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

The Seeding, Evolutionary Growth, Reseeding (SER) Model

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Observations

- we live in a world characterized by **evolution** – that is, by ongoing processes of development, formation, and growth in both natural and human-created systems

- **biology** tells us that complex, natural systems are not created all at once but must instead evolve over time

- we are becoming increasingly aware that evolutionary processes are **ubiquitous and critical for social and technological innovations** as well

- this is particularly true for **complex human centered computational environments** because they do not exist in a technological context alone but are embedded within human organizations
Theory and Practice of Design—A Quest for Evolution

- **Dawkins** — “The Blind Watchmaker”: big-step reductionism cannot work as an explanation of mechanism; we can't explain a complex thing as originating in a single step.

- **Simon** — “The Sciences of the Artificial”: complex systems evolve faster if they can build on stable subsystems.

- **Petroski** — “To Engineer Is Human”: the role of failure in successful design.

- **Brooks** — “No Silver Bullet”: successful software gets changed, because it offers the possibility to evolve.

- **Polanyi** — “The Tacit Dimension”: knowledge is tacit → we know more than we can say.
Karl Popper: Conjectures and Refutations

- “Our whole problem is to make the mistakes as fast as possible.” (foreword to the book by John Archibald Wheeler) — breakdowns as opportunities

- criticism of our conjectures is of decisive importance and all of our knowledge grows only through the correcting of our mistake — critiquing systems

- there are all kinds of sources of our knowledge but none has authority — symmetry of ignorance and mutual competency

- the advance of knowledge consists in the modification of earlier knowledge — evolution
Complex Systems

- design processes often take place over many years, with initial design followed by extended periods of **evolution and redesign**

- in **urban development**:  
  - naturally grown cities: London, Paris  
  - designed cities: Brasilia, Canberra, Abudja

- in **software design**: importance of  
  - design rationale  
  - redesign and reuse (**"complex systems evolve faster if they can build on stable subsystems"** (Simon))
Principles Coping with Complex Systems

- **software systems must evolve**
  - they cannot be completely designed prior to use
  - design is a process that intertwines problem solving and problem framing
  - software users and designers will not fully determine a system’s desired functionality until that system is put to use
  - systems must be open enough to allow “emergent behavior”

- **software systems must evolve at the hands of the users (→ meta-design)**
  - end users experience a system’s deficiencies; subsequently, they have to play an important role in driving its evolution
  - software systems need to contain mechanisms that allow end-user modification of system functionality

- **software systems must be designed for evolution —**
  - systems need to be designed *a priori* for evolution
  - systems must be **underdesigned** to support emergent new ideas
  - **software architectures** need to be developed for software that is designed to evolve
The **Seeding, Evolutionary Growth, Reseeding (SER) Model**

- **at design time:**
  - development of an initial system that can change over time (seed)
  - underdesign: creating design options for users

- **at use time:**
  - users will experience breakdowns at use time
  - end-user modifications allow users to address limitations they experience
  - evolutionary growth through incremental modifications

- **reseeding:**
  - significant reconceptualization of the system
  - lack at all incremental modifications, mitigate conflicts between changes, and establish an enhanced system
A Simplified Illustration of the SER Model

- **SER model** accounts for and facilitates the understanding of:
  - differentiation between design time and use time
  - relation to learning and contributing
  - the way that these concepts/objectives depend on each other
Extended Illustration of the SER Model
Evolution at the Different Levels of the SER Model

- **Evolution of Individual Artifacts (“Artifact”)**
  - ontogenetic development of an individual artifact
  - the computer networks within CU Boulder and the Computer Science Department specifically

- **Evolution of the Domain (“DODE”)**
  - phylogenic development of a generic species
  - Computer network design $\rightarrow$ new network devices, new design guidelines, new simulation support, and new design rationale

- **Evolution at the Conceptual Framework Level (“multifaceted architecture”)**
  - domain-oriented construction kits
  - support for evaluating the quality of an artifact $\rightarrow$ development of critics
  - “reflection-in-action” by making argumentation serve design $\rightarrow$ argumentation component and a specification component
Example: SER Model and Courses as Seeds

Courses As Finished Products

- **instructionist approach**: learners listen and answer problems given to them by the instructor.

- The learners are **recipients** of knowledge → the assumption is that the teacher/instructional designer has all the relevant knowledge.

- This model is
  - **adequate**: for courses where the learners get into a new field and therefore might have little to contribute
  - **not adequate**: it does not account for mutual competency and symmetry of ignorance

- **Quality** is solely determined by the knowledge of the teachers and their ability to present the knowledge effectively.
Courses as Seeds

- **community of learners approach**: learners are knowledgeable people in their own domain of expertise and they are not just passive recipients of knowledge, but act (at least from time to time) active contributors

- **value adde:**
  - at the end of the course, the content of the course will be greatly enriched through a semester-long interaction of knowledgeable people and important and relevant information will be incorporated into the course before it is taught the next time
  - a model for learning in a knowledge society which is built upon distributed cognition, peer-to-peer learning, articulated learners, long-tail knowledge distribution
  - a necessity for many domains/aspects of lifelong learning where communities of learners engage in the incremental construction and evolution of knowledge facilitated by a teacher
Example: SER as a Foundation for Next Generation Wikis

http://l3dswiki.cs.colorado.edu:3232/CreativeIT/
Example: Google’s 3D Warehouse

http://sketchup.google.com/3dwarehouse/modelcycle?scoring=d
SER Model: Relationships and Emerging Themes

- **Relationships:**
  - domain-oriented design environments
  - meta-design
  - participatory design
  - design/use time
  - tipping point

- **Emerging Themes**
  - continuing design in use
  - end-user programming and development
  - open source software
  - web 2.0 technologies
Seeding

- explore **middle ground** between empty frameworks/architectures and complete systems

- seeding by **anticipation**
  - in domains with well-established practices seeding requires anticipating users’ most specific needs → **professionally-oriented design**

- seeding by **participation**
  - in domains with loosely defined practices seeding requires the participation of user representatives → participatory design

- seeding by **emergence**
  - in domains characterized by a high degree of freedom and unpredictability seeding requires users’ spontaneous and direct engagement → **meta-design**
Evolutionary Growth

- what will **motivate** people to contribute? → utility = value / effort

- **addition:**
  - data and/or functionalities are added to the system
  - new infrastructures are implemented and/or created
  - new users join the community of participants

- **composition:**
  - data, functionalities, and infrastructures are created by recombining, exchanging, and reusing existing ones
  - users aggregate and re-aggregate on the basis of their interests and social relationships

- **modification**
  - existing data, functionalities, and infrastructures are updated, changed, or even eliminated;
  - users acquire new knowledge, interests, and skills
Reseeding: Why?

- **People “cannot” participate**
  - technical infrastructures are no longer efficient
  - they cannot satisfy new requirements and/or policies
  - the seed is no longer usable

- **People “do not” participate**
  - social and technical infrastructures are no longer adequate to support users’ practices and engagement
  - the seed has decreased in value
  - the seed is no longer useful
Reseeding: How?

- **when people cannot participate:**
  - **Generalization:** additions, compositions, and modifications are generalized and integrated to “recompose” an artifact that has evolved into incompatible versions at the hands of different users.
  
  - **Re-factoring:** redundancies are thrown away to bring order into an artifact that has become too “messy”

- **when people do not participate:**
  - **Facilitation:** data, functionalities, or motivational strategies are implemented ad hoc as an opportunity to stimulate participation.
  
  - **Tuning:** infrastructures for communication and interaction are adjusted in order to comply, for example, with new policies enforced by institutional authorities.
Design Challenges Associated with the SER Model

<<source: Fogli, D. & Giaccardi, E.(2005): “Make It Flourish! Revising the Idea of Seed in Metadesign”>>

- **build for engagement**
  - enable technical and social infrastructures to evolve
  - encourage an active relationship between people and artifacts

- **enable modifiability**
  - content & functionalities
  - social interaction paths

- **sustain reflexivity**
  - critiquing mechanisms
  - annotation mechanisms

- **encourage social practice**
  - social interaction
  - community strategies
  - institutional policies
Design Challenges Associated with the SER Model

- give users authority to create value
  - ease of use
  - shareability

- perform evaluative thinking
  - continuous and iterative process

- allow reseeding
  - complementary process
  - generalization and re-factoring
  - facilitation and tuning

- think multidimensionally
  - balance anticipatory, participatory and emergence approaches
Example: the American Constitution


- **society as the client** — “the members of an organization or a society for whom plans are made are not passive instruments, but are themselves designers who are seeking to use the systems to further their own goals”

- **how do we want to leave the world for the next generation? → desiderata:**
  - a world offering as many alternatives as possible to future decision makers, avoiding irreversible commitments they cannot undo
  - to leave the next generation of decision makers with a better body of knowledge and a greater capacity for experience
  - essential task: to keep open the options for the future or perhaps even to broaden a bit by creating new variety and new niches
The United States Constitution

<table>
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<th>seed</th>
<th>evolutionary growth</th>
<th>reseeding</th>
</tr>
</thead>
<tbody>
<tr>
<td>1787</td>
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<td>amendments to the U.S. constitution are appended to the existing body</td>
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<td></td>
<td>10 amendments</td>
<td>of the text without altering or removing what already exists</td>
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<td>amendments</td>
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<tr>
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<td>amendments</td>
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- **amendment process (part of the seed)** — the authors of the Constitution
  - were clearly aware changes would be necessary from time to time if the Constitution was to endure and cope with the effects of the anticipated growth of the nation
  - were conscious that such change should not be easy, lest it permit ill-conceived and hastily passed amendment
Evolution in Biology versus Evolution in the Human-Made World — a Word of Caution

- The evolutionary metaphor must be approached with caution because
  - There are *vast differences* between the *world of the made* and the *world of the born*
  - One is the result of *purposeful human activity*, the other the outcome of a *random natural process*

- Does software develop according to the “punctuated equilibrium” theory?
  - If yes, what causes the periods of increased change (subroutines, object-oriented programming, the World Wide Web (WWW), Web 2.0)?
The Theory of the "Punctuated Equilibrium"

- Stephen Jay Gould’s (Biologist) theory of the "punctuated equilibrium"
  - the fossil record long periods of stasis followed by rapid bursts of evolution → this view has replaced the earlier prevailing view of continuous evolutionary change
  - the bursts of evolutionary change in the punctuated equilibrium view are brought about by changes in the environment: a meteor crashes to earth, two continents collide, someone invents penicillin, etc
  - after such dramatic events there are rapid changes in biological organisms until a new equilibrium is reached.

- claim: the evolution of social-technical systems follows a similar pattern
Punctuated Equilibrium