Complex Systems and K-16 Curricula

R W DeGray, Saint Joseph College, Connecticut

MAA Sessions on Quantitative Literacy and Decision Making
presented at the
Joint Mathematics Meetings
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Complex Systems and K-16 Curricula

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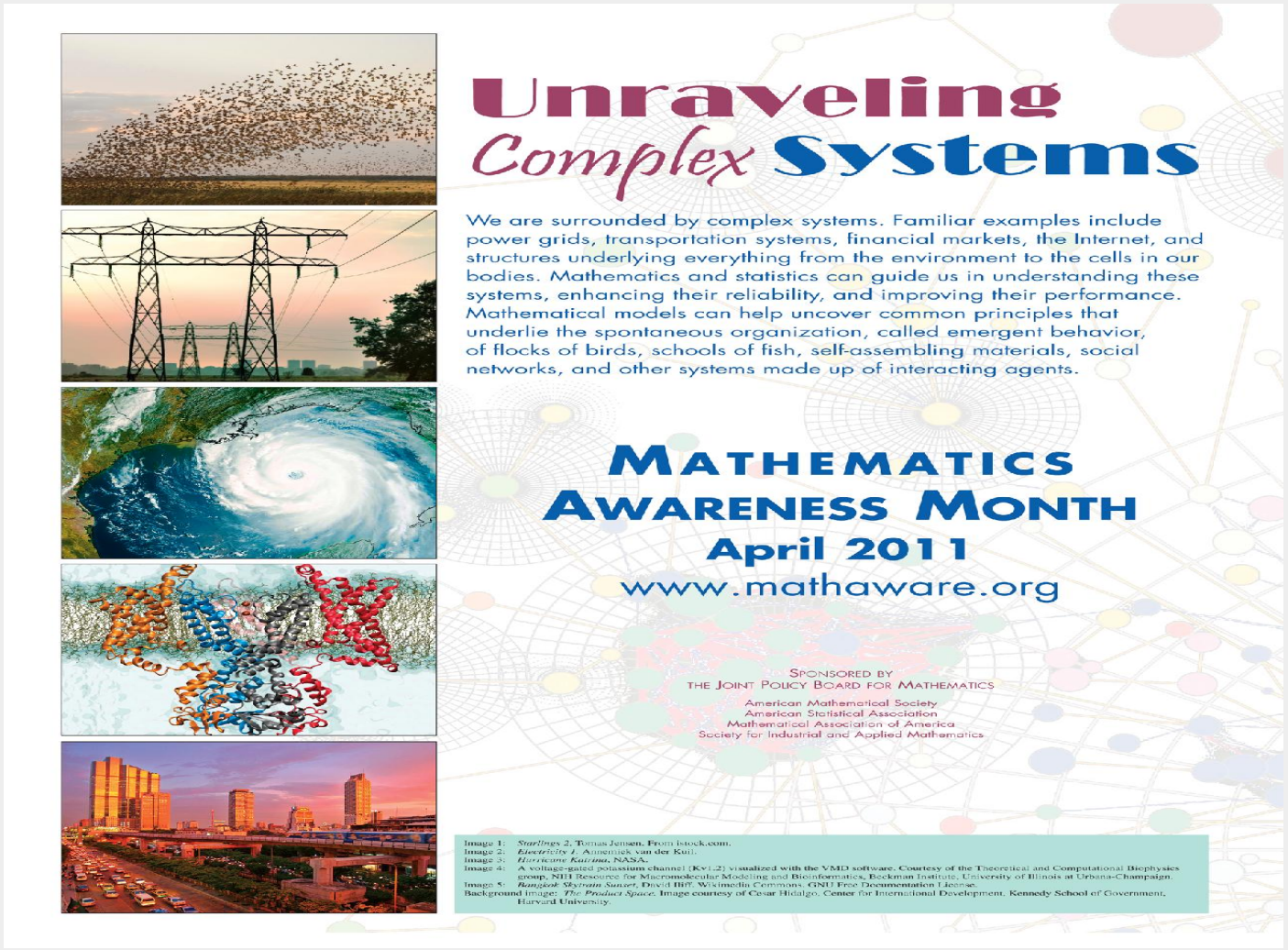
R W DeGray* (rdegray@sjc.edu)
Department of Mathematical Sciences
Saint Joseph College
West Hartford, CT 06117-2791

www.sjc.edu/rdegray



Ref: Joint Policy Board for Mathematics (JPBM)

Complex Systems with Quantitative Literacy/Mathematics

- The Physics of Networks, by Mark Newman
- Thinking Outside the Cube, by César A Hidalgo
- The Power Grid as a Complex System, by Sara Robinson
- The Unruly Power Grid, by Peter Fairly
- If Smallpox Strikes Portland ..., by Chris L. Barrett, Stephen G. Eubank and James P. Smith
- Understanding Large-Scale Social and Infrastructure Networks: A Simulation-Based Approach, by Christopher L. Barrett, Stephen Eubank, V.S. Anil Kumar, and Madhav V. Marathe
- *Science* Special Issue on Complex Systems, (April 1999)
- Articles on complex systems, New England Complex Systems Institute

In the News

- "Using Math To Make Complex Systems Simple," Scott Simon and Keith Devlin, *Weekend Edition*, National Public Radio, 16 April 2011

More Complex Systems with QL/Mathematics from
The Mathematical Association of America
SIGMAA on Quantitative Literacy

QL in the Media

Essays referred to on the JPBM poster Unraveling Complex Systems are:

- Understanding Complex Systems: Population Interactions Resulting in Disease Transmission
  by Sara Y. Del Valle and James P. Smith
- Understanding Complex Systems: Economic Impacts from Catastrophic Events
  by Brian K. Edwards and Mary Ewers
- Organisms as Complex Systems
  by John Guckenheimer (Cornell University)
- Cascading Failures: Extreme Properties of Large Blackouts in the Electric Grid
  by Paul D.H. Hines, Benjamin O'Hara, Eduardo Cotilla-Sanchez, and Christopher M. Danforth
- Understanding Complex Systems: Infrastructure Impacts by Darrin B. Visarraga

Ref: http://www.assystcomplexity.eu/

Mathematics in the Science of Complex Systems workshop

Organisers: J.H.Johnson (Open University), R.S.MacKay

One of a series sponsored by the EC coordination action ASSYST (Action for the Science of Complex Systems and socially intelligent ICT), around the questions:

• which areas of mathematics are used in complex systems science?

Individual or small group efforts:

i) PLANNING DOCUMENTS FOR A NATIONAL INITIATIVE ON COMPLEX SYSTEMS IN K-16 EDUCATION; NECSI; Yaneer Bar-Yam, et al.

ii) 'Complex Systems in Education: Scientific and Educational Importance and Implications for the Learning Sciences'; Journal of Learning Sciences; 15(1), 2006, pp11–34, Lawrence Erlbaum Associates, Inc.Michael J. Jacobson, Uri Wilensky

iii) 'Learning in and about complex systems'; John D. Sterman

iv) Star Logo, 'The Imagination ToolBox'; Eric Klopfer, Simulation/Modeling software

v) NetLogo; Wilensky, U. 1999. Center for Connected Learning and Compurter-Based Modeling

vi) Complex Systems in the Elementary and Middle School Mathematics Curriculum: A Focus on Modeling; Lyn D. English; Queensland University of Technology Australia

vii) Introducing Complex Systems into the Mathematics Curriculum; Lyn D. English

...

Large group initiatives:

i) Citizen Science

ii) A collaborative initiative via the NECSI COMPLEX SYSTEMS WIKI; R. DeGray

From Concepts to Curricula

Historical

Introduction of Arabic numbers to Western Europe by Leonardo of Pisa in the 13th century
Trivium, Quadrivium

Past and currently evolving curricula

Mathematics
Computer Science

and
Developing curricula

Complex Systems/Complexity/Systems Thinking

Complex Systems Concepts

Yaneer Bar-Yam, NECSI

Description	Information
System	Patterns
Observer	Collective
Adaptive	Interdependent
Environment	Indirect
Boundary	Effects
Network	Dynamic
Ecosystem	Response
Development	Feedback
Replication	Linear & Nonlinear
Self-organization	Chaos & Fractals
Selection	Scale
Evolution	Randomness

Related Concepts

Particle	Thermodynamics
Newton's Laws	Statistical mechanics
Control	Nonequilibrium dynamics
Distributed Control	Language / formal languages
Hierarchy	Separation of scales
Influence	Reductionist

Interactive Syllabi

Course Syllabi; Static paper vs. Interactive networked

Ref: Sylvie L. F. Richards

Static syllabi:

* Not easily modified
* Mostly for the mechanics of the course:
  who, where, when, but not why
* Fixed class meeting dates, times, locations
* Assignments only, no course content

Interactive syllabi: Negate the above

Internet Resources

- SIGMA on Quantitative Literacy
- NECSI
- Khan Academy
- MIT Open Courseware
- TED Talks - Ideas Worth Spreading
- Fora.tv
- YouTube
- COMplexity DIgest
- RSA Animate
- ...

Conceptual Foundations Session - 2

The film "Mindwalk" and the book
The Turning Point by Fritjof Capra, Lintschinger, K. and Capra, B. (1991). Mindwalk: Film for Passionate Thinkers, Paramount Pictures, Hollywood, CA

Conceptual Foundations Session - 3

History and Characteristics of Systems Thinking - Ludwig von Bertalanffy, Fritjof Capra,
Business and Management LUDWIG VON Bertalanffy 1901-1972 Father of Systems Thinking

Conceptual Foundations Session - 4

Examples and Hierarchy of Systems Murray Gell-Mann's The Quark and the Jaguar subtitled `Adventures in the Simple and the complex', ISBN 0-7167-2725-0, Freeman

System Dynamics Session - 5

Introduction and origins

System Dynamics Session - 6

Modeling with NetLogo or STELLA - Stocks, Flows, Converters and Connectors, Feedback Loops

Complex Systems Session - 8

Concepts, Properties and Examples"Puget Sound is a complex system of interconnected inlets, bays, and channels with tidal sea water entering from the west, and cold freshwater streams entering from surrounding mountains."; Department of Ecology, Puget Sound

Complex Systems Session - 9

Emergence

Complex Systems Session - 10

Self-OrganizationArtwork by Elaine Wiesenfeld (from Bak, How Nature Works)

Complex Systems Session - 11

Knowledge Management Photo by Margaret J. Wheatley

Review Session Session - 12

Interactive Systems Thinking and Complexity Working Syllabus

The Collaborative Interactive Systems Thinking and Complexity Syllabus

Project Background Information

Conceptual Foundations Session - 1 Introduction to Systems Thinking, Epistemology, Paradigm, Scientific Thinking, Reductionism	**Conceptual Foundations Session - 2** The film "Mindwalk" and the book The Turning Point by Fritjof Capra, Lintschinger, K. and Capra, B. (1991). Mindwalk: A Film for Passionate Thinkers, Paramount Pictures, Hollywood, CA
Conceptual Foundations Session - 3 History and Characteristics of Systems Thinking - Ludwig von Bertalanffy, Fritjof Capra, Business and Management LUDWIG VON Bertalanffy 1901-1972 Father of Systems Thinking	**Conceptual Foundations Session - 4** Examples and Hierarchy of Systems Murray Gell-Mann's The Quark and the Jaguar subtitled `Adventures in the Simple and the complex', ISBN 0-7167-2725-0, Freeman
System Dynamics Session - 5 Introduction and origins	**System Dynamics Session - 6** Modeling with NetLogo or STELLA - Stocks, Flows, Converters and Connectors, Feedback Loops
System Dynamics Session - 7 Constructing a STELLA model	**Complex Systems Session - 8** Concepts, Properties and Examples"Puget Sound is a complex system of interconnected inlets, bays, and channels with tidal sea water entering from the west, and cold freshwater streams entering from surrounding mountains."; Department of Ecology, Puget Sound

Complex Systems Session - 9	Complex Systems Session - 10
Emergence	Self-OrganizationArtwork by Elaine Wiesenfeld (from Bak, How Nature Works)
Complex Systems Session - 11	**Review Session Session - 12**
Knowledge ManagementPhoto by Margaret J. WheatleyMargaret J. Wheatley	Synthesis and Project Presentations
[References]	

Conceptual Foundations Session - 1

Conceptual Foundations Session - 1/Please do not edit this line

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Conceptual Foundations: Paradigm, Epistemology, Scientific Thinking, Abstraction, Reductionism, Metaphors

Topics	Starting Points/Questions/Assignments	Readings/References
Introduction and Conceptual Foundations of Systems Thinking ParadigmEpistemology Scientific Thinking 'Finding the Universal Laws That Are There, Waiting ...'Science, universal laws, patterns, Thomas Kuhn (Ref. 'The Edge', Steven Strogatz video AbstractionReductionismMetaphors	1. What is Thomas Kuhn's explanation of the term *paradigm*? 2. How is knowledge constructed?3. There are several explanations of how the world works. How does a scientist view the world? 4. Give three examples of abstraction used in your disciplinary field.5. What is the problem with reductionism?6. Define and give three examples of metaphors. a. Why are metaphors important in science? File:Elmtree.jpg The American elm, Ulmus americana Saint Joseph College Campus photo by R. DeGray	'Paradigm' with references to Thomas Kuhn Compiled by Keith Cunningham and Rudolph HusarThomas Kuhn Developed by Frank Pajares, Emory UniversityThomas Kuhn and Scientific Revolutions; Science Friday, Archives, August 16, 1996 "From Einstein's theory of relativity to Copernican astronomy, we all know about scientific ideas that changed the way people think about the world. How do revolutionary advances in science come about? In this hour of Science Friday, we'll look at the ideas of science historian and philosopher Thomas Kuhn. Plus, a look at current revolutionary theories." Paradigm Shift: "The Danish physicist Niels Bohr, who worked in Rutherford's lab, was the first to describe orbits of fixed size and energy in which electrons are free to travel without losing energy and falling toward the nucleus. According to this model, published in 1913, electrons can only occupy or jump between fixed energy levels and cannot reside in between these levels. In addition, once in their "ground state," electrons maintain the energy they contain. This energy keeps them in perpetual motion, allowing them to resist the attractive force of the nucleus. Ref: Sciencehak.com

Introduction to Epistemology

Prepared by *Principia Cybernetica Web*Scientific Thinking and its Development

Kevin Dunbar, Dartmouth College (formerly at McGill University))Edward Rothstein, nytimes.com, CONNECTIONS; 'Finding the Universal Laws That Are There, Waiting . . .', The New York Times, January 10, 2004

By Edward Rothstein (NYT) 1061 words , Late Edition - Final , Section B , Page 11 , Column 1

ABSTRACT - Edward Rothstein Connections column on John Brockman, who, on his online scientific salon, Edge.org, begins every year by posing question to distinguished roster of authors and invited guests; this year's question, 'What's your law?', has garnered more than 150 responses that are filled with aura of modesty, tentativeness and skepticism which may show uncertainty about science itself; photo (M)

Steven Strogatz interview by Alan Alda, 'WHO CARES ABOUT FIREFLIES?' The Edge, John Brockman, Editor and PublisherWendell Johnson, General Semantics class University of Iowa. From a series broadcast over WSUI-AM, Iowa City, Iowa. This sample is the lecture delivered December 7, 1956. The subject is the process of abstracting. The clips are in two parts.

WSUI Broadcast, Levels of Abstraction I (1956, date unknown; possibly duplication of December 7 or 10, above) [Real Player file created earlier] Yaneer Bar-Yam, "Concepts in Complex Systems-- Reductionism" New England Complex Systems Institute(NECSI) Metaphor in Scientific Thinking. Workshop on Metaphor and Contemporary Science - 25 & 26 November 2002, University Scholars Programme, National University of Singapore

Summary

1. Mathematics Awareness Month was April 2011, "Unraveling Complex Systems" JPBM
2. What are the mathematics and Quantitative Literacy skills necessary for understanding complex systems? - an on-going project
3. I suggest a collaborative effort to build interactive course syllabi or lesson plans appropriate for levels K-16. An example college level syllabus resides at the NECSI Educational Programs and Wiki site. It can be enhanced and/or additional syllabi can be built in the spirit of Wikipedia. Google Presentation Docs is another means to collaborate.

Please contact me at rdegray@sjc.edu.

The image of collaborating ants is a metaphor for collaborating on building course syllabi at levels K-16; each anthill corresponds to work on an interactive syllabus.