**Center for LifeLong Learning & Design**

**University of Colorado at Boulder**

**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
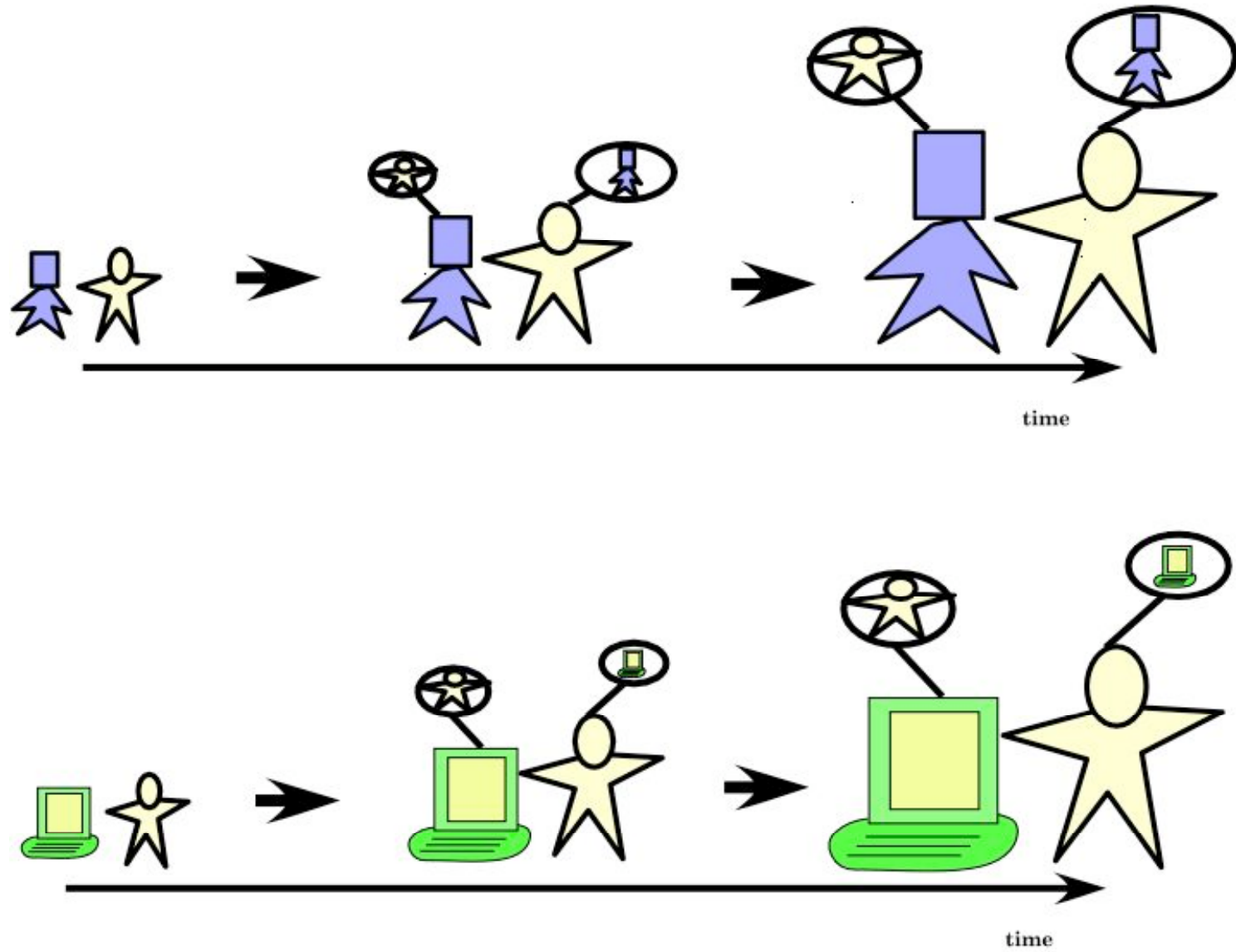
# Science of Learning

- *"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
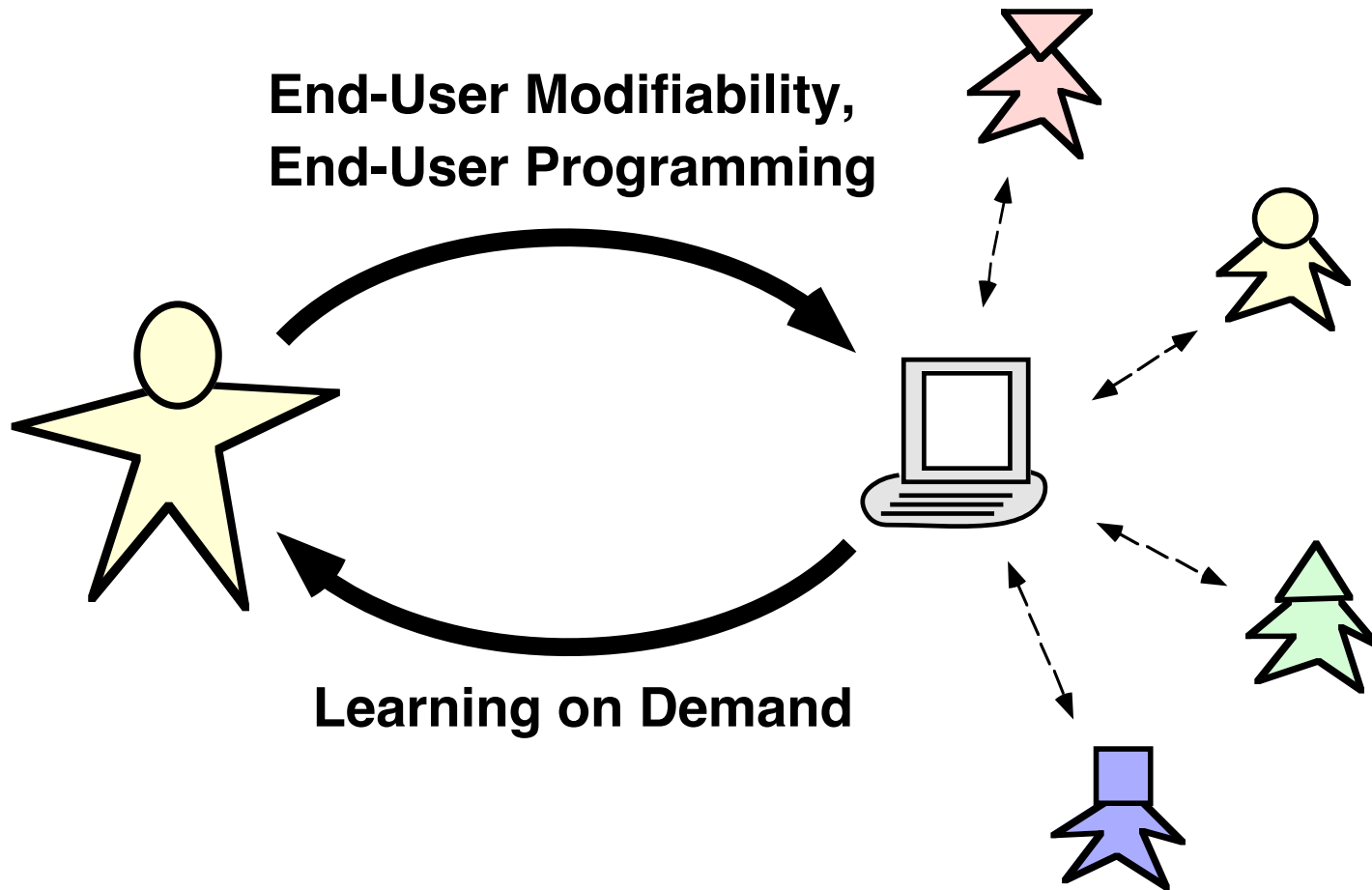
# Classification of Different Relationships

companion

companion

teacher/tutor

learner

Intelligent Tutoring Systems (ITS)

learner
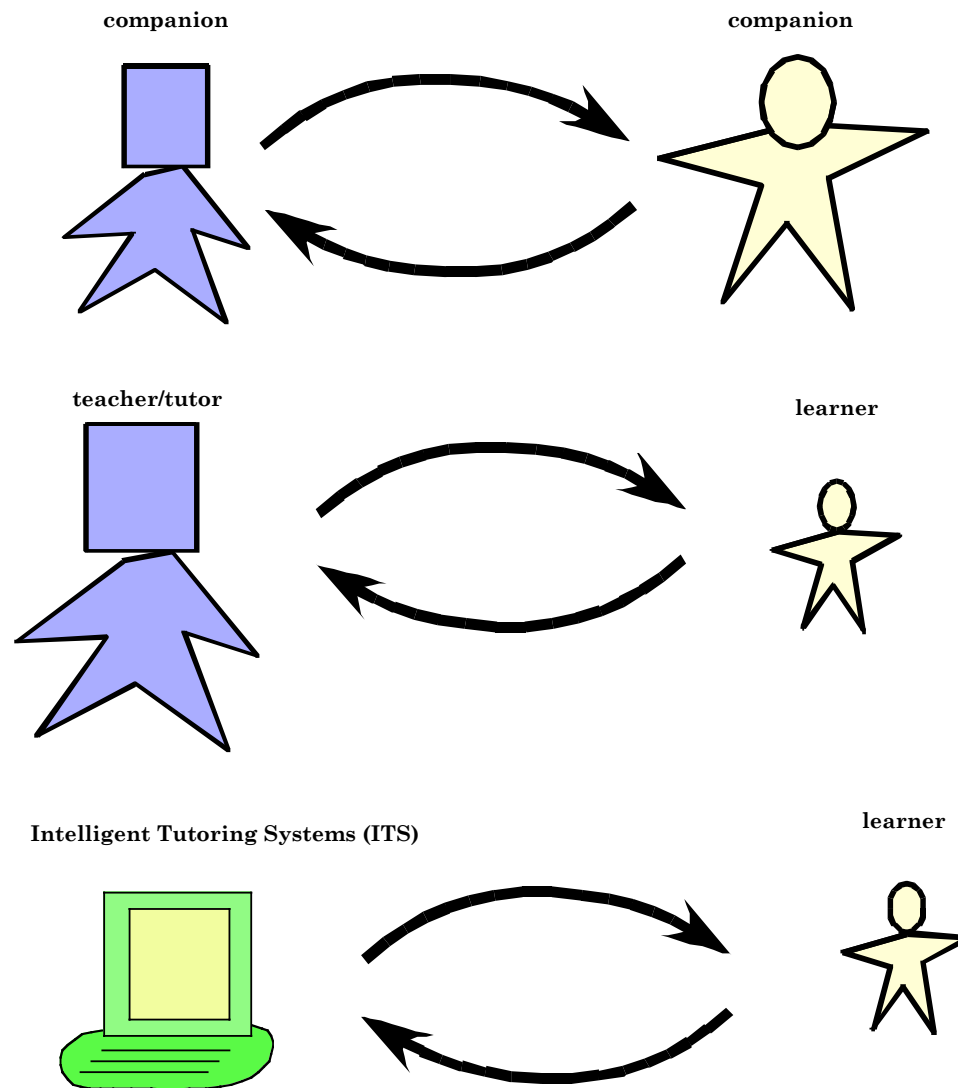
# Lifelong Learning Companions

# 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

- Gemmell, J., Williams, L., Wood, K., Bell, G. and Lueder, R., "*Passive Capture and Ensuing Issues for a Personal Lifetime Store",* in Proceedings of The First ACM Workshop on Continuous Archival and Retrieval of Personal Experiences (CARPE '04), (New York, NY, 2004), ACM Press, 48-55

- Dawe, M., Fischer, G., Gorman, A., Kintsch, A., Konomi, S., Sullivan, J., Taylor, J., & Wellems, G. (2005) *"Smart Care: the Importance and Challenges of Creating Life Histories for People with Cognitive Disabilities"*, Proceedings of the HCI International Conference (HCII), Las Vegas, July 2005, (published on CD). http://l3d.cs.colorado.edu/~gerhard/papers/smartcare-hcii-2005.pdf

# 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>*
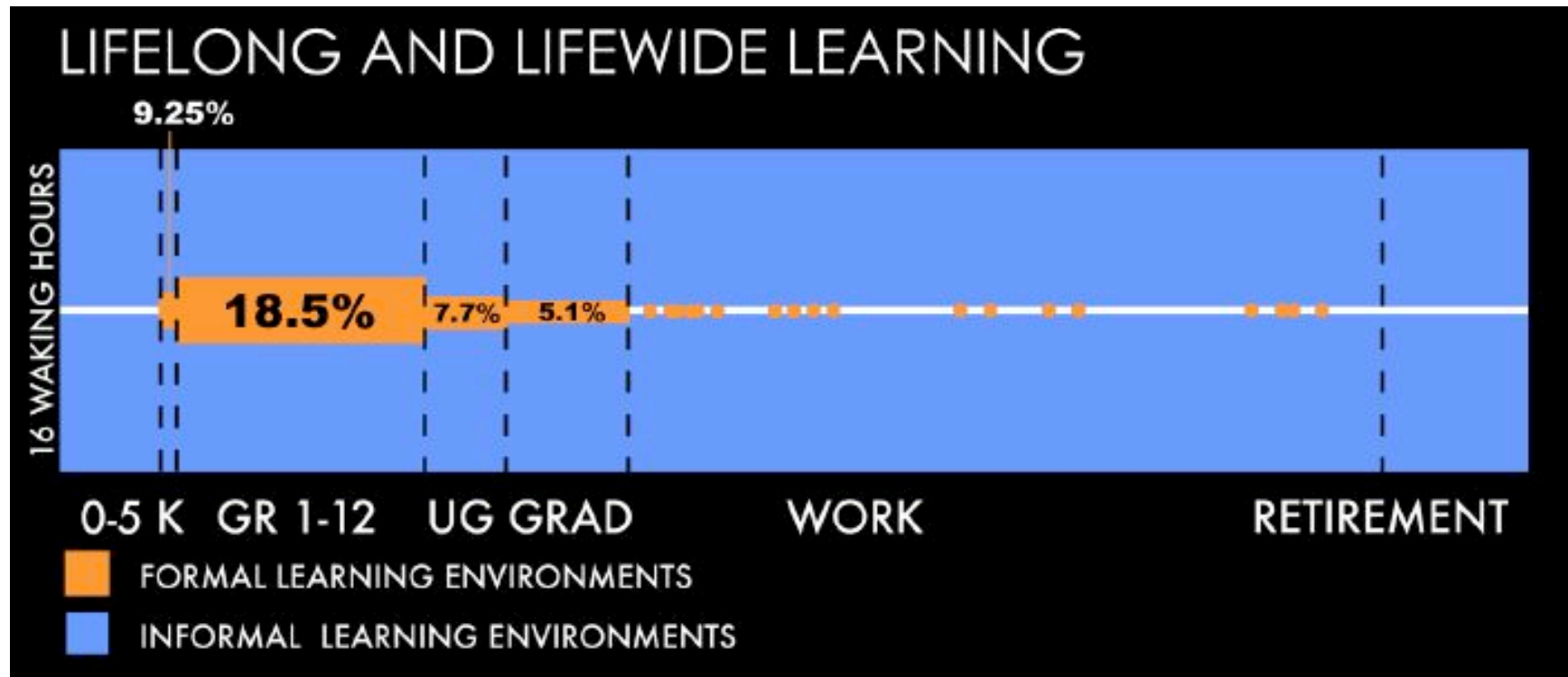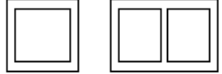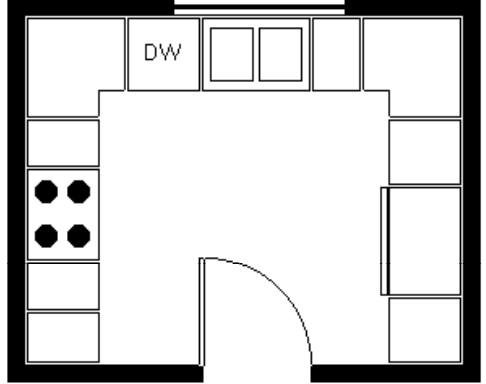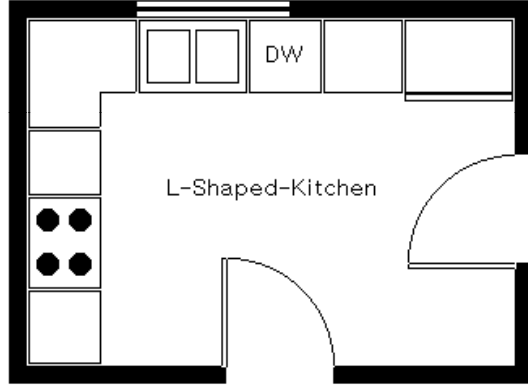
# Examples

- Critiquing Systems Embedded in Domain-Oriented Design Environments

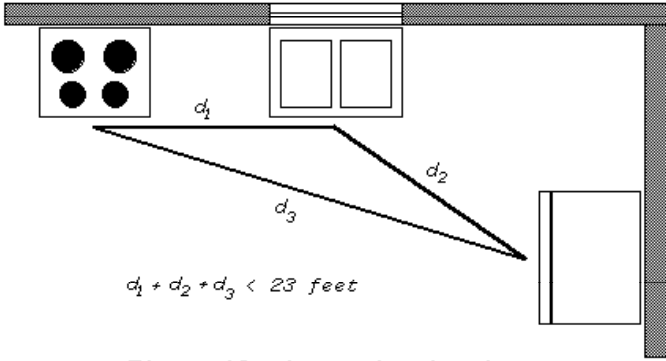- High-Functionality Environments

- Social Learning Environments

# A DODE for Kitchen Design: Construction

## Janus-Construction

Clear Work Area        Critique All        Edit Global Descriptions
Load Catalog        Save In Catalog        Select Context

### Appliance Palette

walls

doors

windows

sinks

stoves

### Catalog

L-Shaped-Kitchen

### 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
► ■

# 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 23 feet.



$$d_1 + d_2 + d_3 < 23 \text{ feet}$$

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 work flow in the kitchen!

**Argument (Small Room)**
In small kitchens where the work triangle is less than 16 feet,

*Viewer: Default Viewer*

### Catalog Example



One-Wall-Kitchen

The length of the work triangle (Stove, Refrigerator, Sink) is less than 23 feet.

### Visited Nodes
⇒  Answer (Refrigerator, Sink, Stove) Section

**Commands**
▶
Show Example: "Answer (Refrigerator, Sink, Stove)"
*Show Example Answer (Refrigerator, Sink, Stove)*
▶■

Show Outline          Resume Construction
Search For Topics     Show Construction
Show Argumentation    Show Example
Show Context          Show Counter Example

# 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

| Level | Description | Strengths | Weaknesses |
|---|---|---|---|
| **Fix-It Level** | fix the problem by giving a solution without detailed understanding; primarily performance support | keep focus on task; learning does not delay work | creates little understanding |
| **Reflect Level** | explore argumentative context for reflection ("reflection-in-action") | understanding of specific issues | piecemeal learning of (disconnected) issues |
| **Tutorial Level** | provide contextualized tutoring (not lecturing on unrelated issues) | systematic presentation of a coherent body of knowledge | substantial time requirements |

# 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)?
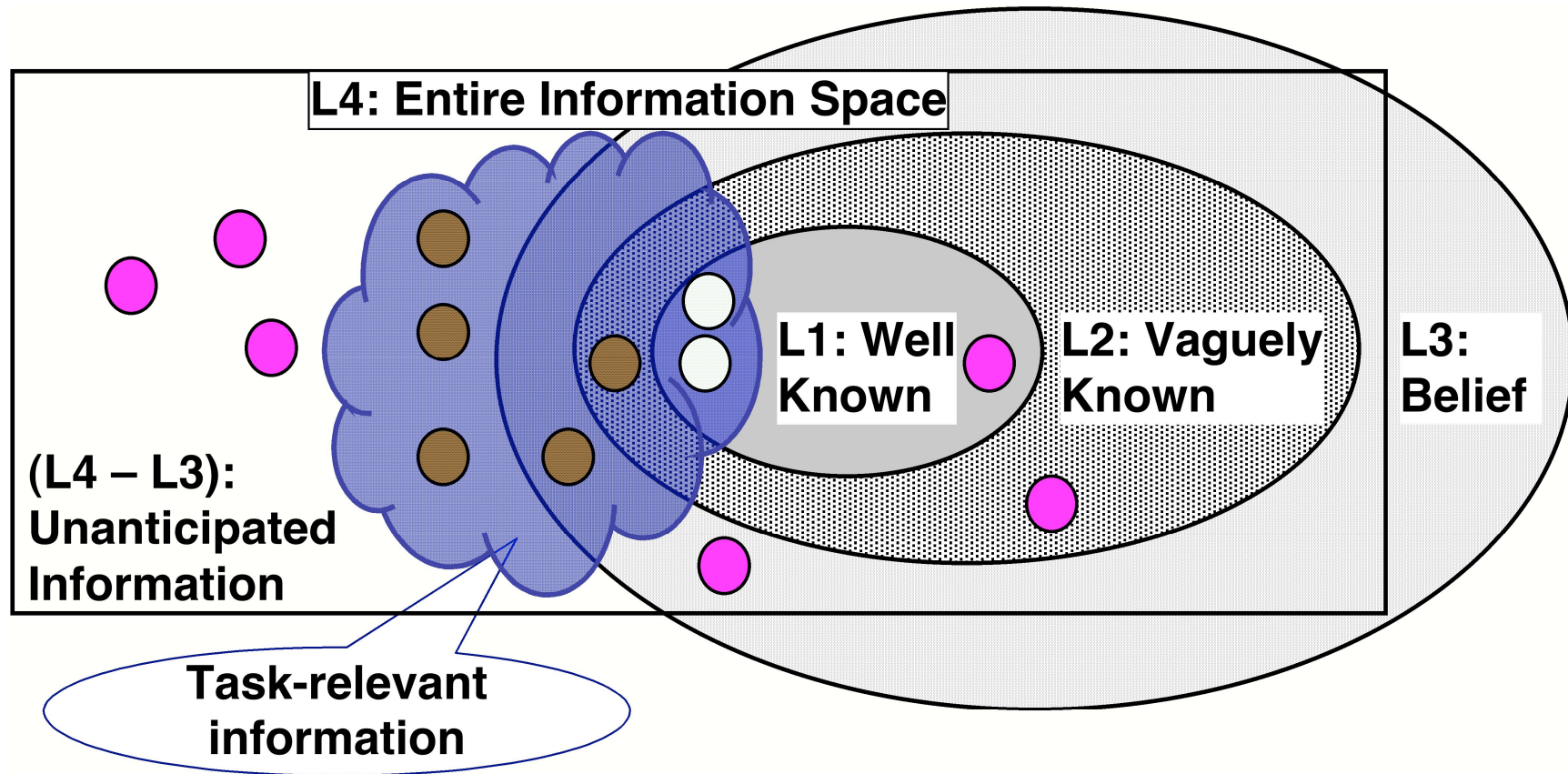
# Interactions with Learning Companions

- **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{person}
    - teacher/learner    $=$    f{context}

# Information Sharing:
# Access ("Pull") and / or Delivery ("Push")

| | access ("pull") | delivery ("push") |
|---|---|---|
| **examples** | browsing, search engines, bookmarks, passive help systems | Microsoft's "Tip of the Day", broadcast systems, critiquing, active help systems, agent-based systems |
| **strengths** | non-intrusive, user controlled | serendipity, creating awareness for relevant information, rule-enforcement |
| **weaknesses** | task relevant knowledge may remain hidden because users can not specify it in a query | intrusiveness, too much decontextualized information |
| **major system design challenges** | supporting users in expressing queries, better indexing and searching algorithms | context awareness (intent recognition, task models, user models, relevance to the task-at-hand) |

# Contextualized Information Delivery ("Push")

in high-functionality environments and large software reuse repositories

**L4: Entire Information Space**

**L1: Well Known**

**L2: Vaguely Known**

**L3: Belief**

**(L4 – L3): Unanticipated Information**

**Task-relevant information**

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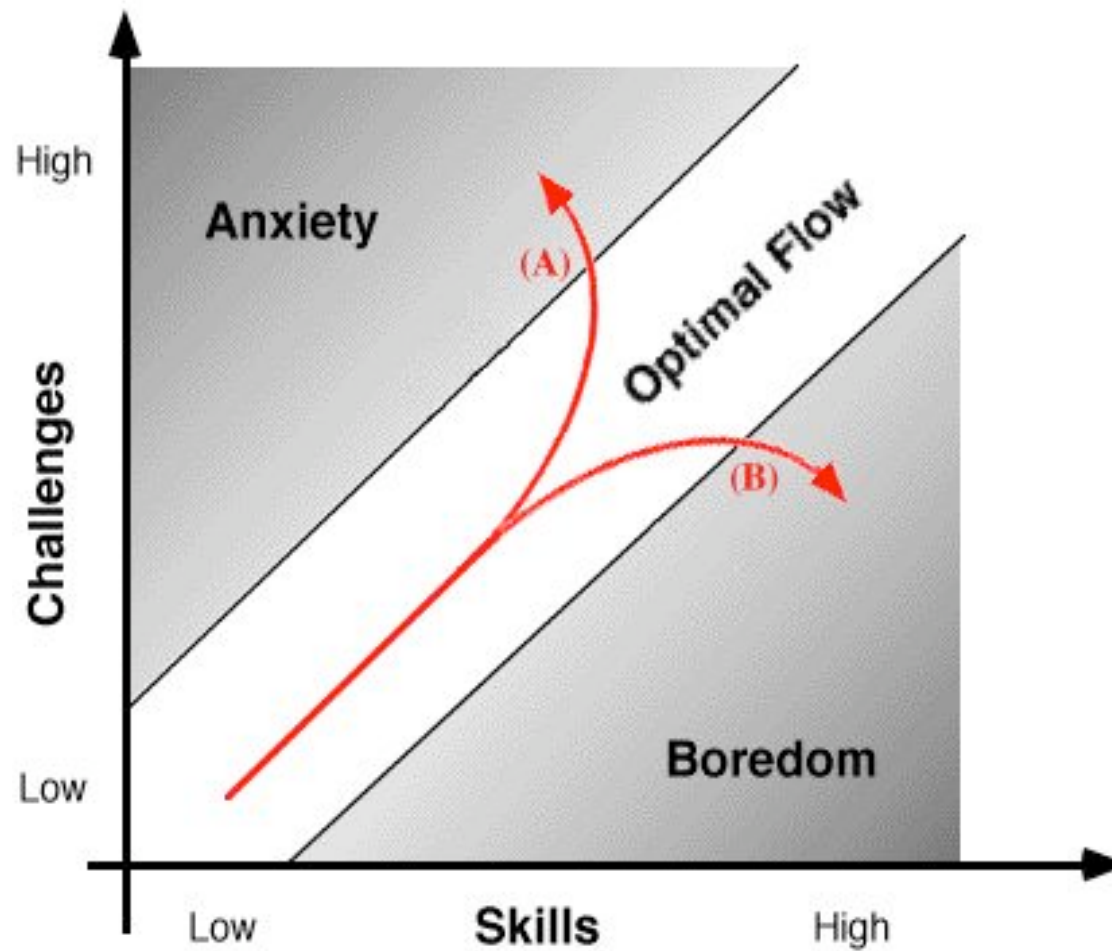
- there are **no expert anymore** (nobody knows the whole system) → learning on demand, incremental learning supported by lifelong learning companions

- **challenge**: beyond "ease of use" → **low threshold and high ceiling**

# Low Threshold and High Ceiling
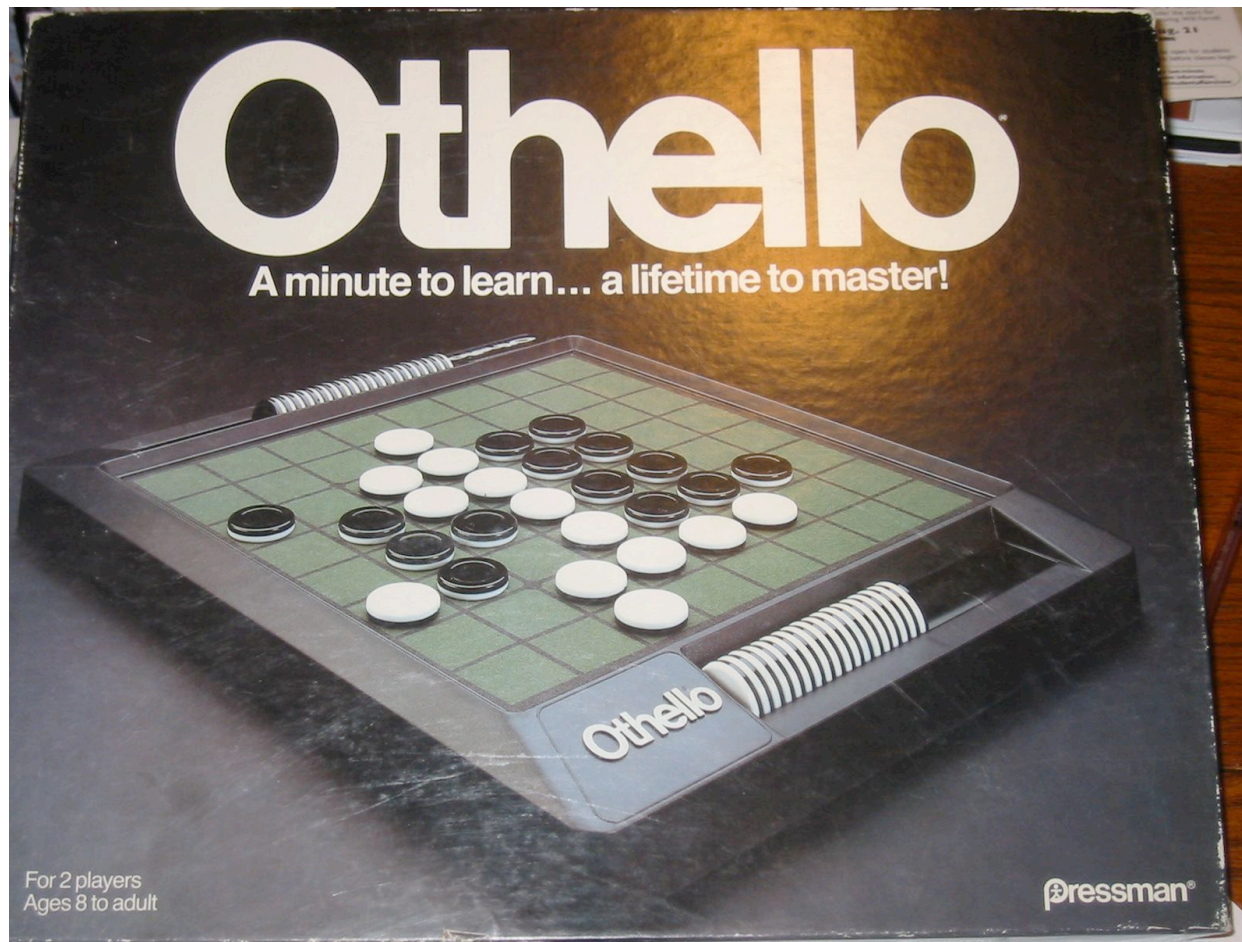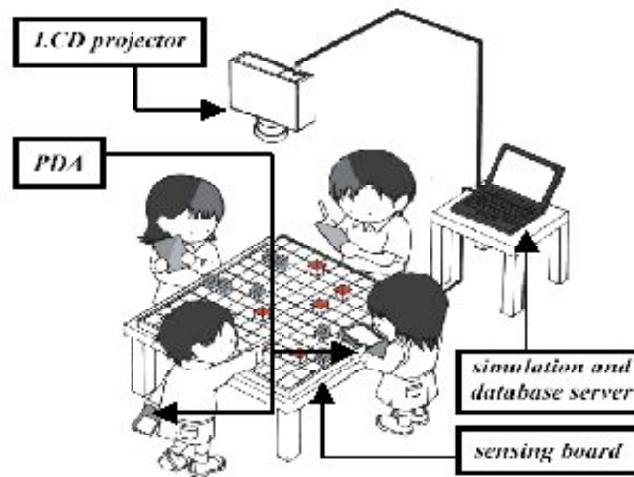
# Finding the Right Challenge

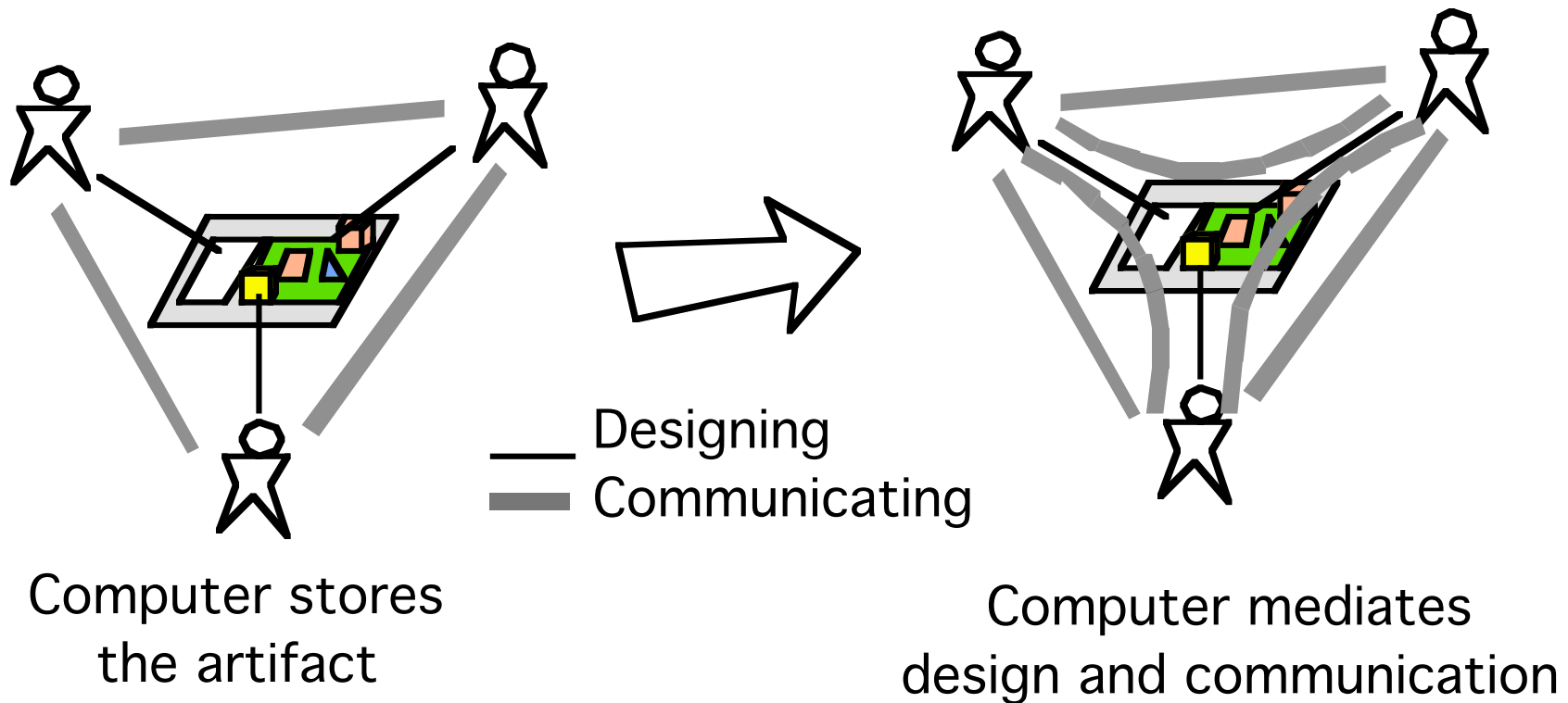# Social (Learning) Environments



social



individual



individual and social

# The Envisionment and Discovery Collaboratory

# Embedding Communication in Design Activities



___ Designing

━━ Communicating

Computer stores
the artifact

Computer mediates
design and communication

# Conclusion = Evidence for the 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