1.1. Transdisciplinarity
CEIE 894
Design and Inventive Engineering

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SOURCE

- Discussions with Professor Andy Sage
- His publications

TRANSDISCIPLINARITY

- The key concept in modern science
- The key to understanding engineering creativity
- A systems perspective

COMPLEX WORLD

- Families of systems
- Systems of systems
- Critical importance of integration
- Required integrative knowledge, or transdisciplinary knowledge

KNOWLEDGE EVOLUTION

- Rapidly growing body of knowledge
- Increasing specialization of knowledge leading to fragmentation
- Emerging "spheres of knowledge" with limited overlap
- Example from economics of natural resources:
  - Natural resources economics
  - Environmental economics
  - Ecological economics
  - Bionomics

KNOWLEDGE EVOLUTION

- TRIZ and Directed Evolution:
  - "Increased complexity then simplification" evolution pattern
- Example: quartz watches,
  - very simple digital watches
  - multifunctional complex analog-digital watches
  - simple analog single-function watches
- Division followed by integration
- Disciplinary knowledge followed by transdisciplinary knowledge

CONTRADICTIONS AND SOLUTIONS

- Contradictions:
  - Knowledge depth versus breath
  - Specialization versus generalization (and abstraction)
  - Disciplinary versus transdisciplinary knowledge
  - Knowledge "soup" versus transdisciplinary knowledge
- Solutions:
  - Integrate relevant knowledge from different disciplines
  - Develop a knowledge acquisition process producing transdisciplinary knowledge

FUSION VERSUS TRANSDISCIPLINARITY

- Fusion: mixing knowledge from various disciplines to create a "knowledge soup"
- Transdisciplinarity: integrating knowledge from various disciplines to create the unity of knowledge, or transdisciplinary knowledge

IT&E EXAMPLE

- IT&E School established in 1984 by Andrew Sage, a visionary and transdisciplinary scholar
- School's mission was to create transdisciplinary knowledge integrating IT and engineering
- First integrative Ph.D. Program in Information Technology open to both engineers and IT workers

IT&E EXAMPLE

- Faculty focused on preserving and protecting their specialties
- Strong paradigm of quantitative, disciplinary, thinking impossible to break
- Very few transdisciplinary researchers
- Very little integrative thinking
- Administrative push for growth in terms of new programs, degrees, etc.
- Fragmentation of the Ph.D. program into IT, CS, EE, CEIE, etc.
- "Increased complexity then simplification," but also "simplification followed by increased

TRANSDISCIPLINARITY

- It is a knowledge acquisition process from multiple disciplines, which through transformation, restructuring and integration produces transdiciplinary knowledge

- Acquiring knowledge from multiple perspectives to produce a new holistic perspective

TRANSDISCIPLINARY KNOWLEDGE

- Product of transdisciplinarity
- Represents a synthesis of knowledge from several disciplines
- Intellectual basis for:
  - Systems engineering
  - Design and inventive engineering

DESIGN AND INVENTIVE ENGINEERING

- A transdisciplinary knowledge
- Main contributing disciplines:
  - Engineering
  - Design Science
  - Cybernetics
  - Systems Engineering
  - Heuristics
  - Cognitive Psychology

DESIGN AND INVENTIVE ENGINEERING

- Transdisciplinary engineering science
- Example: Engineering Creativity is considered from three perspectives:
  - Society (Creative Class)
  - Community (the Medici Effect)
  - A man (the Renaissance Man)
- Objective: to create transdisciplinary understanding of engineering design and creativity

CONCLUSIONS

- Natural evolution of science
- Emerging paradigm
- New understanding of science and technology
- Source of creativity
- Incredible potential to accelerate progress in science and technology
- Key to understanding Design and Inventive Engineering