



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**

Overview of Design

**Gerhard Fischer and Hal Eden
Spring Semester 2004**

January 12, 2005

Interrelationships

- **design**

- designing to learn
- designing to collaborate
- designing for designers → meta-design

- **learning**

- learning to design
- learning to collaborate
- learning to learn

- **collaborate**

- collaborating to design
- collaborating to learn

The Sciences of the Artificial

Understanding the Natural and the Artificial World

- **natural science: “how things are”**
 - knowledge about natural objects and phenomena
 - primary interest: analysis
 - examples: physics, chemistry

- **sciences of the artificial: “how things might be (and ought to be in order to attain goals and to function)”**
 - knowledge about artificial objects and phenomena
 - primary interest: synthesis
 - artificial things are as they are only because of a system's being molded, by goals and purposes, to the environment in which it lives
 - examples: engineering, medicine, business, architecture, painting, universities, cognitive artifacts, notations,

Definition of “Artificial”

- **Definition of "artificial":** human-made as opposed to natural
- **questions:** where does mathematics / computer science / biology belong too?
- **claims by Herbert Simon:**
 - the world in which we live in today is much more a human-made, or artificial, world than it is a natural world
 - a plowed field is no more part of nature than an asphalted street — and no less
- **Alan Kay (Scientific America, Sept 84, p 57)**
“molecular biology has the advantage of studying a system already put together and working; for the composer of software the computer is like a bottle of atoms waiting to be shaped by an architecture he must invent and then impress from the outside”

Science of Design

- **Definition:**

Everyone designs who devise courses of action aimed at changing existing situations into preferred ones. The intellectual activity that produces material artifacts is no different fundamentally from the one that prescribes remedies for a sick patient or the one that devises a new sales plan for a company or a social welfare policy for a state (Simon, “Sciences of the Artificial”, p 130)

- **generic design — does it exist?**

- design as an activity has a distinct conceptual and cognitive realization from non-design activities
- it can be abstracted away from the particulars of the knowledge base of a specific task or discipline and studied in its own right

- **a new major research program** of the Computer Science Directorate of the National Science Foundation (NSF): **A Science of Design**

Design Deals with Wicked or Ill-Defined Problems

- there is no **definitive formulation** of a wicked problem. For any given tame problem, an exhaustive formulation can be stated containing all the information the problem-solver needs for understanding and solving the problem.
- Ill-defined problems have **no stopping rule**. In tame problems, problem solvers know when they have done the job. Problem solvers terminate work on a wicked problem, not for reasons inherent in the 'logic' of the problem.
- solutions to wicked problems are not “true-or-false”, but “**good-or-bad**”
- every wicked problem is essentially **unique**
- the aim of design is not to find the truth, but **to improve some characteristics of the world where people live**

Integration of Problem Framing and Problem Solving: An Example from McGuckin Hardware Store

Customer: I want to get a couple of heaters for a downstairs hallway.

Sales Agent: What are you doing? What are you trying to heat?

Customer: I'm trying to heat a downstairs hallway.

Sales Agent: How high are the ceilings?

Customer: Normal, about eight feet.

Sales Agent: Okay, how about these here?

(They proceed to agree on two heaters.)

Customer: Well, the reason it gets so cold is that there's a staircase at the end of the hallway.

Sales Agent: Where do the stairs lead?

Customer: They go up to a landing with a cathedral ceiling.

Sales Agent: OK, maybe you can just put a door across the stairs, or put a ceiling fan up to blow the hot air back down.

Complexity of Designs

*from Dawkins, R. (1987) The Blind Watchmaker,
W.W. Norton and Company, New York - London.*

- **biology** is the study of complicated things that give the appearance of having been designed for a purpose
- **physics** is the study of simple things that do not tempt us to invoke design
- treat **complex human-made artifacts** (e.g., computers, airliners, cars, books) as biological objects
- the behavior of physical, non-biological objects is so **simple** that it is feasible to use existing mathematical language to describe it
- a complex thing is something whose constituent parts are arranged in a way that it is unlikely **to have arisen by chance** alone

The Shape of the Design: Hierarchy

—

The Problem of Modularity

- **claim:** to design a complex structure, one powerful technique is to discover viable ways of decomposing it into semi-independent components corresponding to its many functional parts. The design of each component can then be carried out with some degree of independence of the design of others, since each will affect the others largely through its function and independently of the details of the mechanisms that accomplish the function.

- **examples:**
 - functional programming
 - object-oriented programming
 - rule-based systems
 - nearly decomposable systems

Different Design Approaches

- **professionally-dominated design**
 - works best for people with the same interests and background knowledge

- **user-centered design:**
 - analyze the needs of the users
 - understand the conceptual worlds of the users

- **participatory design**
 - involve users more deeply in the process as co-designers by empowering them to propose and generate design alternatives
 - focus on system development at design time by bringing developers and users together to envision the contexts of use

- **meta-design:**
 - create design opportunities at use time
 - requires co-creation

Some References for Design

- Simon, H. A. (1996) *The Sciences of the Artificial*, 3rd edition, The MIT Press, Cambridge, MA.
- Norman, D. A. (1993) *Things That Make Us Smart*, Addison-Wesley Publishing Company, Reading, MA.
- Schön, D. A. (1983) *The Reflective Practitioner: How Professionals Think in Action*, Basic Books, New York.
- Winograd, T. (Ed.) (1996) *Bringing Design to Software*, ACM Press and Addison-Wesley, New York.
- Alexander, C., Ishikawa, S., Silverstein, M., Jacobson, M., Fiksdahl-King, I., & Angel, S. (1977) *A Pattern Language: Towns, Buildings, Construction*, Oxford University Press, New York.
- Gamma, E., Johnson, R., Helm, R., & Vlissides, J. (1994) *Design Patterns - Elements of Reusable Object-Oriented Systems*, Addison-Wesley,
- Dawkins, R. (1987) *The Blind Watchmaker*, W.W. Norton and Company, New York - London.
- Rittel, H. (1984) "Second-Generation Design Methods," In N. Cross (eds.), *Developments in Design Methodology*, John Wiley & Sons, New York, pp. 317-327.
- Ehn, P. (1988) *Work-Oriented Design of Computer Artifacts*, Almquist & Wiksell International, Stockholm, Sweden
- Fischer, G. (1994) "Domain-Oriented Design Environments," *Automated Software Engineering*, 1(2), pp. 177-203.