Engineering Systems Doctoral Seminar ESD.83-- Fall 2011

Class 4

Faculty: Chris Magee and Joe Sussman

TA: Rebecca Saari

Guest:Dr. Donna Rhodes, Senior Lecturer, ESD and co-founder of SEAri

Class 4-- Overview

- Welcome, Overview and Introductions (5-10 min.)
- Dialogue with Dr. Rhodes (55 min)--Redaction provided by Steve Fino
- Break (10 minutes)
- Discussion of ESD.83 faculty-provided theme-related papers led by Bill Young (approximately 40 min)--***looks like all AF, all the time!***
- Theme and topic integration: Report from the front; Words and Quotes:Representations, Models, Frameworks, Processes and Architecture (Sussman)
- Next Steps-preparation for Class 5-(Sussman)

Theme and topic integration: Class 4, October 5, 2011

- Report from the front "China Bullet Trains Trip on Technology" WSJ, October 3, 2011
- Words
- Quotes
- "Teaching and Learning Time"
- Class 5 Plan (Sussman)

Words/ Phrases

- Intuition, instinct, insight
- Hierarchy

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Quotes

- In a turbulent, competitive environment........... , the underlying source of superior performance is integration

  Clark and White 1991- Product Development Performance

- An important job of management is to recognize and manage the interdependence between components. Resolution of conflicts and removal of barriers to cooperation, are responsibilities of management.

  Deming 2000, The new economics

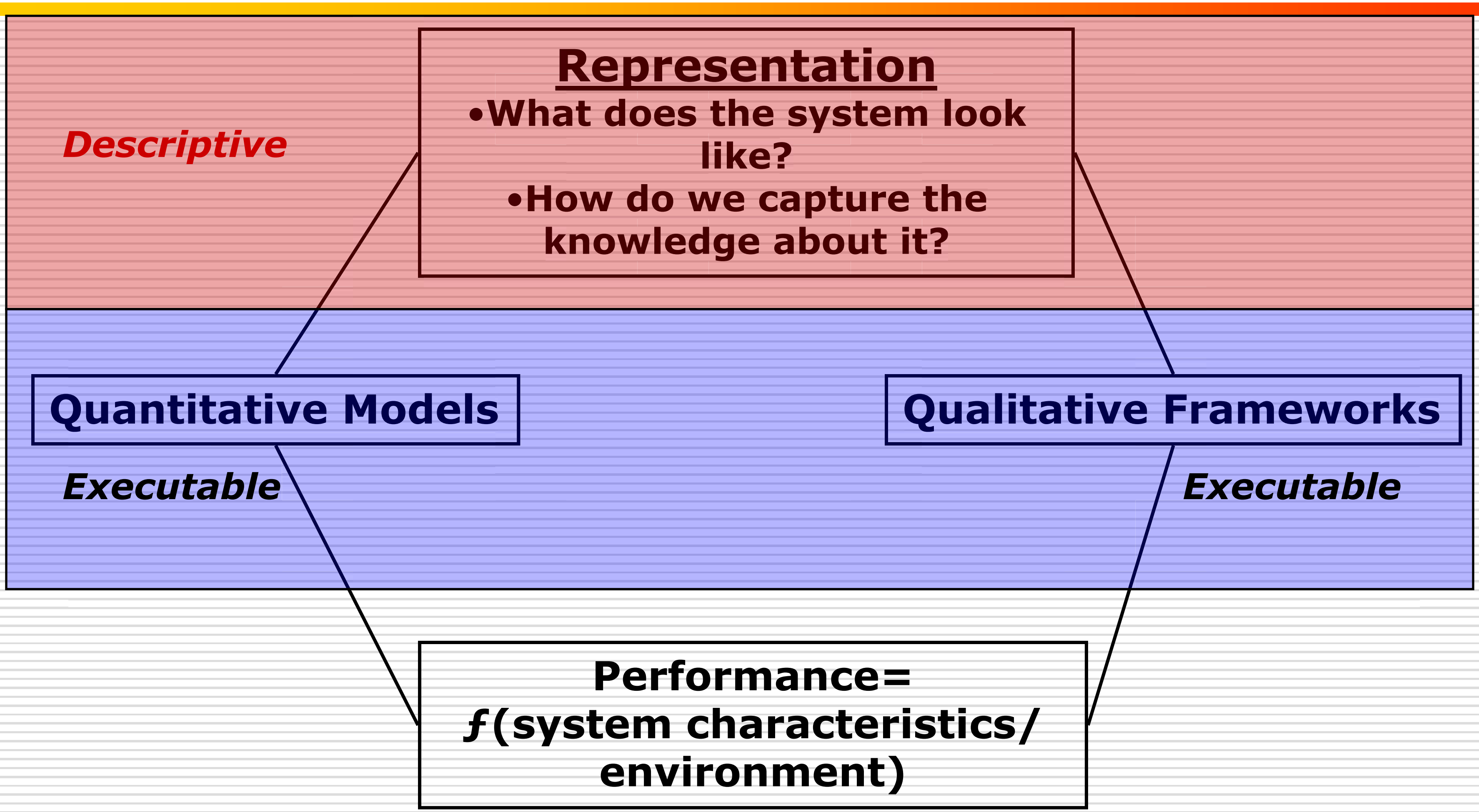
“Teaching and Learning Time”

Representations, Models, Frameworks, Processes and Architecture

Match-up of Class 3 with

- Framing Questions
- Learning Objectives

Representations, Models, Frameworks and Performance



- Representations
  - Simply the description of a system in both qualitative and quantitative terms
- Models
  - Quantitative - The language is usually math
  - Executable-by this we mean you can get **"answers"** from it
- Frameworks
  - Qualitative - Usually natural language
  - Executable (but what does this mean in the case of a framework?)
    - Example: Stakeholder analysis

- How do you decide when to go from a descriptive representation to
  - A executable model
  - A executable framework

- In the case of a model, this requires <u>quantification</u>
  - When is it the "right time" to quantify?
  - It takes a lot of time to do the quantification
  - This is time that might better be spent being sure you understand the "structure" of your system
  - I argue there is <u>no</u> <u>one</u> answer to the "right time" question

The model form

- System Dynamics, Agent-based Models, Discrete Event Simulation and so forth
- The model you select constrains your worldview…but it's the only way to get "answers"
- A hammer is a great tool, but you don't want to use one to wash windows

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Decisions/ Conclusions

How do you make decisions/draw conclusions about a complex system?

Story - names changed to protect the innocent

"I thought really hard about the system and its environment and critical issues surrounding it…and out came the decision/conclusion"

We need a better answer.

The need for a formal process…

Processes

- There is another level above representations, models and frameworks.
- A Process - a series of well-defined steps leading to a result/conclusion/insights
- Part of a process may be
  - Representations
  - Models
  - Frameworks
  - "Subprocesses"--so processes inside of processes

The CLIOS Process

- 3-Stage Process for studying and designing complex, large-scale, interconnected, open, sociotechnical (CLIOS) systems
- A Christmas Tree--hang appropriate methods from the tree
- System representation separates all organizations (formal or informal) from other system components-- "the institutional sphere" with the rest of the CLIOS System nested within it.
- Concepts: nested complexity, evaluative complexity, dealing with uncertainty, stakeholder identification and categorization

CLIOS Process

Stage 1:
Representation
-- Descriptive and Normative

Stage 2:
Design, Evaluation, and Selection
-- Normative and Prescriptive

Stage 3:
Implementation
-- Prescriptive
NB-- Iterative by nature, throughout

CLIOS Process

Stage	Key Ideas	Outputs
Representation	▪Understanding and visualizing the structure and behavior ▪Establishing preliminary goals	System description, issue identification, goal identification, and structural representation
Design, Evaluation, and Selection	▪Refining goals aimed at improvement of the CLIOS System ▪Developing bundles of strategic alternatives	Identification of performance measures, identification and design of strategic alternatives, and selection of the best performing bundle(s)
Implementation	▪Implementing bundles of strategic alternatives ▪Following-through -- changing and monitoring the performance of the CLIOS System	Implementation strategy for strategic alternatives in the physical domain and the institutional sphere, actual implementation of alternatives, and post-implementation evaluation

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CLIOS System Checklists

Characteristics Checklist	Opportunities/Issues/ Challenges Checklist	Preliminary CLIOS System Goals Checklist
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________

Architecture

- What do we mean by an architecture?
  - A lot of things, it turns out--
  - One possibility: Architecture as a “very high level” design?
  - Principles of Architecting?
  - Are they very different from design principles?

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Architecture

- Is an architecture a representation, an executable model, an executable framework, none of the above, all of the above?

Framing questions for ESD.83 I

- What is a complex system?
- What are our ways of thinking about these complex systems?
- What kinds of research questions do we want to **ask** in the field of Engineering Systems and how do we **answer** them?

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Framing questions for ESD.83 II

- What are the historical roots of the field of Engineering Systems and what is their relevance to contemporary engineering systems issues and concepts?

- What does "practicing" Engineering Systems mean?

Framing questions for ESD.83 III

- What are the **design** principles of Engineering Systems?
- What does it mean to advance the field of Engineering Systems and how do we accomplish it?
- How do we integrate engineering, management and social science in Engineering Systems?

Learning Objectives

- **Basic Literacy**: Understanding of core concepts and principles - base level of literacy on the various aspects of engineering systems

- **Interdisciplinary capability**: The capability to reach out to adjacent fields in a respectful and knowledgeable way and the ability to engage with other ES scholars in assessing the importance to ES of new findings in related fields

Learning Objectives

- **Historical Roots**: Understanding of historical/intellectual roots of key concepts and principles in engineering systems

- **ES and observations, data sources and data reduction**: An appreciation of the importance of empirical study to cumulative science and its difficulty in complex socio-technical systems

Learning Objectives

- **Critical Analysis**: Ability to critically assess research and scholarship aimed at furthering knowledge in engineering systems; development of defendable point of view of important contributing disciplines in Engineering Systems Field

- **Links Across Domains and Methods**: Ability to identify links/connections across different fundamental domains and methods relevant to engineering systems

Learning Objectives

- **Scholarly Skills**
  - 1) The ability to write a professional-level critical book review;
  - 2) A beginning level ability to develop and write a research proposal in the ES field;
  - 3) The ability to present and lecture on critical analysis of material that one is not previously familiar with;
  - 4) Developing wider reading skills and habits

THE END

Disciplinary Boundaries

- Boston Globe "report from the front"
  - Climate change-- National security
- Jasanoff
  - Science -- Policy/Regulatory
- Weigel
  - <u>Politics</u> <u>Arch</u> <u>Technical</u>
    - The system architect is the moderator between politics and technical regimes

Taxonomy

Why is taxonomy important? Because it suggests that different concepts apply for different categories-- like the difference between a system and a SoS--calling things by the right name helps

Osorio-- MEUs providing Broadband

- CLIOS Process had some strengths and some weaknesses
- OPM had some strengths and some weaknesses
- Create new hybrid process called COIM

CLIOS Process and OPM- strengths and weaknesses

- OPM
  - Strengths-- can represent a system in terms of form, functions and concept drawing on theory of systems architecture
  - Weaknesses-- no consideration of broader social or organizational context,
- CLIOS Process
  - Strengths-- good at socio-technical systems, explicit consideration physical and institutional domains, “common drivers”
  - Weaknesses-- no operators and functions, no explicit way to show hierarchy

Hybridized Processes/ Models

- Why do we need hybridized processes/models?
- And what does the fact that we need them say about the field?
- How is this distinct from Kaiser? Mixing theories (cosmology and particle physics) vs mixing processes/models? Or is it different at all?