Wisdom is not the product of schooling but the lifelong attempt to acquire it.
- Albert Einstein

Lifelong Learning Companions:
Intelligent Computational Agents for Intelligent Lifelong Learners

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2008 ICT Workshop on “Building Lifelong Learning Companions”
Overview

- Basic Message

- Conceptual Framework
  - lifelong learning
  - Who learns: the human, the companion or both?
  - opportunities for “lifelong learning companions”

- Examples

- Requirements
Basic Message

- **claims:**
  - lifelong learning companion research is more than the next generation of ITS research
  - the research should move beyond the St. Thomas symposium proposal to develop a "personalized teaching machine that would adapt itself to someone's specific circumstances, difficulties, and needs."

- **objective:** explore fundamentally new challenges and opportunities for intelligence augmentation, distributed intelligence, multiple learning strategies, context awareness of users, task, and circumstances
A Lifelong Learning Perspective for Lifelong Learning Companions

- **assumption**: If the world of working and living relies on *collaboration, creativity, definition and framing of problems* and if it requires dealing with *uncertainty, change, and intelligence that is distributed* across minds, cultures, disciplines, and tools

- **consequence**: Then education should foster on competencies that prepare learners for having meaningful and productive lives in such a world

- **school ↔ lifelong learning**
  - teach important topics (cultural literacy) ↔ self-directed learning, learning on demand, informal learning
  - learning when the answers is known ↔ learning when the answer is **not** known
Science of Learning

- “A decade of interdisciplinary research on everyday cognition demonstrates that school-based learning, and learning in practical settings, have significant discontinuities. **We can no longer assume that what we discover about learning in schools is sufficient for a theory of human learning.**” — Scribner and Sachs

- “In important transformations of our personal lives and organizational practices, we must learn new forms of activity which are not there yet. They are literally learned as they are being created. **There is no competent teacher.** Standard learning theories have little to offer if one wants to understand these processes.” — Yrjö Engeström
Classification of Different Relationships

Companion

Teacher/tutor

Intelligent Tutoring Systems (ITS)

Learner
Lifelong Learning Companions
Who Learns?

End-User Modifiability, End-User Programming

Learning on Demand
Related Work

- Chih-Yueh Chou, Tak-Wai Chan, and Chi-Jen Lin: "Redefining the learning companion: the past, present, and future of educational agents", Computer & Education 40 (2003), 255-269


MyLifeBits = a lifetime store of everything

- the fulfilment of Vannevar Bush's 1945 Memex vision → digital memories can
  - assist the recollection of past events, conversations and projects
  - portable sensors can take readings of things that are not even perceived by humans, such as oxygen levels in the blood or the amount of carbon dioxide in the air.

- a project at Microsoft Research: to digitally chronicle every aspect of a person's life, starting with the life of Gordon Bell

- raises critical privacy issues (personal memory aids + monitoring and assisting others)
Case Studies as Inspiration:  
Humans as Lifelong (Learning) Companions

- my collaborations for **over 20 years** with an administrative assistant and a technology wizard

- large amount of **shared background knowledge**
  - people, previous events and interactions
  - processes (ordering hardware, food for meetings)
  - preferences (non-smoking rooms in hotels, ........)

- **most important gain over time:** explicit communicative acts are greatly reduced and taken over by independent acting based on shared background knowledge

- **mutual learning** by taking advantage of distributed complementary knowledge ("symmetry of ignorance")
  - native speaker → critiquing my writings
  - administrative details
  - power users in different applications (high-functionality environment)
Capabilities of a Lifelong Learning Companion

- **teach** me → intelligent tutoring systems
- **critique** my work → critiquing systems
- **remind** me → prompting systems
- **locate** information → information retrieval systems, search
- **take care** of routine efforts → new divisions of labor
A Lifelong Personal Information Store:  
the Hard Disk of my Computer

- hard disk:
  - files
  - email messages

- support: Spotlight (MAC OS X application = Google for my hard disk)

- research topic: reflexive CSCW
Intelligent Tutoring Systems (ITSs)

- **major contributions:**
  - domain expert module
  - student model
  - pedagogical model: tutor, coach, guide, critique

- **claim:** self-directed learning, learning on demand, informal learning are not the strengths of ITSs

- **challenge:** for *self-directed learning* to be maximally effective → it needs to be supported with opportunities to explore *systematic bodies of knowledge* that are contextualized to the task at hand and the learner’s needs and interests — *contextualized tutoring*
The Importance of **Informal** Learning in **Lifelong** Learning

<source: LIFE Center, University of Wash + Stanford>
Examples

- Critiquing Systems Embedded in Domain-Oriented Design Environments
- High-Functionality Environments
- Social Learning Environments
A DODE for Kitchen Design: Construction

Janus-Construction

Appliance Palette
- walls
- doors
- windows
- sinks
- stoves

Catalog
- L-Shaped-Kitchen
- DW

Work Area
- DW

Messages
- The length of the work triangle (Double-Bowl-Sink-1, Four-Element-Stove-1, Single-Door-Refrigerator-1) is greater than 23 feet.
- Single-Door-Refrigerator-1 is not near Four-Element-Stove-1.

Commands
- Critique All
- Critique All
A DODE for Kitchen Design: Argumentation

Janus-Argumentation

Answer (Refrigerator, Sink, Stove)
The distance between sink, stove and refrigerator, the work triangle, should be less than 25 feet.

\[ d_1 + d_2 + d_3 < 25 \text{ feet} \]

Figure 10: the work triangle

Argument (Walking Distance)
The work triangle is an important concept in kitchen design. The work triangle denotes the center front distance between the three main appliances: sink, stove and refrigerator. This length should be less than 23 feet to avoid unnecessary walking and to ensure an efficient workflow in the kitchen!

Argument (Small Room)
In small kitchens where the work triangle is less than 16 feet.
Multiple Learning Strategies

- offer support at **different levels** *(Fix-It, Reflect, Tutorial)* and let learners choose among the levels

- **contextualize a tutoring episode** dynamically to the work learners have been engaged in and to relate it to the preexisting understandings that they bring with them
## Three Learning Strategies in HYDRA

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fix-It Level</strong></td>
<td>fix the problem by giving a solution without detailed understanding; primarily performance support</td>
<td>keep focus on task; learning does not delay work</td>
<td>creates little understanding</td>
</tr>
<tr>
<td><strong>Reflect Level</strong></td>
<td>explore argumentative context for reflection (“reflection-in-action”)</td>
<td>understanding of specific issues</td>
<td>piecemeal learning of (disconnected) issues</td>
</tr>
<tr>
<td><strong>Tutorial Level</strong></td>
<td>provide contextualized tutoring (not lecturing on unrelated issues)</td>
<td>systematic presentation of a coherent body of knowledge</td>
<td>substantial time requirements</td>
</tr>
</tbody>
</table>
Self-Directed Learning, Learning on Demand and 
Contextualized Tutoring

- How can the larger (often unarticulated) context of what the learner wants to achieve be inferred?

- How can we gain leverage by integrating
  - explicit modeling (e.g., with specification components, questionnaires) with
  - implicit modeling (analyzing user performance on tasks and inferring the knowledge background and interests based on previous interactions)?
Interactions with Learning Companions

- **basic assumption:** the scarce resource is not information, but human attention

- **intrusiveness**
  - pull = information access
  - push = information delivery

- **learning companion**
  - prescriptive or permissive
  - authorative or non-authorative

- **reciprocal teaching**
  - teacher/learner  \(\neq\)  \(f\{\text{person}\}\)
  - teacher/learner  =  \(f\{\text{context}\}\)
# Information Sharing:
**Access (“Pull”)** and / or **Delivery (“Push”)**

<table>
<thead>
<tr>
<th></th>
<th><strong>access (“pull”)</strong></th>
<th><strong>delivery (“push”)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>examples</strong></td>
<td>browsing, search engines, bookmarks, passive help systems</td>
<td>Microsoft’s “Tip of the Day”, broadcast systems, critiquing, active help systems</td>
</tr>
<tr>
<td><strong>strengths</strong></td>
<td>non-intrusive, user controlled</td>
<td>serendipity, creating awareness for relevant information, rule-enforcement</td>
</tr>
<tr>
<td><strong>weaknesses</strong></td>
<td>task relevant knowledge may remain hidden because users cannot specify it in a query</td>
<td>intrusiveness, too much decontextualized information</td>
</tr>
<tr>
<td><strong>major system design challenges</strong></td>
<td>supporting users in expressing queries, better indexing and searching algorithms</td>
<td>context awareness (intent recognition, task models, user models, relevance to the task-at-hand)</td>
</tr>
</tbody>
</table>
Contextualized Information Delivery ("Push")
in high-functionality environments and large software reuse repositories

(L4 – L3): Unanticipated Information

Task-relevant information

L4: Entire Information Space
L1: Well Known
L2: Vaguely Known
L3: Belief
The **Right Information** at the **Right Time**, in the **Right Place**, in the **Right Way** to the **Right Person**

- **right information**: relevant to the task at hand → task modeling
- **right time**: intrusiveness (pull versus push)
- **right place**: location-aware cell phone (noisy environment versus movie theatre), smart tour guides
- **right way**: multimodal presentation (textual, visual, auditory, tactile)
- **right person**: taking background knowledge and interests of specific users into account → user modeling, “who do I ask and who do I tell”
High-Functionality Environments

- **examples:**
  - operating systems and application systems (Microsoft Word, Photoshop, ….)
  - cell phones
  - reuse libraries
  - **McGuckin study** (hardware store in Boulder) famous for its knowledge sale agents (question: are they a good example of lifelong learning companions?)

- there are **no expert anymore** (nobody knows the whole system) \(\rightarrow\) learning on demand, incremental learning supported by lifelong learning companions

- **challenge:** beyond “ease of use” \(\rightarrow\) **low threshold and high ceiling**
Low Threshold and High Ceiling

A minute to learn... a lifetime to master!
Finding the Right Challenge
Social (Learning) Environments

social

individual

individual and social
The Envisionment and Discovery Collaboratory
Embedding Communication in Design Activities

Computer stores the artifact

Computer mediates design and communication

Designing
Communicating
Conclusion = Evidence for the Basic Message

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