) user pull</td>
</tr>
</tbody>
</table>

**Dashboard**

**Audio Signal**

**Messenger**

**Cognitive Process Dimension**

**Evaluate**

**Create**

**Ambient Design Dimensions**
Research Design
Methodology

Ambient Design Dimensions

Information Capacity | Representational Fidelity | Aesthetic Emphasis | Notification Level
--- | --- | --- | ---
high | indexical | high | demand
somewhat high | iconic | somewhat high | interrupt
medium | iconic (metaphors) | medium | make
somewhat low | symbolic | somewhat low | change
low | symbolic (abstract) | low | blind

Dashboard Audio Signal Messenger

Evaluate Create

Cognitive Process Dimension

➡ Which domain?
Mathematics
Ecological Facts
Social Game

➡ Evaluation technique?
Experience
Sampling Method
Thank you!

Dirk Börner

Valkenburgerweg 177  
6419 AT Heerlen  
The Netherlands

tel: +31 45576 2506  
skype: dirk_boerner  
email: dirk.boerner@ou.nl
Background

Mobile Internet Outpaces Desktop Internet Adoption
iPod + iPhone Users = 8x AOL Users 8 Quarters After Launch

iPhone + iTouch vs. NTT docomo i-mode vs. Netscape vs. AOL Users
First 20 Quarters Since Launch

Note: *AOL subscribers data not available before CQ3;94; Netscape users limited to US only.
Source: Company Reports, Morgan Stanley Research.

Background

AT&T
50x Mobile Data Traffic Increase in Past 3 Years

AT&T Mobile Data Traffic Growth, CQ2:06 – CQ2:09

4,932% Increase

Morgan Stanley

Source: AT&T

Background