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Four Decades of Systems Science Teaching and Research at PSU

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Four Decades of Systems Science Teaching and Research in the USA at Portland State University

Systems Science Seminar, 10/10/14

Wayne Wakeland, PhD

Professor and SySc Program Chair

Systems Science

- The study of general principles that govern systems of widely differing types
- Use of systems ideas and methods in interdisciplinary / transdisciplinary research and for socio-technical system design and management

Some History

- 1956
 - International Society for the Systems Sciences founded
 - System dynamics established as a new field
- 1967
 - First Hawaii International Conference on Systems Sciences
- 1970
 - International Journal of Systems Science
- 1976
 - First System Dynamics conference

Growing Recognition

- Interdisciplinary approaches are needed to solve complex problems
- Understanding complex systems is central to advances in science, engineering, real-world problem solving, and interdisciplinary research

Example Systems-Oriented Research Institutes

Name	Focus	Founded	Location
International Institute for Applied Systems Analysis	Policy-oriented global problems	1972	Vienna, Austria
Santa Fe Institute	Complex adaptive systems	1984	Santa Fe, NM, USA
New England Complex Systems Institute	Complex systems	1996	Cambridge, MA, USA
Max Planck Institute for Dynamics and Self Organization	Complex, self-organizing systems	2003	Gottingen, Germany
ARC Centre for Complex Systems	Complex systems	2004	Australia

Systems Science PhD Program

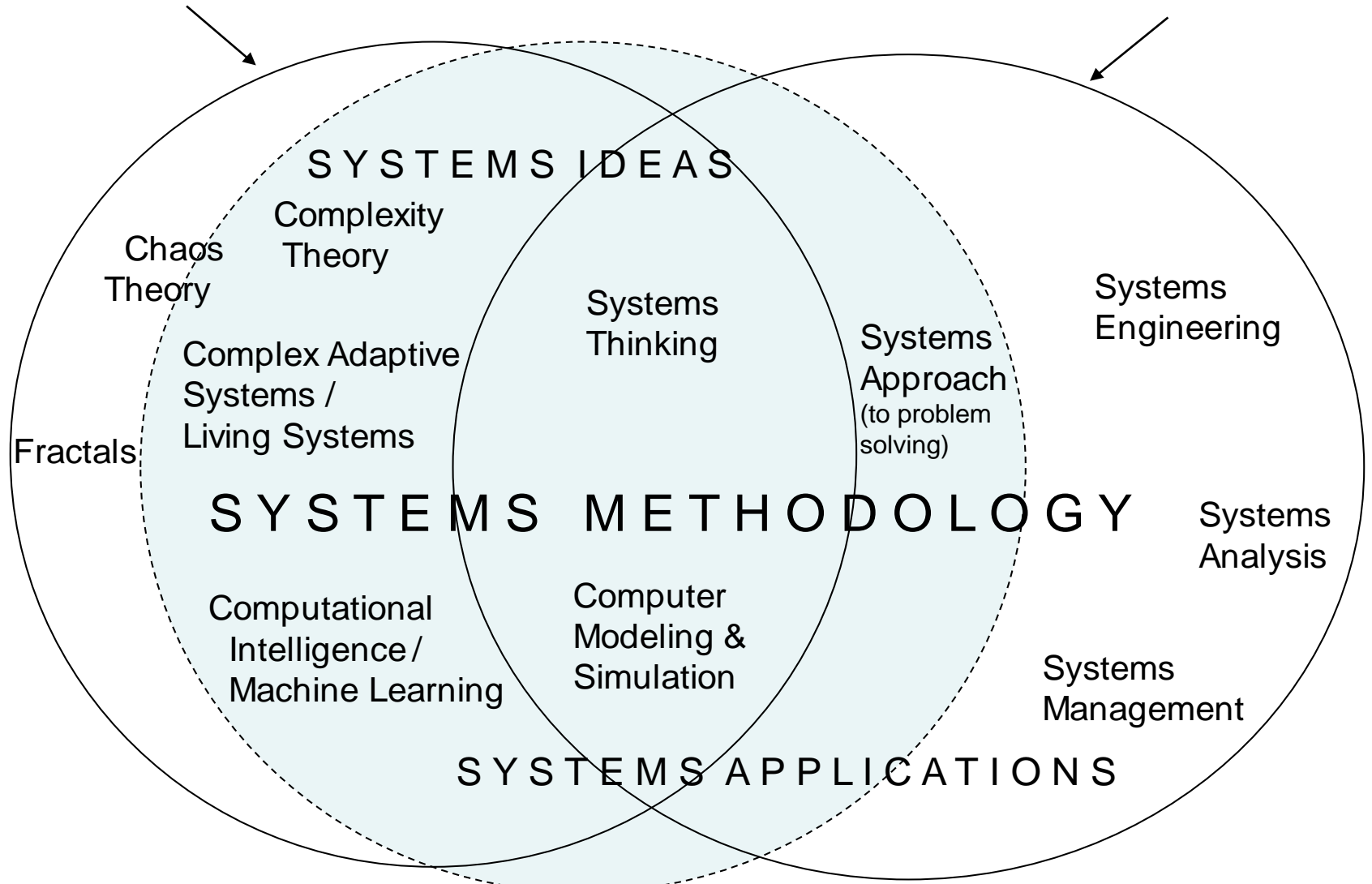
- Launched in 1970
 - One of PSU's first three doctoral programs
 - Along with environmental studies and urban studies
- Focal point for integrative, systems-oriented teaching and research
- Reported to the Dean of Graduate Studies
- Early people...
 - Lendaris in '69 to help create and launch
 - Linstone in '70 as first director
 - Wakeland matriculated in '73, graduated in '77 (#6)
 - Zwick joined core Faculty in '76

Evolution

- In the mid-1980s, departmental options created
 - 9 participating departments
 - Most popular: ETM, Psychology, School of Bus. Admin.
- In early 2000s, ETM & Psych created standalone PhD programs
- SySc transitioned to a stand-alone program
 - Added graduate certificates
 - Added SySc MS degree
 - Added “multi-disciplinary” track
 - Sought to complement not compete with departments
- In 2010, began to create an undergraduate presence

Systems Research

Systems Practice



PSU Systems Science Program

Graduate Curriculum

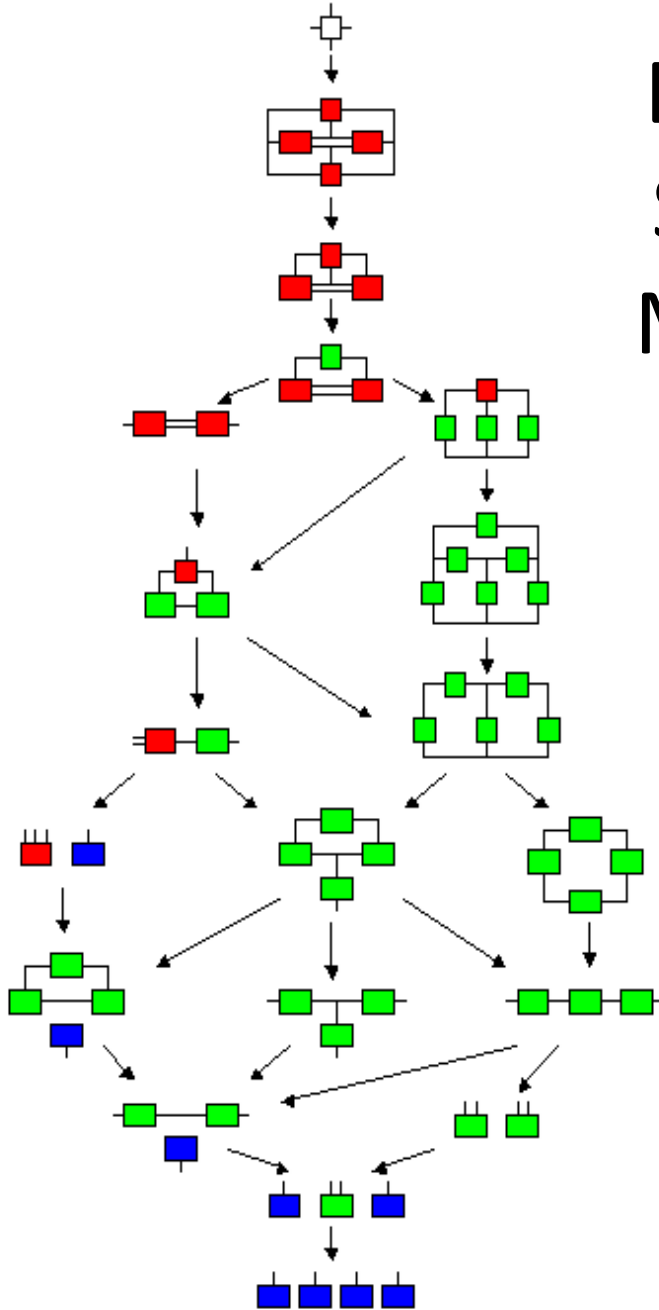
Level	Name	Role	When?	Notes
Grad	Systems Theory	Core	70's	
Both	Systems Approach (renamed Holistic Strategies for Problem Solving)	Core	70's	added UG section recently
Grad	System Dynamics	Core Methods	80's	
Both	Game Theory	Elective	80's	Added UG section recently
Grad	Artificial Life	Elective	80's	
Grad	AI: Neural Networks	Methods	80's	Instructor retired; needs revamping
Grad	Discrete System Simulation	Methods	80's	
Grad	Quantitative Methods of Systems Science	Core Methods	90's	Major revision planned to incr. relevance to environ. scientists
Both	Systems Philosophy	Elective	90's	Added UG section recently
Grad	Discrete Multivariate Models	Core Methods	90's	
Grad	Business Process Modeling & Simulation	Methods	90's	Outreach: business
Grad	Manufacturing System Simulation	Methods	90's	Outreach: engineering & technology management
Grad	Agent Based Simulation	Methods	2002	Outreach: social science, computer science
Both	Systems Ideas and Sustainability	Elective	2009	Added UG section recently
Grad	System Sustainability and Organizational Resilience	Elective	2011	Outreach: public policy
Both	Systems Thinking for Business	Elective	2013	+UG Outreach: business
Both	Data Mining with Information Theory	Elective	2013	+UG Outreach: computer science, social science, biomedicine

Undergraduate Curriculum

Title	When
Complexity in Science and Technology (from CS)	2009
Models in Science (Fletcher)	2010
Indigenous and Systems Perspectives on Sustainability (Hall)	2011
Intro to Agent Based Modeling (Sotnik)	2012
Modeling Social-ecological Systems (Sotnik)	2012
Networks in Society (Straus, Echt)	2013
Decision-Making in Complex Environments (Venkatachalapathy*)	2013

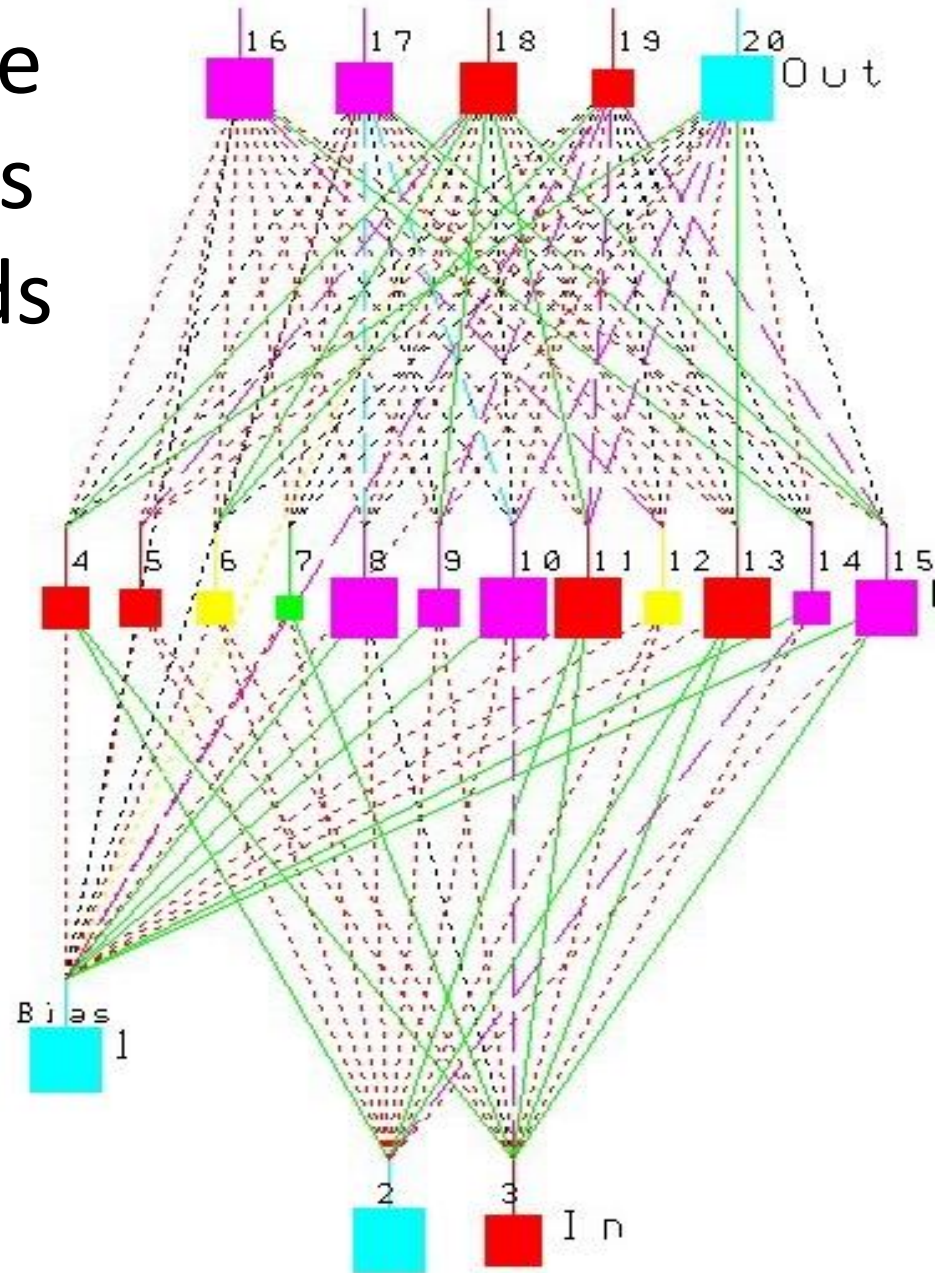
* also developed a prototype course “Darwinian Thought in Society”

Reconstructability Analysis: lattice of models of four variables



Example
Systems
Methods

Artificial Neural Network: model with one hidden layer



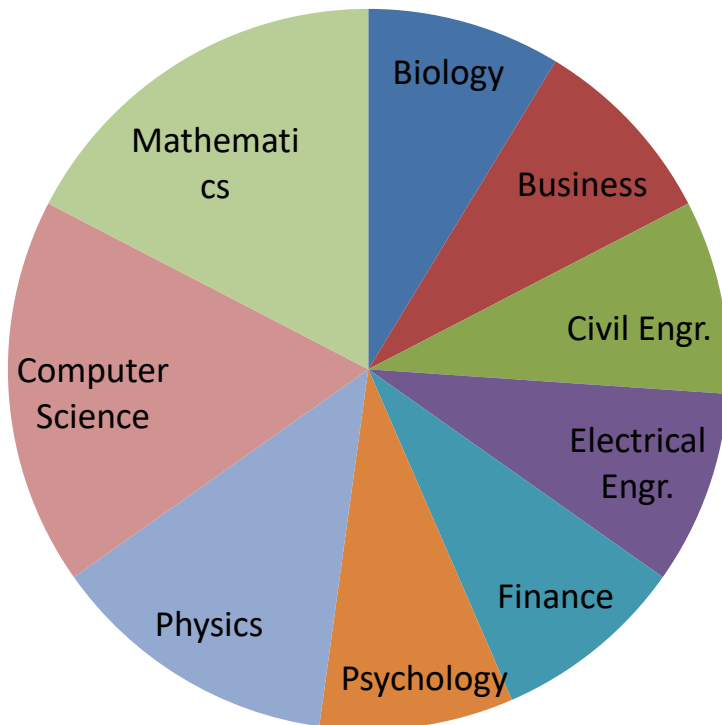
Other Systems Science Programs vs. PSU's

- Dozens of systems science programs created in 60's and 70's
 - Few remain
- Binghamton University (SUNY) Systems Science PhD Program has been closely linked with industrial engineering and automation for the past decade
- Washington University Systems Science PhD Program is housed in Electrical and Systems Engineering
- University of Ottawa has a Systems Science MS degree
- Systems-oriented programs in Europe and Australasia mostly focus on systems engineering or mathematical complex systems
- Like the above, PSU's program has connections with engineering, computer science, and mathematics
 - And also features practitioner focused with applications in biomedicine, health policy, and environmental sustainability

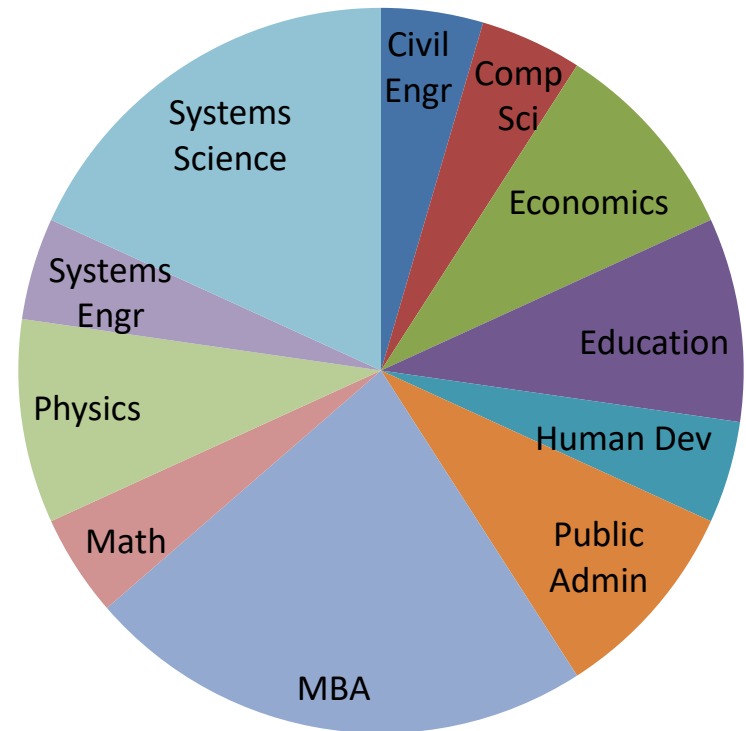
Student Population

- From 10-20 in early years to over 100 at the peak of the period when the departmental options fluro
- Core remained small (10-15) for decades; has grown recently to ~50 (30 doctoral and 20 MS students)

Bachelor's Degrees



Master's Degrees



Annual Graduation Rates, Avg. Student Credit Hours

	1972– 79	1980– 89	1990– 99	2000– 09	2010– 13
Departmental Ph.D. Graduates	0	0.7	2.7	6.2	3.0
SySc Core Ph.D. Graduates	1.1	2.0	2.6	1.3	1.3
SySc MS Graduates	0	0	0	2.8	6
Graduate Student Credit Hours	n/a	n/a	n/a	900	865
Undergraduate Student Credit Hours	0	0	0	156	480

Recent Externally Funded Research

Project Period	Brief Project Description	Researcher	Role	Funding Source	Amt.
1999–2002	Adaptive Critics for Controller Design	Lendaris	PI	NSF	\$300K
2002–2003	State Space Designs for Aircraft Control	Lendaris	PI	NASA	\$57K
2003–2006	Surface Design for Controllers	Lendaris	PI	NSF	\$218K
2003–2006	Modeling Intracranial Pressure Dynamics in Pediatric Traumatic Brain Injury	Wakeland	co-PI	Thrasher Research Fund	\$320K
2003–2006	Optimizing IV & V Costs and Benefits using Simulation	Wakeland	co-PI	NASA	\$624K
2008	Occam Improvement	Zwick	PI	Wells Fargo	\$30K
2009–2011	SD Model for Reducing Risks of Prescription Drug Abuse and Diversion	Wakeland	PI	Purdue Pharma, L.P.	\$198K
2011–2014	System Dynamics of Prescription Opioid Misuse	Wakeland	PI	NIH/NIDA	\$360K
2014-2017	Dynamic Model of Concussion Recovery	Wakeland Zwick	PI co-PI	Brain Trauma Found.	\$544K

From Dissertation Titles 1972 to 1993



Placement of SySc Grads

- Generalist skills are apparently valued by employers
 - To complement the specific skills they are seeking
- Some grads are faculty members at PSU and other universities
- Others have started consulting or software development firms
- Many work in governmental agencies
 - E.g., BPA, VA, National Labs
- Others work as researchers at public and private enterprises
 - Healthcare, high technology, energy consulting, etc.
- Some teach or serve as administrators in K-12 or community colleges
- SySc grads often create their own roles

The Future...

- The evolution continues: SySc is now part of PSU's School of the Environment within the College of Liberal Arts and Sciences
- Research may shift over time towards environmental concerns and sustainability-related topics
 - But not to the exclusion of systems methods development, biomedicine, health policy, energy systems, etc.
- Being located in a highly interdisciplinary environmental school rather than a specific department seems likely to bode well for SySc
 - In part because SySc methods can contribute quantitative analysis capabilities for environmental studies, env. science, and env. management students