



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

## **Anatomy is Not Destiny: Creating Eyeglasses for the Mind**

Gerhard Fischer

Center for LifeLong Learning & Design (L<sup>3</sup>D)

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

Department of Computer Science and Institute of Cognitive Science  
University of Colorado, Boulder

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# Acknowledgements

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- ♣ **Assistive Technology Partners** (Cathy Bodine), University of Colorado
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- ♣ **Boulder Valley School District**
- ♣ **Interactions with many participants attending the conference**
- ♣ **NSF-CISE SGER Grant** *“Designing and developing mobile computing infrastructures and architectures to support people with cognitive disabilities and caregivers in authentic everyday tasks”* (Program Director: Ephraim Glinert)
- ♣ **Cognitive Levers (CLever) Research Team, Center for LifeLong Learning and Design, CU Boulder**

# Outline

- ♣ Basic Message
- ♣ Distributed Intelligence
- ♣ Global Research Landscape
- ♣ Cognitive Levers (CLever) Research
- ♣ Assessment
- ♣ Opportunities and Recommendations
- ♣ Conclusions

# Basic Message and Fundamental Opportunity



# Why Anatomy does not have to be Destiny?

*“The invention of eyeglasses in the twelfth century not only made it possible to improve defective vision but suggested the idea that human beings need not accept as final either the endowments of nature nor the ravages of time.*

*Eyeglasses refuted the belief that anatomy is destiny by putting forward the idea that our minds as well as our bodies are improvable!”*

**source:** Postman, N. (1985) *Amusing Ourselves to Death—Public Discourse in the Age of Show Business*, Penguin Books, New York, p 14)

# Distributed Intelligence (or Distributed Cognition)

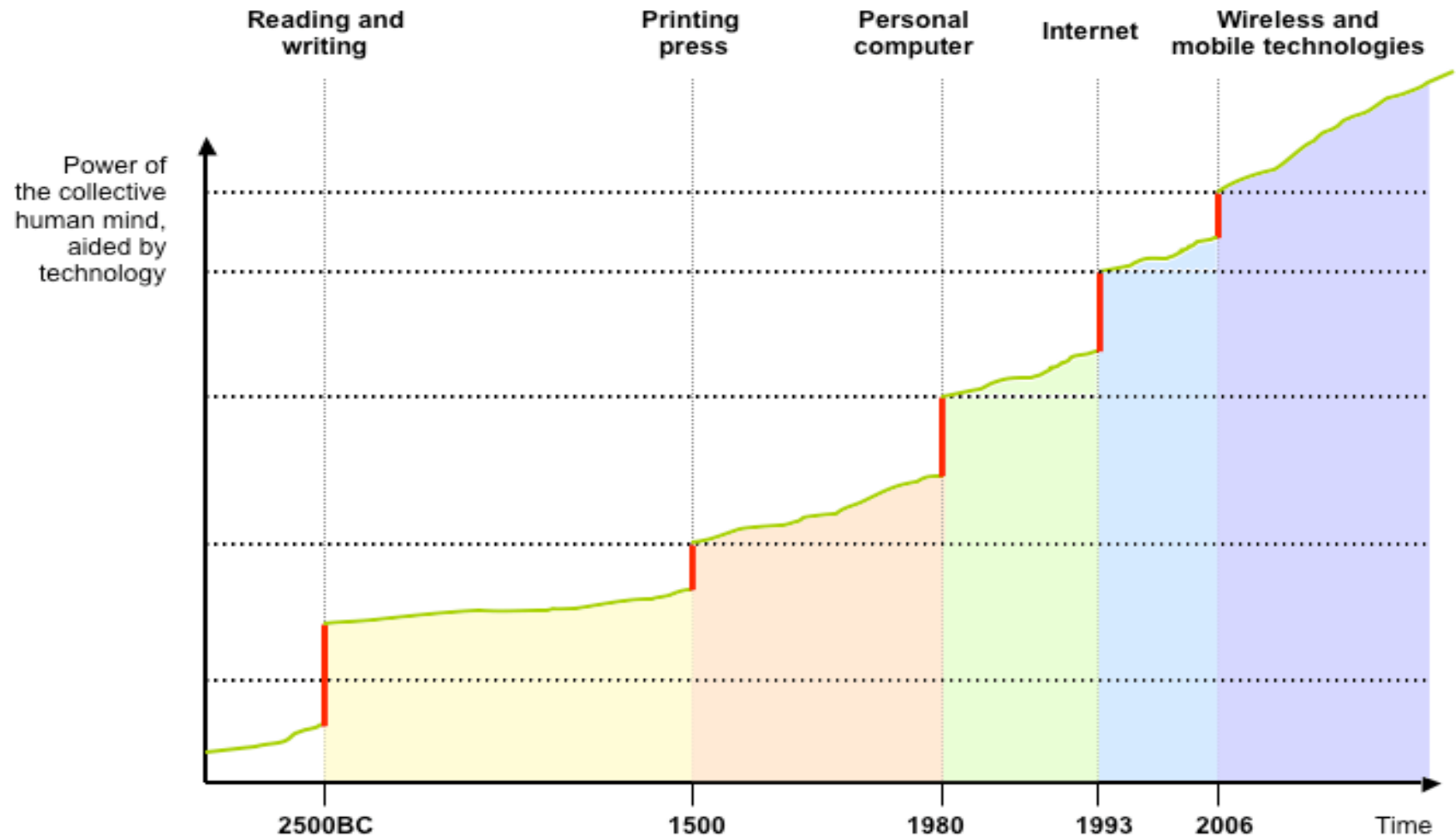
## ♣ **claim:** distributed intelligence

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

# Beyond the Unaided, Individual Human Mind



# Technologies for Improving Cognitive Function

## ♣ technologies for improving cognitive function

- are not restricted to people with cognitive disabilities
- are the fundamental achievement of humankind to create the world in which we live today
- technologies in this context are very broadly defined including “**mind tools**” for performing cognitive work (e.g.: musical notation, Arabic instead of Roman numerals,.....)

## ♣ all human beings have cognitive limitations (limits of short-term memory ◇ reading and writing)

## ♣ working with people with cognitive disabilities provides **unique challenges and unique opportunities** to further advance our understanding of distributed intelligence by exploiting the duality and creating a symbiotic relationship between

- distributed intelligence    ◇    cognitive disabilities
- cognitive disabilities       ◇    distributed intelligence



# Two Perspectives on Distributed Intelligence

♣ **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?

# Independence

- ♣ tools for living  $\diamond$  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

# Global Research Landscape

## ♣ Mobility:

- Assisted Cognition project at University of Washington — <http://www.cs.washington.edu/assistcog/>

## ♣ Prompting:

- Visions — <http://www.thevisionssystem.com/>
- AbleLink (Dan Davies) — <http://www.ablelinktech.com>

## ♣ Independent living-related Surveillance:

- Oatfield Estates — <http://www.elite-care.com/oatfield.html>
- ADT — [http://www.adt.com/resi/products\\_services/medical\\_alert\\_systems](http://www.adt.com/resi/products_services/medical_alert_systems)

## ♣ Synergy between Basic Research, Industry, Policies

- RERC-ACT: <http://www.uchsc.edu/atp/RERC-ACT/>

## ♣ Matching Needs and Technologies:

- Institute for Matching Person and Technology (Marcia Scherer) — <http://members.aol.com/IMPT97/mpt.html>

# **Cognitive Levers (CLever)**

## **A Research Project of the Center for LifeLong Learning and Design**

♣ supported by the **Coleman Institute** (begin: August 2000)

### **♣ Coleman Institute at the University of Colorado**

- funded by a **generous endowment** from **Bill and Claudia Coleman** for research on *Cognitive Disabilities*
- supports research across many different disciplines
- director: David Braddock
- more information: <http://www.colemaninstitute.org/>

### **♣ objectives of CLever:**

- “helping people help themselves”
- “give people a voice that do not have one”
- supporting clients by empowering caregivers
- more information: <http://l3d.cs.colorado.edu/clever/>

# Identity of CLever within the Cognitive Disabilities Research Community

- ♣ next generation of **socio-technical environments**
- ♣ understanding and honoring the **tradition** (“how things are”)
- ♣ **transcending** current practices and processes (“how things could be”)
- ♣ **transdisciplinary** collaboration and education between research communities in cognitive disability and information and communication technologies ◇ “Computers and X”



# The Story Shown in the Video

## ♣ **specific:**

- **scenario:** a woman with cognitive disabilities (memory problems, no capacity for planning and remembering) and her mother
- **focus:** human-centered public transportation systems

## ♣ **general:** the scenario shows socio-technical environments to help people with cognitive disabilities — applicable also for:

- elderly people (e.g., with Alzheimer)
- out-of-town visitors and foreigners
- everyone

## ♣ **empirical study to understand “how things are”:** many people have difficulties to use current public transportation systems including

- maps
- schedules
- labels and signs
- landmarks
- time

## **Vision: demonstrate “how things can be”**

**—  
innovative technologies to simplify the use of  
public transportation systems**

- ♣ personal device such as personal digital assistants (PDAs)
- ♣ mobile phones
- ♣ global positioning systems (GPS)
- ♣ remote monitoring tools (for caregivers and service providers)

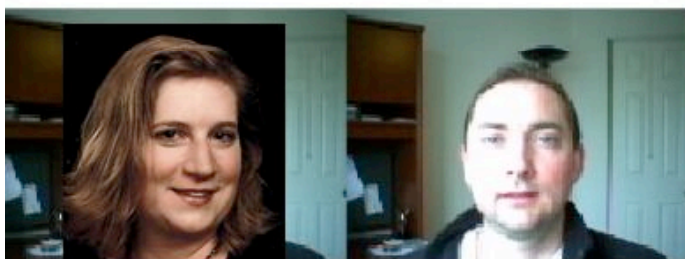
## Selected CLever Projects Shown in the Video

- ♣ **Web2gether: Online Community Environment** — supporting the members of a community
- ♣ **TEA: The Evaluation Assistant** — matching the needs of individuals to specific technologies (overcome *lack of adoption* and *high level of abandonment*)
- ♣ **MAPS: Memory Aiding Prompting Systems** — creating (simple) computer programs (scripts) by end-users (caregivers) who have no interest in technology per se
- ♣ **Mobility-for-All: Human Centered Public Transportation Systems** — exploiting the power of ubiquitous, mobile, wireless technologies
- ♣ **Lifeline: Remote Monitoring** — embedding the technological component in a socio-technical environment (tracking environment, panic button) ◇ activate human support networks when the technology fails

# MAPS, Mobility-for-All, and Lifeline



# Remote Support Environments: Lifeline **Caregiver** Console



Name:

Amy

Name:

Andy

Motion not detected

Disconnect



| Step | Image | Description          | Status        | Time            |
|------|-------|----------------------|---------------|-----------------|
| 0    |       | Wash Dishes Script   | Activated     | Apr 25 11:10:20 |
| 1    |       | Plug sink            | Moved to Next | Apr 25 11:10:45 |
| 2    |       | Fill sink with water | Moved to Next | Apr 25 11:12:32 |
| 3    |       | Add soap             | Moved to Next | Apr 25 11:12:36 |
| 4    |       | Wash dish            | Current Step  | Apr 25 11:12:36 |
| 5    |       | Rinse dish           | Pending       |                 |



# Remote Support Environments: Lifeline **Client** Console



# Assessment

♣ **medical model** (focus on the disability) ◇ **social model** (empowerment, independence, socialization)

♣ the analogy with eyeglasses — a **simple** problem:

- they represent technologies that can be "fitted" in a lab setting
- if done properly, can be used in the world with little need for social support
- **refinements:**
  - contact lenses
  - Lasik surgery

# Assessment

- ♣ **21<sup>st</sup> 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
  - “**always on**” implies ◇ constantly being accessible makes someone inaccessible
  - **over-reliance** on tools for living



## 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”)



# Technologies are “Faustian Bargains”

♣ **claim:** all important technologies are “Faustian bargains”: they give and take away ♦ technological change always produces winners and losers

♣ **example: reading and writing**

- **gain:** external memory
- **loss:** “books will destroy thoughts” (Socrates)

♣ **examples: tracking /sensing of human beings and human actions**

- **gain:** independence and support (Lifeline, Panic Button)
- **loss:** privacy

♣ while the growth of technology is certain, the **inevitability of any particular future is not**

♣ **visions** for possible futures

- **techno-utopians** romanticize the future
- **techno-pessimists** glorify the past
- **socio-technical environments** serving real human needs

# Recommendations for Future Research Agendas

## ♣ universal access, universal design, design for all

- beyond usable

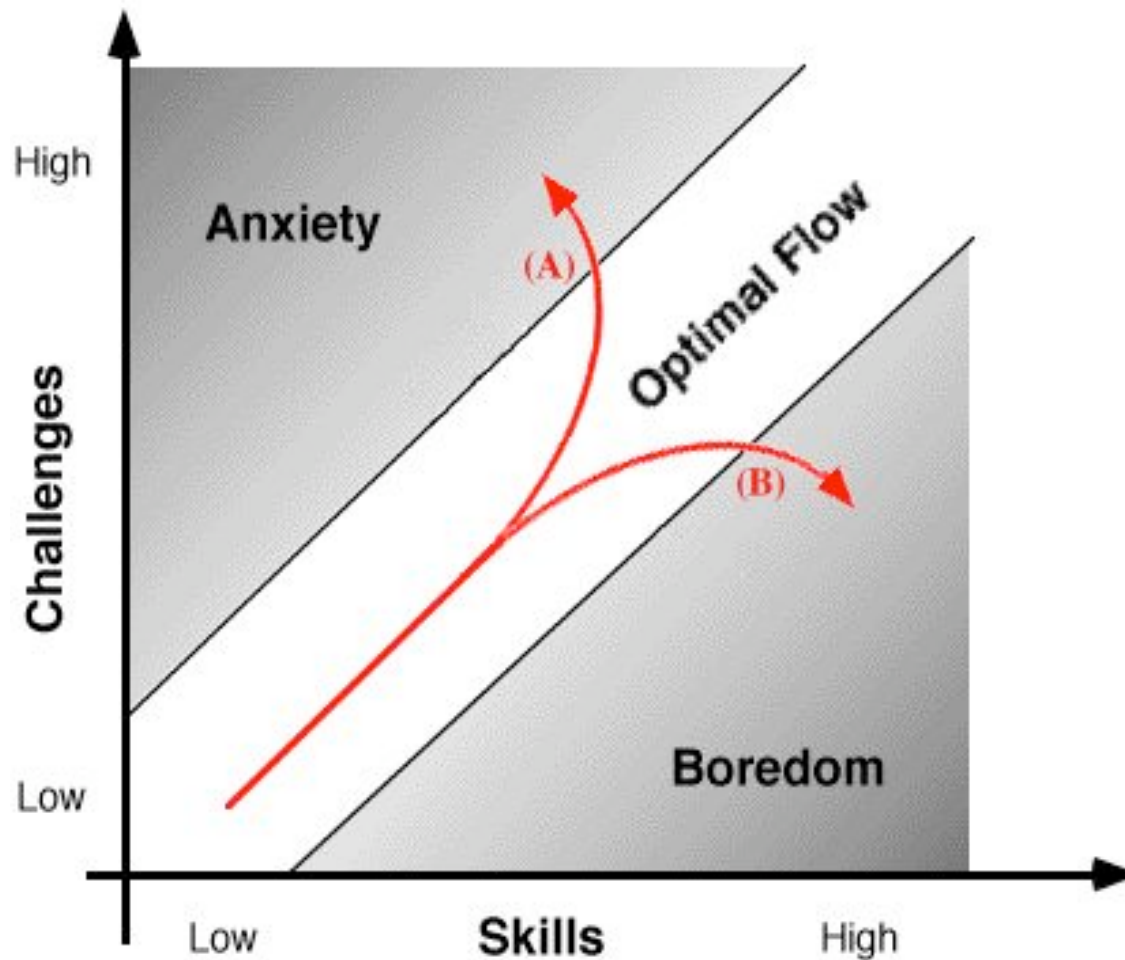
## ♣ human computer interaction

- context awareness
- people with disabilities form “a universe of one” ◇ research in personalization, user modeling, adaptation, end-user development, *meta-design*

# Beyond Usable



useful, engaging, exciting, challenging, low threshold and high ceiling



♣ **source:** Csikszentmihalyi, M. (1990) *Flow: The Psychology of Optimal Experience*,

# The MAPS Script Editor: Design for Designers



## **Recommendations: Science of Design**

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### **applied to and inspired by cognitive disabilities**

- ♣ **new architectures for socio-technical environments** providing new user experiences
- ♣ **standard tool sets fail** for people with disabilities because they are lacking the cognitive prerequisites to use the tools
- ♣ **challenge:** create more than just alterations to existing tools developed for people without disabilities ◇ design tools **explicitly** for people with cognitive disabilities



# Recommendations

## related to new NSF-CISE objectives

### ♣ **human-centered computing**

- integration and co-evolution of social and technical systems ◇ socio-technical environments
- new design methodologies:
  - technology-centered
  - professionally-dominated
  - user-centered
  - participatory design
  - learner-centered
  - meta-design
- transform learning and discovery
- enhance quality of life and economic prosperity for all people
- reduce digital divide

### ♣ **distributed intelligence**

- increase the capabilities of human beings **and** machines
- **information overload**: beyond anywhere, anytime, anyone ◇ the 'right' information at the 'right' time, in the 'right place', in the 'right way', to the 'right' person

# Creating “Windows into the Mind” with Engaging Activities

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## Example: Google/SketchUp and Autism

- ♣ **SketchUp:** useful and usable tool with a low threshold and a high ceiling for 3-D representations
- ♣ **accidental observation:** children with **Autism spectrum disorders** were using SketchUp to produce remarkable work
- ♣ **question:** why and how?

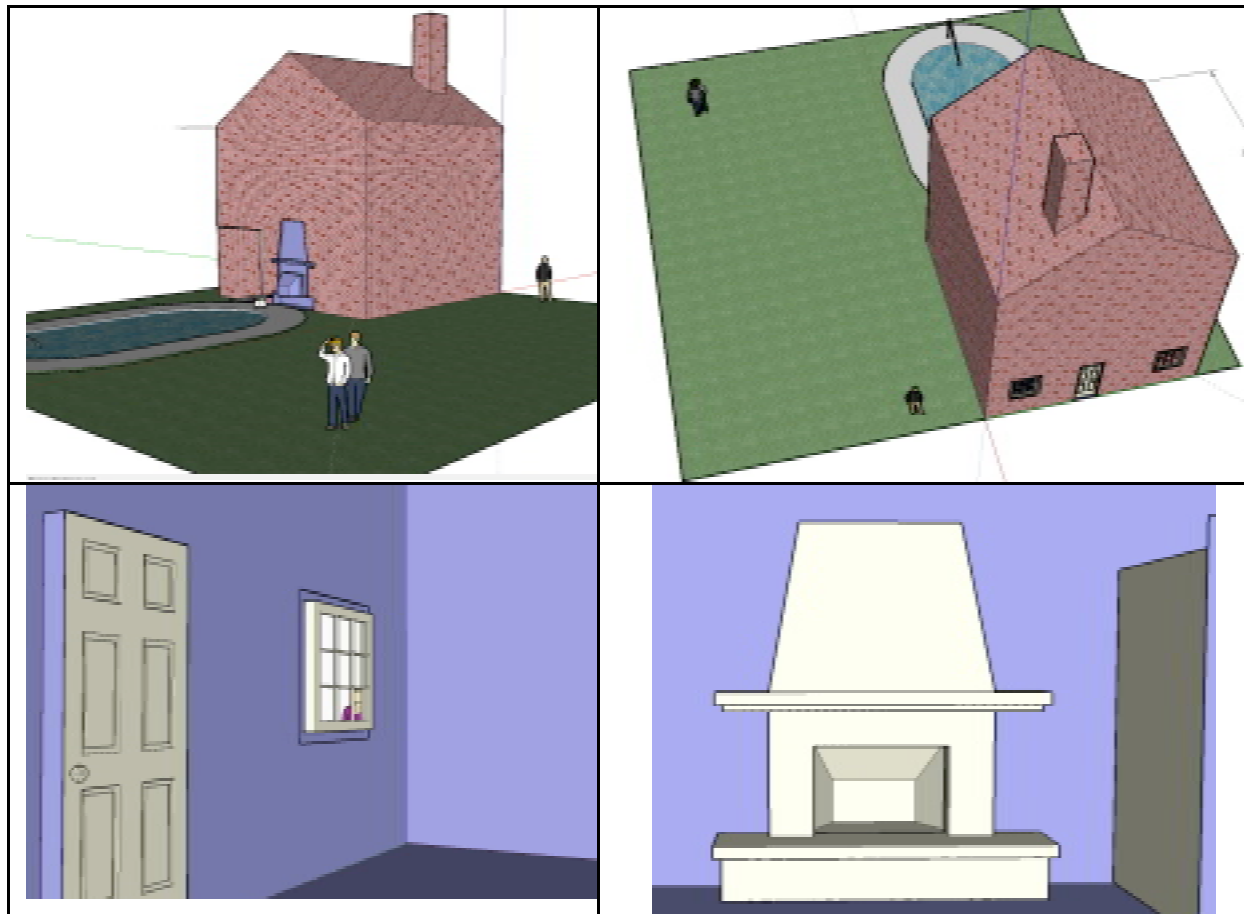
## Example-1 (from high school student with Asperger's Syndrome)

Student was given drawing to the left and asked **to reproduce it using SketchUp (result on the right)**



## Example-2 (from same student)

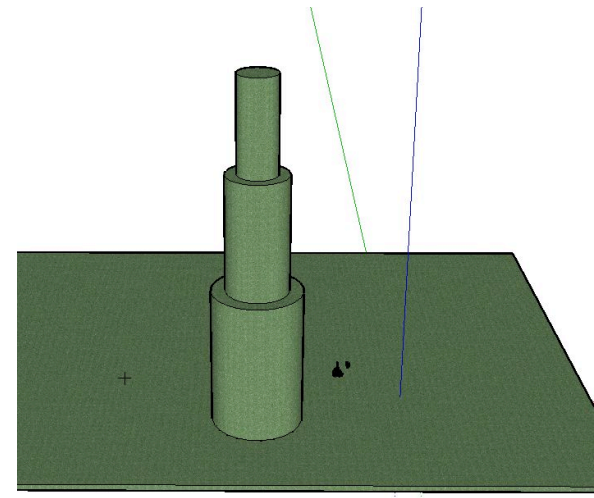
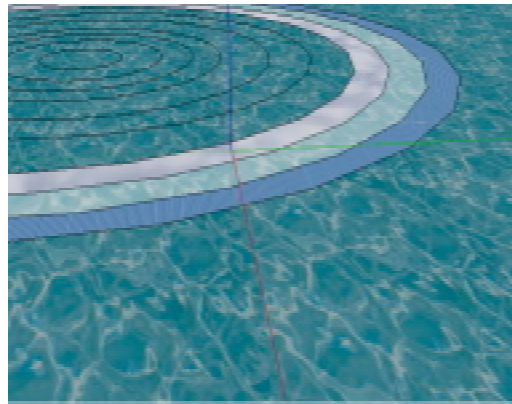
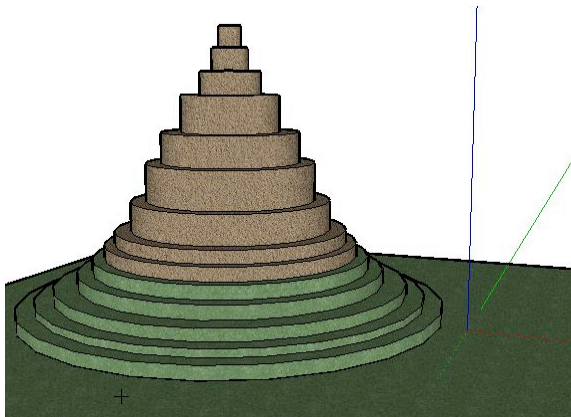
a home complete with pool and inside features



### **Example-3** (different high school students profoundly affected by his Autism: non-verbal, socially isolated)

unlikely that he will be able to use SketchUp in a vocational manner ◇ but it offers him one of very few recreational opportunities

#### **Mountains and Concentric Circles**



# Recommendations

## Explore New Research Methodologies

- ♣ exploit the **dual use strategy** (or “space program effect”)
  - humans with special needs and with different cognitive abilities can help to understand the thinking of humans in general
  - National Research Council Study: “scientific understanding of the aging population and technological support”
- ♣ **beyond the laboratory** ◇ emphasize the social dimensions of technology approaches, and *contrast* it with technology explored only in a laboratory context
- ♣ **claim: ethnographic methods** are a natural approach to designing assistive technologies, because the human and social aspects are crucial
- ♣ **global objective of CLever:** engage in **basic research on real problems**

## Recommendations

### — Educating the “Minds of the Future”

- ♣ a specific responsibility for a **university research group** (such as CLever)
- ♣ technologies for improving cognitive function will **continue to change** on an ongoing basis (requiring lifelong learning by all stakeholders)
- ♣ **claim**: these application domains will attract different student populations in Computer Science
- ♣ **transdisciplinary education and collaboration** — a core element in creating socio-technical environments is the
  - process of creating a mutual understanding between all stakeholders of a design community (e.g., between technologists and technology users)
  - communities are composed of people with different areas of expertise and concerns ◇ it is crucial that they understand the perspectives of each other



## Ryan Patterson — A L3D Undergraduate Research Apprentice





# Conclusions: Returning to the Basic Message

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## Technology for Improving Cognitive Function

- ♣ will provide people with cognitive disabilities with **new opportunities and a different quality of life**
- ♣ will address **major social and economical challenges** (e.g., aging populations, traumatic brain injury)
- ♣ has the potential to make **fundamental contributions and identify fundamental research issues** in the world of the 21st century by **“creating eyeglasses for the mind”!**

# Conclusions

♣ the future is not out there to be discovered — it has to be **invented and designed**

♣ where are we?

*“This is not the end. It is not even the beginning of the end. But it is, perhaps, the end of the beginning.”* —Winston Churchill

## Further Information

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- ♣ Pollack, M. E. (2005) "Intelligent Technology for an Aging Population: The Use of AI to Assist Elders with Cognitive Impairment," *AI Magazine*, 26(2), pp. 9-24.
- ♣ ACM CHI 2006 Workshop on Designing Technology for People with Cognitive Impairments  
[http://www.cs.ubc.ca/~joanna/CHI2006Workshop\\_CognitiveTechnologies/](http://www.cs.ubc.ca/~joanna/CHI2006Workshop_CognitiveTechnologies/)

## Further Information – L3D

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