



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

Distributed Cognition

Gerhard Fischer

Center for LifeLong Learning & Design (L³D), Department of Computer Science and Institute of
Cognitive Science, University of Colorado, Boulder

<http://l3d.cs.colorado.edu/>

University of Milan, February 2012

Distributed Cognition

- **claim:** distributed intelligence

- **combines** “knowledge in the head” with “knowledge in the world”
- provides an effective **theoretical framework** for technology for improving cognitive function
- provides guidelines how artifacts, tools, and **socio-technical environments** can change tasks and empower human beings
- **transcends** the traditional view that human cognition exists solely ‘inside’ a person’s head

- **forms of distribution:**

- **human** \leftrightarrow **human**: across groups, teams, social networks, communities
- **human** \leftrightarrow **artifacts**: between *internal* (memory, attention, executive function) and *external* (artifacts, tools) structures and resources

Hand-Held Calculators — What Do Learning Scientists Have to Say?

- **position 1:** ignore the existence of the gadget; we are not interested in technology, but in important mathematical skills — do ***not use*** hand-held calculators in schools
- **position 2:** keep the curriculum the same, make children learn arithmetic, multiplication tables, long division, drawing square root by hands — ***after*** they have it all mastered, allow the use of hand-held calculators.
- **position 3:** create new calculators, new curricula, new scaffolding mechanisms that make learning these skills more fun and create a deeper understanding of underlying concepts — using these hand-held calculators, the learners would acquire the skills and the knowledge and eventually become ***independent*** of the gadget (“scaffolding with fading”, “tools for learning”)
- **position 4:** find new ways to ***distribute responsibilities between humans and machines*** such that humans do the qualitative reasoning, use estimation skills, relate the mathematical result to the real world and machines do the detailed quantitative computations (“distributed intelligence”, “tools for living”)

Basic Skills in the 21st Century?

<source: John Anderson in Cog Sc Panel 1993 about “learning on demand”>

- If most job-relevant knowledge must be learned on demand what is the role for **basic education**?
- consider the role of a traditional high school mathematics education
 - there is a general perception that American children are poorly prepared in mathematics and that this is part of the reason for our lack of international competitiveness
 - the kind of mathematics that American schools fail at teaching (and which other countries excel at) has increasingly little relationship to work performance
 - almost all of the mathematics that students learn in traditional high school mathematics is **job-irrelevant** (e.g., doing proofs in geometry) or now **automated** (e.g., algebraic symbol manipulation).
 - most people's on-the-job contact with mathematics (if they have any) will be in using tables and software packages based on mathematics
- perhaps the function of a high-school mathematics education is to train students to **intelligently use these mathematical artifacts**
- perhaps we need only teach traditional mathematics to a small minority of the population who will maintain these systems

Two Perspectives on Distributed Cognition

- **personal point of view:** distributed intelligence **changes the nature of the tasks** that human beings do → examples:
 - check-out clerk in a supermarket
 - pilots flying a modern airplane
 - velcro
 - **human-centered public transportation systems**

- **system point of view:** the “person + artifact” is smarter than either alone → examples
 - cockpit (pilot + computers + air traffic controllers) of an airplane
 - **socio-technical environments for people with cognitive abilities**

- **Einstein:** *“My pencil is cleverer than I”*

Technologies Changing Tasks

From the Neighborhood Store to the Smart Store of the Future

- **changes based on new technologies:**
 - *calculations in the head*
 - *calculations using pencil and paper*
 - *adding machines*
 - *UPC, scanners and databases*
 - *RFID tags*
- **different tasks done by sales clerks:**
 - ***adding prices:*** *in their heads → using pencil and paper → using adding machines → using scanners*
 - ***money:*** *computing the change in the head → by the machine → processing credit cards*
 - ***will clerks still be needed in the future?***
 - *will customers check out their own groceries?*
 - *will RFID tags eliminate the need for the check-out process altogether?*
- **overall performance of the system:** speed, reliability, visibility, cost, privacy,

Distributed Intelligence: Claims, Observations, and Challenges

- **“how the mind works”** is dependent on the tools at its disposal
 - analogy: “how the hand works” cannot be fully appreciated unless one takes into account whether it is equipped with a screwdriver, a pair of scissors,

- socio-technical environments
 - integrate technical and social developments
 - based on: what is technologically possible and what is socially desirable
 - externalize memory and greatly amplify the permanence and power of distributed intelligence
 - **problem:** external information environments can overwhelm humans with their richness (→ information overload)

Tools for Living and Tools for Learning

- **tools for living (doing tasks with tools):**
 - grounded in a distributed intelligence perspective
 - intelligence is mediated by tools for achieving activities that would be error prone, challenging, or impossible to achieve (e.g., microscope, telescope, ...)

- **tools for learning (scaffolding with fading):**
 - *objective*: autonomous performance by people without tools
 - *examples*: training wheels, wizards, external scripts, templates, prompting systems

- **the fundamental question**: what does it mean to “**learn**” in the 21st century in which powerful tools are available for many intellectual activities?

A Tool for Learning — Training Wheels



A Tool for Living — Adult Tricycle



Independence

- tools for living → people will be **dependent** on the tool
- **but:** the availability of the tool may give people the **independence** to engage in personally relevant activities (e.g., reading, mobility, living by themselves,)
- **question:** will **dependence** in one dimension increase **independence** in another dimension?
- **opportunity:** while some people might have no problems to learn to perform the tasks without tools (e.g., spelling), they use tools for doing these “low level tasks” and can therefore focus on the more interesting tasks

CLever: Cognitive Levers Project - “Helping People Help Themselves”

<http://l3d.cs.colorado.edu/clever/>



Cognitive Levers: Helping People Help Themselves (CLever)

<supported by the Coleman Institute>

- to support people with cognitive disability by increasing their **independence**
- new insight into **distributed intelligence** by identifying new relationships between **external and internal scripts**
- creating “**eye glasses for the mind**” to demonstrate that anatomy does not need to be destiny
- **application areas:** human-centered public transportation systems, smart care,

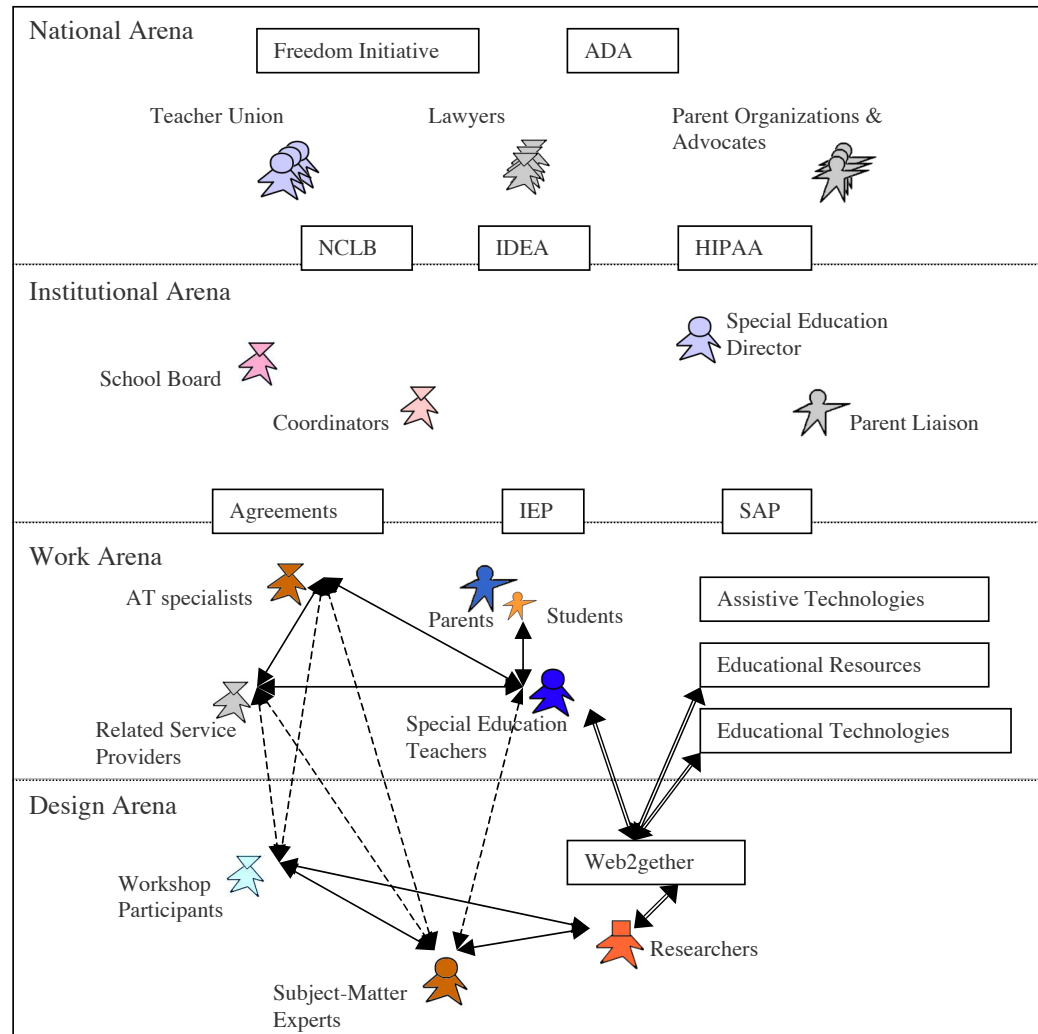
Selected CLever Projects

- **Web2gether: Online Community Environment** — supporting the members of a community (not only information management)
- **TEA: The Evaluation Assistant** — matching the needs of individuals to specific technologies
- **MAPS: Memory Aiding Prompting Systems** — creating new “knowledge” (scripts) by end-users who have no interest or technical knowledge
- **Mobility-for-All: Human Centered Public Transportation Systems** — from “anywhere, anytime, anyone” \Rightarrow right information, right person, right time, right way (exploiting the power of ubiquitous, wireless technologies)
- **Lifeline: Remote Monitoring** — reuse of the technological infrastructure for a different purpose

The Story Shown in the Multi-Media Presentation

- **specific:** a woman with cognitive disabilities (memory problems, no capacity for planning and remembering) and her mother
- **general:** the scenario shows socio-technical environments to help people with
 - cognitive disabilities
 - elderly people (e.g., with Alzheimer)
 - out-of-town visitors
 - foreigners
 - everyone
- many people can not use current public transportation systems
- innovative technologies to “simplify” their use
 - personal device such as personal digital assistants (PDAs),
 - mobile phones,
 - global positioning systems (GPS),
 - web-based collaboration tools

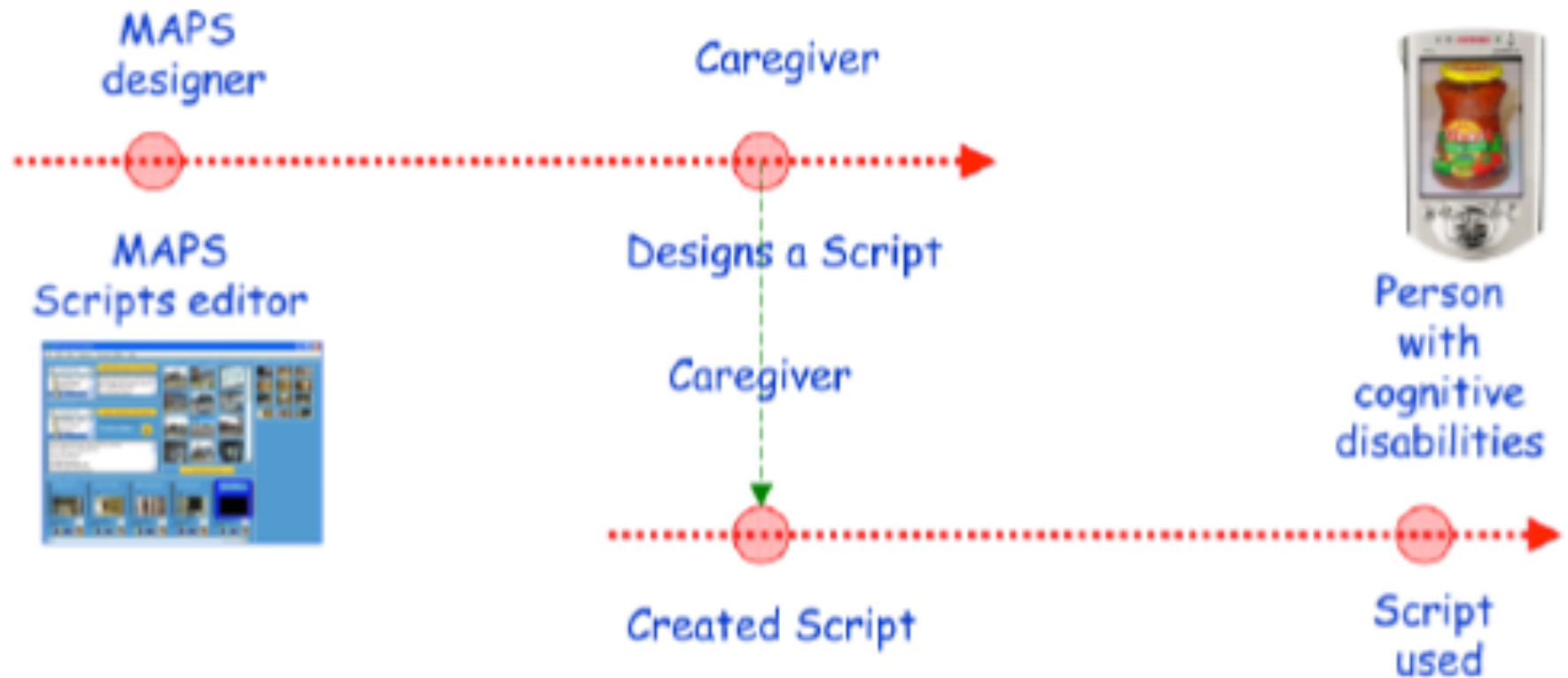
Web2Gether



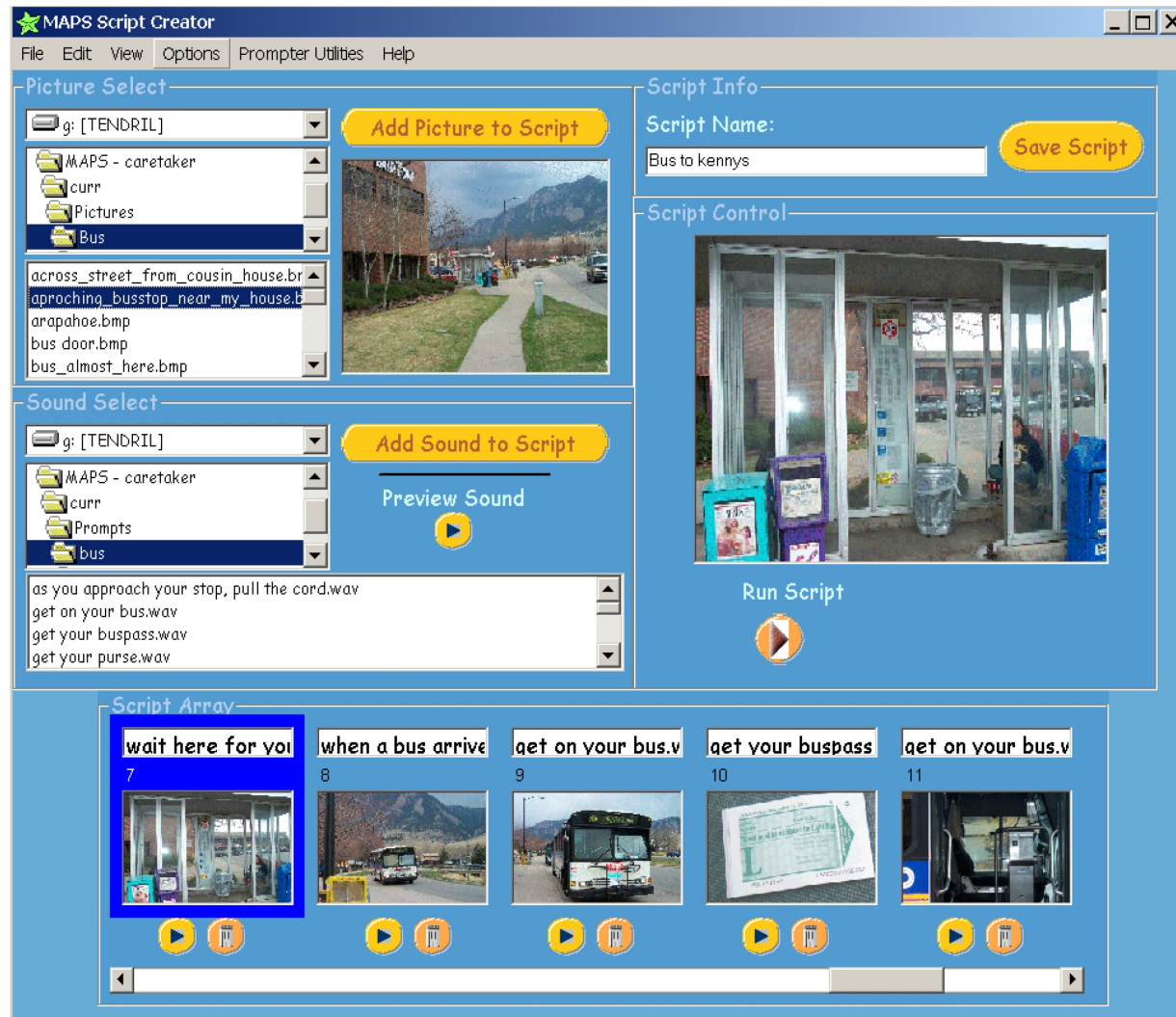
Web2Gether

- **participatory design:** socio-technical environments constructed by different social groups who participated throughout this research
- **design through cycles of closure and opening**
- ***co-evolution of design and context:*** shaped to fit the needs of the context — and at the same time the context was reevaluated
- **seeding process:** not restricted to creating initial content, but supporting structured activities, the technology, and the envisioned use community
- **integration of innovations** into the practices of users and the merging of new with existing organizational structures

End-User Development (by Caregivers) in the Memory Aiding Prompting System (MAPS)



The MAPS Script Editor: Design for Designers



Use of MAPS in Mobility-for-All



Script Use Time



Over-Reliance on Tools for Living



Over-Reliance on Tools for Living



"Nurse, get on the internet, go to SURGERY.COM, scroll down and click on the 'Are you totally lost?' icon."

Low-Tech (“Tradition”) versus High-Tech (“Transcendence”)



Summary: Tools for Living and Tools for Learning

	Tools for Living	Tools for Learning
Definition	do task with tools	do tasks without tools
Examples	eye glasses, phone, radar, cockpits, scuba diving gear	spelling correctors, hand-held calculators, tricycles, wizards,
people with disabilities	spelling correctors, hand-held calculators, tricycles, wizards	learning Braille, learning how to use prompts, learning a bus route
prompting systems (MAPS)	for people with memory problems (disabilities, elderly)	for people without memory problems (but: people use calendars on paper, reminding systems)
distributed cognition perspective	resource rich (professional life)	become independent of external resources (school)

Conclusion

- **21st century skills:** what do human need to learn to successfully take advantage of tools and external resources (e.g., pervasive computing, always-on Internet access, reliable service networks, and sufficient level of technological fluency)?
- **danger** of a decrease in the power of the aided, collective human mind?
 - **information overload:** continuous partial attention and the attention economy
 - **over-reliance** on tools for living