An invited presentation to SIG Design and Technology

Education for Design
Design for Education

Charles L. Owen
Institute of Design
Illinois Institute of Technology

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The Fundamental Problem
Population Growth

More people = greater need for resources

The big four
• Energy
• Water
• Food - fisheries
• Food - agriculture

Cost of matching western lifestyles:
• 3 Earths!
  (World Wildlife Fund)

Derivative Problem
Global Warming 1989

Climate change exacerbates problem

$\text{CO}_2$ concentration increases
- 278 ppm <1900
- 353 ppm 1989

Geographic changes predicted:
- Droughts
- Intense precipitation
- Violent, frequent storms
- Rising seas
- Moving climate zones

Net: 3 GtC added per year

Source: Scientific American, April 1989
Climate change accelerates

**CO₂ concentration increases**
- 278 ppm <1900
- 353 ppm 1989
- 383 ppm 2007

**Annual mean growth rate (18 yr)**
- 1.87 ppm
  std dev. = .67

**Extrapolation:**
- 600 ppm 2100

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**Sources:** UNESCO - Scope, The Global Carbon Cycle, Policy Briefs No. 2, October 2006.
Possible Solutions?  
Advanced technology

Technologies that offer hope

**Nanotechnology**
- *Nanotube membranes that can remove salt from water cheaply*

**Robotics**
- *Robot-constructed solar power satellites*

**Biotechnology**
- *Crops that can survive in harsh climates*

**Sources:**  
*Nanotechnology*: Lawrence Livermore Lab, May 2006.  
Preparation
How will we address the problems?

Not just a few will be called

Leaders
- Will leaders plan and act wisely?

Citizens
- Will society accept and adapt to change?

Educators
- Are we providing the tools needed to understand and plan well?

Understand Plan Decide Act
Kinds of Thinking
The Creative Basis

The two-domain thinking model

Understanding and planning increase in value with:

**Discovery**
- Oriented toward **Analysis**

**Invention**
- Oriented toward **Synthesis**
Qualitative Difference
Map of Fields

Process & Content differentiate fields

Process
- Analytic
  VS
Synthetic

Content
- Symbolic
  VS
Real

<table>
<thead>
<tr>
<th>Analytic</th>
<th>Synthetic</th>
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Qualitative Difference
Map of Fields

Fields on the map reveal differences by their position

**Process**
- *Analytic* vs *Synthetic*

**Content**
- *Symbolic* vs *Real*

![Diagram of Qualitative Difference Map of Fields]

- Law
- Art
- Science
- Medicine
- Design

- Analytic Symbolic
- Synthetic Symbolic
- Analytic Real
- Synthetic Real
- Real
- Symbolic
Qualitative Difference
Map of Fields

Science on the Map

Process
- heavily Analytic

Content
- more Symbolic than Real

![Diagram showing the relationship between Analytic, Symbolic, Synthetic, and Real dimensions in science.](image-url)
Qualitative Difference
Map of Fields

Process
- **Analytic**, but less so than Science

Content
- **Extensively Symbolic**

Law on the Map

Law

• Analytic, but less so than Science

Symbolic

Analytic

Real

Synthetic

Real

Analytic

Synthetic

Logical

Law
Qualitative Difference
Map of Fields

Art on the Map

Process
- Almost evenly divided

Content
- Strongly Symbolic

Symbolic

Analytic

Real

Art

Synthetic

Analytic

Real

Synthetic

Analytic

Symbolic

Synthetic

Symbolic

Art

Real

Analytic

Synthetic

Symbolic

Analytic

Real

Synthetic

Symbolic

Analytic

Real

Synthetic

Symbolic
Qualitative Difference
Map of Fields

Medicine on the Map

Process
• *Strongly Analytic*

Content
• *Sharply Real* concerned with real problems of health
Design on the Map

Process
- Highly **Synthetic**

Content
- Strongly concerned with the **Real** world

Diagram:
- Symbolic
- Synthetic
- Analytic
- Real
- Design
Hierarchies within Fields

Decomposition
• Separates disciplines by sharpening specialization

Composition
• Merges disciplines by leveling generalization
Qualitative Difference

Complementary Fields

Science/Design: high-value complements

Science
- Analytic/Symbolic

Design
- Synthetic/Real

- Together: critical finding and making resources
Knowledge is generated and accumulated through action.

Doing something:
- Using knowledge to create works

Judging results:
- Evaluating works to build knowledge
Foundations
Knowledge Building and Using

Building/Using:

dual Realms
dual Paradigms

Realm of Theory:
• Inquiry paradigm

Realm of Practice:
• Application paradigm

Diagram:

- Analytic
- Synthetic

- Knowledge building measures
- Inquiry paradigm
- Principles
- Knowledge using

- Work
- Invention Making

Finding Discovery
Foundations
The Value-based Structure of Fields

Foundations dictate structure and process

Need/Goal
- Generates a field

Values
- Identify the qualities important to fulfilling the need

Measures
- Guide the creation of instruments to manage knowledge using and building
Foundations
Value Chains for Five Fields

<table>
<thead>
<tr>
<th>Field</th>
<th>Need/Goal</th>
<th>Values</th>
<th>Measures</th>
<th>Procedures</th>
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<tbody>
<tr>
<td>Science</td>
<td>Understanding</td>
<td>Correctness, Thoroughness, Testability</td>
<td>True/False, Correct/Incorrect, Complete/Incomplete, Provable/Unprovable</td>
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<tr>
<td>Art</td>
<td>Expression</td>
<td>Insightfulness, Novelty, Stimulation</td>
<td>Thought-provoking/Banal, Fresh/Stale, Exciting/Boring</td>
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<tr>
<td>Law</td>
<td>Justice</td>
<td>Fairness, Thoroughness, Appropriateness</td>
<td>Just/Unjust, Right/Wrong, Appropriate/Inappropriate</td>
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<tr>
<td>Medicine</td>
<td>Health</td>
<td>Correctness, Effectiveness</td>
<td>Fair/Unfair, Works/Doesn’t Work, Fits/Doesn’t Fit</td>
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</tr>
<tr>
<td>Design</td>
<td>Form</td>
<td>Cultural Fit, Appropriateness, Effectiveness</td>
<td>Elegant/Inelegant, Better/Worse, Sustainable/Unsustainable</td>
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Realm of Theory
- Finding
- Discovery

Realm of Practice
- Invention
- Making

Knowledge
- Building
- Application

Analytic
- Inquiry paradigm
- Knowledge

Synthetic
- Application paradigm
- Knowledge

Proposal
- Principles

Correct/Incorrect
- Complete/Incomplete
- Provable/Unprovable

True/False
- Thought-provoking/Banal
Education for Design
The Recruiting Problem

Selection by Rejection

Counseling filter
- Reject what you’re not good at

Bad/no information
- Fine arts as path of least resistance
- Design as option with jobs
Education for Design

The Development Problem

The incestuous loop

Built-in resistance to change
- Student enters – running "away from"
- Faculty teach with similar biases
- Graduates move to industry
- School hires faculty from industry
- Faculty teach with unchanged bias
Education for Design
The Recruiting Solution

Selection by Election

Counseling filter
• *Elect what you’re good at*

Good information
• Design *as an inclusive option*
• Design *as option for those who want to do it all*
Education for Design
The Development Solution

Breaking the loop

Faculty augmentation
- Kindred spirit departments
- Specialists with general interests

Internal development
- PhD research and teaching programs in Design

Diagram:
- Student
- Advanced design programs
- School of Design
- Other university depts.
- Industry

Arrows indicate the flow of influence and hiring:
- Faculty hire
- Election screens
- Professional hire
- Faculty hire
- Influence from industry
Positioning for interaction

Responsibility accepted
• Design is its own field
• Design operates best in its own college

Communications reinforced
• Design needs and enhances other fields
Education for Design
Curricular Components

Foundation Core

Inventiveness
- *Making* as a creative act

Sensitivity
- *Seeing* and *Sensing* critically
- The *Feel* of good and bad

Skill
- Mental skills
- Motor skills
Education for Design
Curricular Components

Knowledge Ring

Fine & Liberal Arts
- The social and cultural world

Science & Technology
- The natural and physical world

Design Theory & Process
- The means to effect constructive change
Education for Design
Curricular Components

Performance Ring

Concerns
- Guidelines
- Principles

Attitudes
- Approaches
- Frameworks

Strategies
- Ways of thinking
- Ways of working
- Capabilities

Diagram:
- Ways of Design Thinking
- Knowledge Ring
- Foundation Core
Conditioned inventiveness

**Specialized creativity**
- Invention *rather than* Discovery

**Inventiveness within limits**
- Not *free-form* innovation
- Invention *for clients*
- Client-directed *rather than* designer-directed

How learned?
- Project finding
- Phased reviews
Education for / Design / for Education
Ways of Design Thinking

Human-centered focus

View of the User
- Interactions between user and system
- User-artifact vs artifact-artifact

Fundamental value
- Good = better for individuals and society

How learned?
- Activity analysis
- Prototype evaluation
Environmental concern

Whole system sensitivity
- Sustainable development
- Light-touch disturbance

Less is more
- Achieving more; using less

Fundamental value
- Good = harmless or good for the environment

How learned?
- Environmental impact analysis
- Environmental impact critique
Ability to visualize

Concepts as diagrams
- Manipulable elements
- Crystallized relationships
- Big picture overview

Form for ideas
- Conjectural images
- Mock-ups, models and prototypes

The elephant for the blind men

How learned?
- 2D skill development
- 3D skill development

Tempered optimism

Dampened peaks and valleys
- Successes taken in stride
- Failures accepted as incentive

Enthusiasm on demand
- Depression blocks creativity
- Optimism restores enthusiasm
- Tempered optimism supports professionalism

How learned?
- Project review
- Competition

Sources: Hydrospace, 1969; Massive Change, 2006. Institute of Design, IIT.
Bias for adaptivity

Adaptivity in production
• Adapted by the producer
• Custom fit to users’ needs

Adaptivity in use
• Adapted by the user
• Adjustable to evolving needs

How learned?
• Project charter
• Review and critique

Predisposition toward multifunctionality

**Multi- vs Mono- functionality**
- Multiple benefits from single projects

**Problem solving should bring rewards**
- The reward intended
- Economic rewards where value is added
- Social rewards where society is benefited

**How learned?**
- User analysis
- Economic/social impact review

*Source: Project Phoenix, 1989. Institute of Design, IIT.*
Systemic vision

Holistic thinking
- Broad range of problem inquiry
- Solutions as Systems rather than artifacts

Hierarchical system structure
- Multiple organized components
- Components as subsystems, entities, procedures, services, organizational constructs, policies ...

How learned?
- Project charter
- Multi-user analysis

View of the generalist

Generalist vs Specialist
• The more general the knowledge, the greater the diversity of ideas

Special roles of the generalist
• Communication across disciplines
• Coordination and leadership
• Methodological expertise

How learned?
• Broad education
• Structured planning

Ability to use language as a tool

**Mathematical language**
- Exploring "what if’s" by approximation

**Visual language**
- Abstracting the essence of concepts
- Revealing and explaining patterns

**Verbal language**
- Developing detail not apparent visually

How learned?
- Qualitative calculation
- Diagramming
- Descriptive writing

**Sources:** Aerotecture, 1993; National Park System, 1994. Institute of Design, IIT.
Affinity for teamwork

**Multidiscipline design teams**
- Concept development
- Members from relevant function groups

**Design contributions**
- Planning methodology
- Translation between special and general
- Communication across disciplines
- Work with qualitative information
- Visualization of concepts

**How learned?**
- Team projects
- Leader and member evaluations

*Source: Space Station, NASA, 1985. Institute of Design, IIT.*
Facility for avoiding the necessity of choice

**Choice as a last resort**

- *Choosing: A Losing* as well as winning proposition

**Avoiding the choice**

- "Have your cake and eat it too!"
- Search choices for essential characteristics
- Reformulate in a new configuration

**How learned?**

- Ends/means synthesis
- Project competitive reviews

Self-governing practicality

Governed flights of fantasy
- Flight to the limits of what can be conceived
- Tether to ways the conceivable can be realized

Style of self-governed thinking
- Foreground: free exploration
- Background: realistic appraisal of costs/functionality

How learned?
- Ends/means synthesis
- Conjectural/evaluative resolution

Institute of Design, IIT.
Ability to work systematically with qualitative information

**Information processing**
- Methodology for finding, distilling, organizing, using and communicating information

**Structured Planning**
- Toolkit for conducting projects
- Accessible to any discipline
- Tuned to the goals of design/planning

**How learned?**
- Project theory/exercise workshop
- System design project

Design for Education
Where and When to Begin Learning

Ways of Design Thinking

- Sensitivity
- Inventiveness
- Visual mental and motor skills
- Ability to visualize
- Affinity for teamwork
- Systemic vision
- Conditioned inventiveness
- Environment-centered concern
- Human-centered focus
Design for Education
Where and When to Begin Learning

### Ways of Design Thinking

- Ability to use language as a tool
- Design theory and process
- Bias for adaptivity
- Predisposition toward multifunctionality
- View of the generalist
- Tempered optimism
- Facility for avoiding the necessity of choice
- Self-governing practicality
- Ability to work systematically with qualitative information

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Design for Education
Thoughts for Next steps: Post-graduate Level

Policy Design Synthesis

Professional program
- Combined studies in Policy Planning and Design Thinking
- Designed to enhance policy-making capabilities for governmental staff

Eligible Students
- Graduates of graduate level programs in governmental studies
- Graduates of graduate level programs in design

Design thinking
- Ability to work systematically with qualitative information
- View of the generalist

Sources: Design Thinking, 2005.; Climate Change, 2007. Institute of Design, IIT.
Design for Education

Thoughts for Next Steps: Graduate/Undergraduate Level

Inter-professional Projects

**Interdisciplinary research/development projects**
- Projects applying academic knowledge to professional purposes
- Designed to apply project-oriented learning across the curriculum
- Faculty-generated and recruited

**Eligible Students**
- Graduate and undergraduate students throughout the university
- Students apply to course leaders

**Design thinking**
- Pre-disposition toward multifunctionality
- Facility for avoiding the necessity of choice

Design for Education
Thoughts for Next Steps: *Secondary School Level*

**Quantitative Reasoning**

**Mathematical Language As a Tool**
- *Projects using mathematics to estimate and verify projections*
- *Designed to support conceptual creativity with quantitative practicality*

**Eligible Students**
- *All secondary school students*

**Design thinking**
- *Ability to use language as a tool*
- *Self-governing practicality*

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**Sources:** Project Phoenix, 1989; KORE Computer, 1990. Institute of Design, IIT.
Integrated theme projects

Content supported by design
- Teams with goals to visualize
- Opportunities for invention through representation and presentation

Eligible Students
- Students in traditional subject courses: English, mathematics, science, social studies, etc.

Design thinking
- Ability to visualize
- Affinity for teamwork

Design for Education
Thoughts for Next Steps: Primary School Level

Learning to see and hear

Critical consideration of the sensory environment
• Sights and sounds placed in focus
• Digital photography as a framing tool
• Cell phone technology for sensory exploration

Eligible Students
• Students in traditional art classes

Design thinking
• Sensitivity
• Visual mental and motor skills

Sources: Institute of Design, IIT.
Action
We need to act. The problems will not wait.

Educators have responsibility

Leaders
• Leaders need more and better advice

Citizens
• Citizens need to see more critically, act more effectively

Educators
• Design needs better education
• Education needs better design
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Institute of Design
Illinois Institute of Technology
www.id.iit.edu

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