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

Distributed Intelligence, Tools for Living, Tools for Learning, and Scaffolding

Gerhard Fischer and Hal Eden
Spring Semester 2007, March 19, 2007

Pea, R. D. (2004) "The Social and Technological Dimensions of Scaffolding and Related Theoretical Concepts for Learning, Education, and Human Activity,"

and/or:

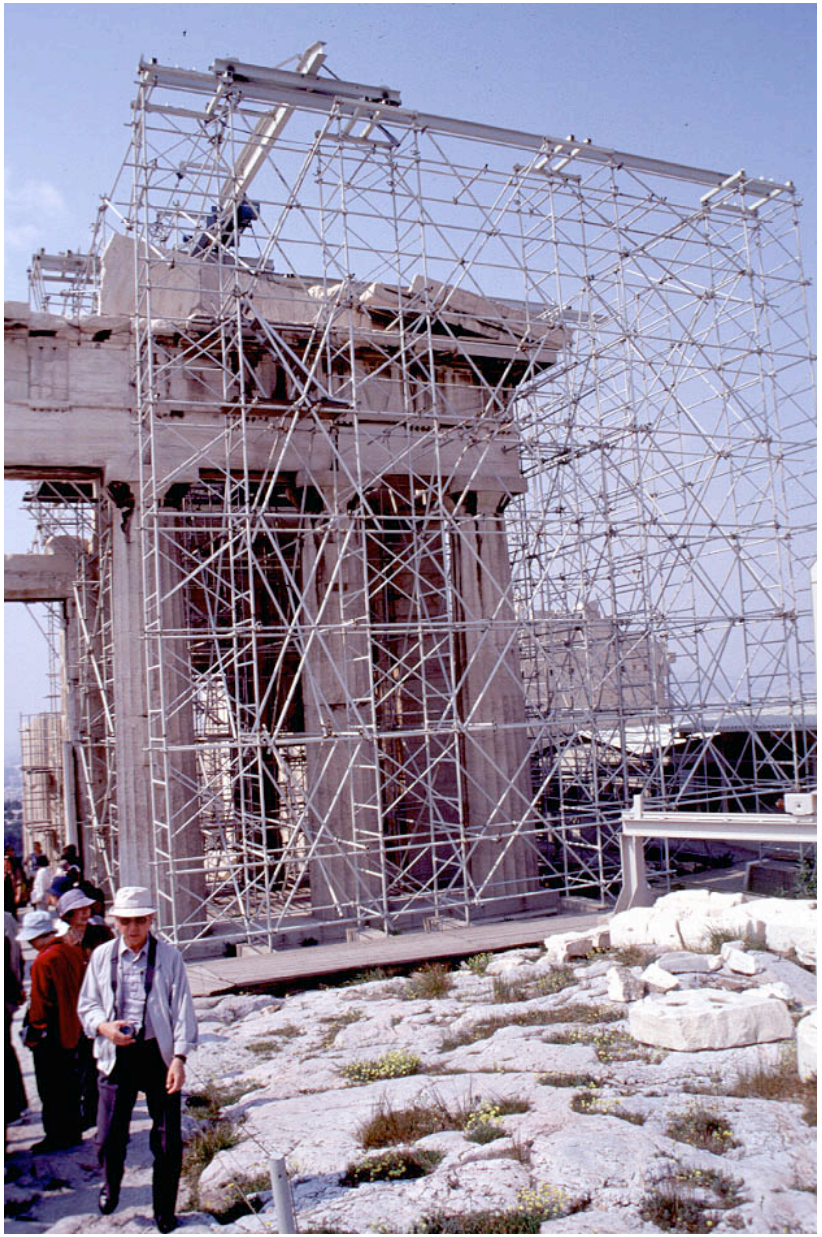
Carmien, S., & Fischer, G. (2005) "Tools for Living and Tools for Learning"

Scaffolding

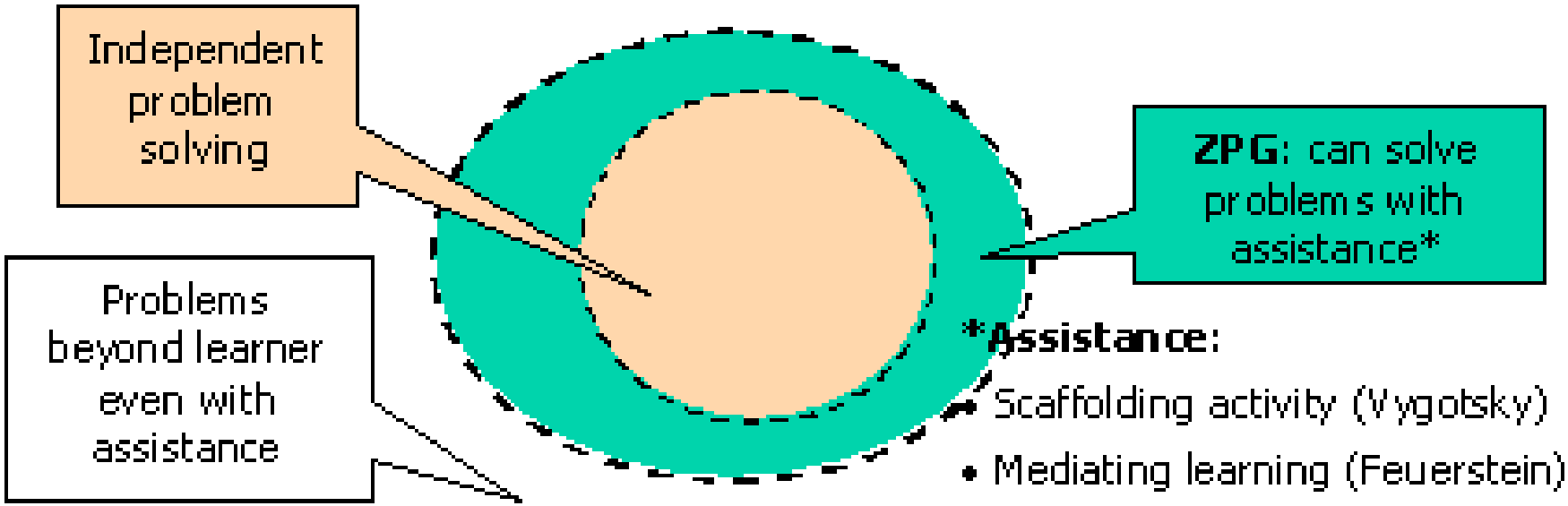
- **scaffolding**
  - the provision for assisted performance
  - "a 'scaffolding' process that enables children or novices to solve a problem, carry out a task or achieve a goal which would be beyond their unassisted efforts"

- **dimensions**
  - extending reach
  - simplifying a task
  - **temporary → "fading"**

- **theoretical origins: zone proximal development (ZPD) (Vygotsky)**
  - ZPD = the distance between the actual development of a child as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers
  - learners ultimately internalize (appropriate) the knowledge transacted through assisted performance so that it becomes their own
  - a teacher's task is to place learning in the ZPD



Scaffolding



Common Elements of Scaffolding

- task definition
- direct or indirect instruction
- specification and sequencing of activities
- provision of materials, equipment and facilities
- scaffolding may include assistance with planning, organizing, doing and/or reflecting on the specific task → such assistance is best made available in a timely manner matched to the learning needs and interests of the learner

The Value of Scaffolding

- makes it easier for the learner to undertake a task successfully
- expands the possible learning activities and experiences
- increases the rate at which learning may be achieved
- assistance of scaffolding was provided
  - traditionally by a teacher directly to a learner in real time
  - scaffolding can also be provided indirectly with media
  - **claim:** technology has the potential to contribute to the provision of scaffolding

Distributed Intelligence (or Distributed Cognition)

- ***claim:*** many scientific approaches have seen *human cognition* as existing solely "inside" a person's head, and studies on cognition have often disregarded the physical and social surroundings in which cognition takes place

- **distribution:**
  - distributed among **people** → collaborative learning and working (social dimension)
  - distributed between **humans minds and artifacts** → intelligence augmentation (technological dimension)
  - these two dimensions can and should be **integrated** (technological support for collaboration)

- **working hypothesis:** distributed intelligence provides an effective theoretical framework for understanding what humans can achieve and how artifacts, tools, and socio-technical environments can be designed and evaluated to empower humans beings and to change tasks

Distributed Intelligence

—

Creating ‘Eye-Glasses’ for the Mind

- **“anatomy is not 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!” — Neil Postman

Distributed Intelligence

- **claim:** in real life (in contrast to the classroom and the psychological laboratory) mental work is rarely done **without the assistance of tools**

- **challenge: develop, apply, and evolve a distributed cognition framework**
  - learning, education, and instruction
  - social creativity
  - collaborative human-computer systems

- **claim:** working with people with **cognitive disabilities**
  - creates new unique challenges for theories about distributed intelligence
  - provides a deeper understanding of distributed intelligence

Tools for Living ("Distributed Intelligence")

- **definition**: do task **with** tools

- **examples**:
  - **eye-glasses**: to compensate for poor eyesight (⇒ question: is the correction of eyesight with "lasik surgery" conceptually different?)
  - **pencil and paper** (literacy): to overcome the limitations of short-term memory

- **opportunity**: while some people might have no problems to learn to perform the tasks without the tools (e.g., spelling), they use tools for doing these "low level" tasks and can therefore focus on the more interesting tasks

- **independence**:
  - people will be **dependent** on the tool
  - analyze how **dependence** in one dimension can increase **independence** in another dimension?

Tools for Learning ("Scaffolding with Fading")

- **definitions**:
  - ***scaffolding:*** situations in which learners get assistance or support to perform a task beyond their reach if pursued independently when "unassisted"
  - ***fading:*** people learn to perform the tasks over time without tools (an objective of many things students learn in school)

- **examples:** training wheels, wizards, external scripts, templates, prompting systems,

- **independence**: people will become independent of these tools

- **external resources**
  - profoundly affect our conception of what, how, and why one needs to know and learn
  - put greater emphasis on access to tools to-think-with than a solo understanding without tools

A Tool for Learning —Training Wheels

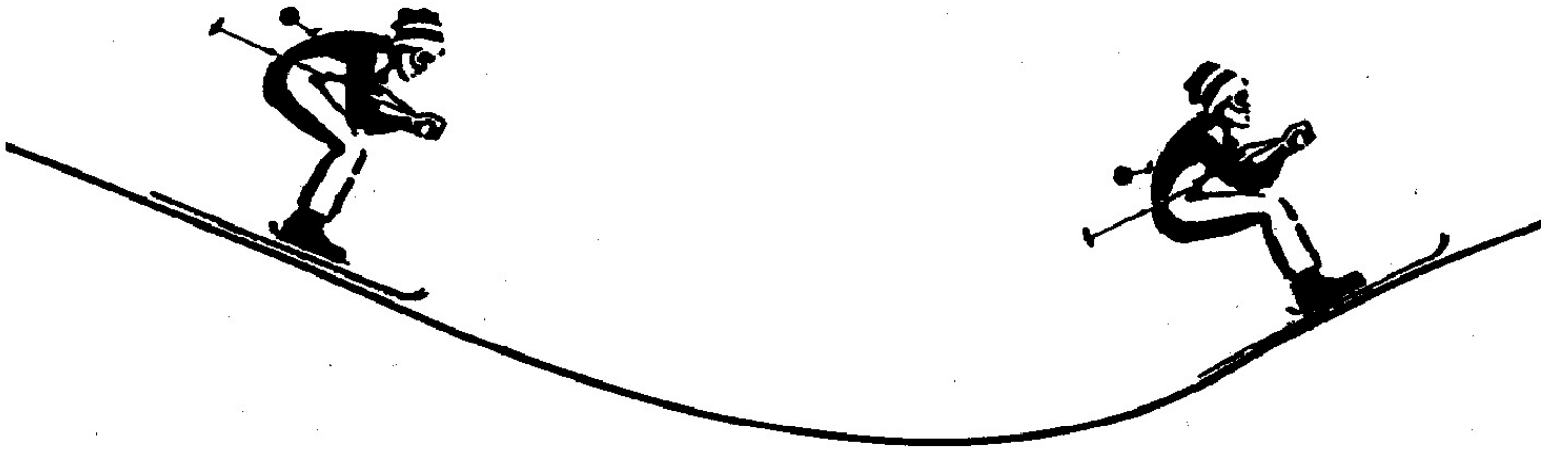
A Tool for Living — Adult Tricycle

Scaffolding (Temporary) and Technology Support (Permanent) in Skiing

source: Burton, R. R., Brown, J. S., & Fischer, G. (1984) "Analysis of Skiing as a Success Model of Instruction: Manipulating the Learning Environment to Enhance Skill Acquisition." In B. Rogoff, & J. Lave (Eds.), *Everyday Cognition: Its Development in Social Context,* Harvard University Press, Cambridge, MA - London, pp. 139-150.

- decoupling gliding and stopping
- graduated length method
- ski lifts → allow people to spend "time on the essential task"
- safety binding

How physical environments can simplify the skill of skiing



GLIDING
(INCREASING SPEED)

GLIDING
(DECREASING SPEED)

No subskill for stopping
is required.

Increasingly Complex Microworlds Paradigm

- **microworlds can provide:**
  - the right entry points into an environment, making it easier to get started on a subskill
  - an environment in which the student feels safe, allowing him to focus his attention on learning skills
  - intermediate goals or challenges that are, and seem to be, attainable
  - practice of the important subskills in isolation, allowing the common "bugs" to occur one at a time instead of in bunches

- **danger of oversimplification**
  - packed slopes → perfecting performance in one environment, such as packed slopes, may reduce the willingness of a skier to practice in another environment, such as powder, because the difference between his performance in the two environments may be too great
  - knowledge about avalanches → one of a coach's jobs is gradually to reduce the level of protectiveness, leading people to the right new challenges

Basic Skills in the 21st Century?

- 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

Overview of Distribution (Distances and Diversity)

Dimension	Rationale	Addressed by	Media / Technologies	Challenges
spatial	participants are unable to meet face-to-face; low local density of people sharing interests	computer-mediated communication	e-mail, chat rooms, video conferences, local knowledge in global societies	achieve common ground; involve large communities *("the talent pool of the whole world")*;
temporal	design and use time: who is the beneficiary and who has to do the work?	long-term, indirect communication; meta-design	group memories, organizational memories	build on the work of the giants before us; design rationale, reflexive CSCW

Overview of Distribution — Continued

Dimension	Rationale	Addressed by	Media / Technologies	Challenges
conceptual within domains	shared understanding	communities of practice (CoPs),	domain-oriented design environments (DODEs)	innovation; avoid group-think
conceptual between domains	make all voices heard	communities of interest (CoIs); boundary objects	Envisionment and Discovery Collaboratory	common ground; different ontologies; integration of diversity
technological	things are available; complement human abilities	distributed cognition, socio-technical environments; meta-design	agents, critics, simulations	formalization; human-problem-domain interaction; digital fluency

Education in a World of Omnipotent and Omniscient Technology

- **question:** in terms of efficiency, economics, reliability, and human gratification and enjoyment → what tasks (or part of tasks) are really better reserved for
  - an educated human mind, and
  - which should be taken over by or aided by what kind of cognitive artifacts?

- **important assessment question: over-reliance on tools for living**
  - under which conditions lead tools for living to *learned helplessness* and *deskilling*, ruining the users native abilities by making them dependent on the tool?

Claims / Assertions by Roy Pea

- delineating the boundaries between
  - *scaffolding with fading ("tools for learning")*
  - *distributed intelligence without fading ("tools for living")*

  *is a central problem for the learning sciences and for education and the arguments structures and warrants used in marking these boundaries will be informative (*p 431)

- many new forms of human activity that involve computing would be simply unachievable without the computing supports enabling the acts of distributed intelligence
  - fading is simply out of the question. People cannot do the activities without the technologies, or it becomes meaningless to ask whether they can do so
  - If the support does not fade, then one should consider the activity to be distributed intelligence, not scaffolded achievement

Claims / Assertions by Roy Pea — Continued

- considered scaffolding activity to be assisting performance generally (p 439):
  - walking up stairs, sitting in chairs, flying in planes, scuba-diving, skiing with lifts,
  - each of which is assisted performance that would not be possible if unaided

- the computer- supported activities of adult scientists using advanced scientific visualizations for reasoning about qualitative and quantitative relations about physical variables as in global warming, or making inferences about statistical relations in census data, or longitudinal data modeling → activities to be done without these tools?

Claims / Assertions by Roy Pea — Continued

- a world in the coming years with
  - pervasive computing
  - with always-on Internet access,
  - reliable quality of service networks, and
  - sufficient levels of technological fluency,

- the context assumptions that help shape **cultural values for distributed intelligence versus scaffolding with fading are changing**

Hand-Held Calculators: What Should the Boulder Valley School District Do?

- **position 1:** ignore the existence of the gadget; we are not interested in technology, but in important mathematical skills; **recommendation:** 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; **recommendation:** ***after*** they have it all mastered, allow the use of hand-held calculators.

- **position 3:** invent/ create new calculators, new curricula, new scaffolding mechanisms that make learning these skills more fun and create a deeper understanding of underlying concepts — **recommendation:** using these hand-held calculators, the learners would acquire the skills and the knowledge and eventually become ***independent*** of the gadget ("scaffolding with fading")

- **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 **recommendation:** establish new divisions of labor, rely on distributed intelligence

Results

Name	Position 1	Position 2	Position 3	Position 4	No Recomm
Huang, Yingdan			xxx		
Mangalath, Praful			xxx		
Shao, Michael		xxx			
Brown, Tyler					xxx
Davis, Corey		xxx			
Hoffner, Andy					xxx
Held, Jason					xxx
Lavallee, Jarret					
Musson, David		xx (today)	xx (tomorrow)		
Sax, Brian Robert		xxx			
Speir, Jessica			xxx		
Zeles, Joseph			xxx		
John Bacus					
Brian Brown					

Gerhard's Reflections

- **Asimov, I. (1959). Nine Tomorrows: Fawcett Crest.**

THE FEELING OF POWER by Isaac Asimov *Worlds of Science Fiction*, February 1958 Copyright 1957 by Quinn Publishing Co., Inc.

Inspiration moves in strange paths. As we look farther and farther into the future, it becomes possible to ask stranger and stranger questions. If society grows more and more computerized, what happens if human beings forget how to do simple arithmetic? Questions of this sort are NOW being asked, but the following story was written in 1957, well before anyone (except perhaps a few science-fiction writers) was thinking of such things. It might be the job of scientists, someday, not to discover, but to re-discover.

Limits of Analogical Reasoning
+
Syntactic Understanding of Math

$$\lim_{x \to 0} \frac{8}{x} = \infty \quad \longrightarrow \quad \lim_{x \to 0} \frac{5}{x} = \infty$$

Panic-Driven Educational Reform in the USA

- **panic #1: USSR first in space → emphasis of STEM (Science, Technology, Education, Mathematics) disciplines**
  - this is an area where many other countries (including Singapore) do extremely well

- **panic #2: US lagging in test scores → high-stake testing**
  - this is an area where many other countries (including Singapore) do extremely well

- **panic #3: outsourcing of knowledge work → education for creativity, imagination, and innovation**
  - question: which country does well in this area?
  - focus on 21st century skills (e.g.: soft skills are becoming more important)