This is not a paper
This is an *advertisement* for my paper
Outline

- Complexity theorising in the sciences and education: a brief (and partial) history
- Complexity and complexity reduction: implications for education
- Complexity reduction and ‘methodology borrowing’: some issues and implications for environmental education research

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Complexity theorising in the sciences and education: a brief (and partial) history

Complexity...

- a heterogeneous assemblage of concepts and metaphors arising from studies of complex systems in a variety of scholarly disciplines, including the sciences
- has transformed many of these disciplines, but has had less impact in education
  - not mentioned as a key scientific concept in the draft documentation of Australia’s national science curriculum
  - ‘complex’ in relation to ‘systems’ appears only once to reinforce reductionism: ‘The world is complex but can be understood by focusing on its smaller components’
Complexity and science explicitly linked during the 1940s

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Complexity in mainstream science

Objects of scientific inquiry

mid-16th – late 19thC:
material structure of simple systems

from late 19thC:
informational structure of complex systems
  • protein folding in cell nuclei
  • task switching in ant colonies
  • nonlinear dynamics of the earth’s atmosphere
  • far-from-equilibrium chemical reactions
Complexity in social sciences, humanities and arts

Complexity characterises many networked systems

• Katherine Hayles: complex dynamics in literature and science

• Paul Cilliers: synthesises insights from computational theory with those of postmodernist philosophers (including Jacques Derrida and Jean-François Lyotard)

• David Colander: implications of complexity for teaching economics.

Complexity cf. ‘complexity theory’

• no coherent ‘complexity theory’ (Cilliers)

• not necessarily (or exclusively) a theory – might also be understood as an ontology or methodology (Biesta & Osberg)

• signals the emergence of ‘a new structure of feeling… which frames the future as open and full of productivity’ (Thrift)

• invites us to understand that many of the processes and activities shaping our worlds are open, recursive, organic, nonlinear and emergent

• invites caution in accepting mechanistic and/or reductionist explanations of these processes and activities – explanations that assume linearity, determinism and predictability and, thus, that they can be controlled
Complexity and education

- William Doll (1986, 1989, 1993): implications of reconceiving education in terms of emergence, disequilibrium, and dissipative structures that allow us to see education in non-linear, unpredictable and generative terms – to value the unexpected.

- Deborah Osberg and Gert Biesta (2007): theorise pedagogical implications of emergence drawing on Prigogine’s research on ‘irreversible processes’ in open and far-from-equilibrium chemical systems that give rise to increasingly higher levels of organisational complexity and which ‘begin to exhibit novel properties that… transcend the properties of their constituent parts, and behave in ways that cannot be predicted on the basis of the laws governing simpler systems’.

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emergence may occur if...

A. …a system of agents…
B. …richly connected…
C. …gives rise to an emergent pattern…
D. …which feeds back into the system

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Education as a mechanistic system

• from early 20th C: Frederick Taylor’s principles of scientific management inspire a factory model of education
• concepts of mechanistic control (imposed, overt, top-down, centralised) persist until the late 1960s
  > Smith, Stanley & Shores (1951, 1957) ‘Curriculum development as educational engineering’
• Many educational theorists opposed crude mechanism but others refined Taylor’s principles by appropriating the language of cybernetics

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Francis Hunkins (1980): ‘the cybernetic principle is essential to the monitoring aspect of program maintenance’ (but which principle?)

David Pratt (1980) applies ‘a cybernetic perspective’ to the problem of ‘managing aptitude differences’ (but which perspective?):

The problem of maintaining consistently high achievement from a group of learners who differ in aptitude and other characteristics can be seen as an instance of the general question of how a system with variable input can be designed to produce stable output. Phrased in this way, the question lies squarely within the field of cybernetics, the study of self-regulation in systems (p. 335).

Pratt (1980):

- temperature regulation in a building is a simple cybernetic system
- ‘the most elegant and complex [sic] cybernetic systems are found in nature’ - e.g. temperature regulation in the human body [complicated not complex]

Unexamined assumptions:

- curriculum and cybernetic systems should ‘produce stable output’
- ‘natural’ order – e.g. ‘stable output’ – should inform curriculum work
Katherine Hayles (1994):

> 1945-1960: homeostasis privileged 'constancy over change, predictability over complexity, equilibrium over evolution' and 'reflected the desire for a “return to normalcy” after World War II'

> 1960-1972: reflexivity displaced homeostasis: reflexivity led ‘away from the closed circle of corrective feedback, privileging change over constancy, evolution over equilibrium, complexity over predictability’

> 1980s: emphasis shifted to emergence, focused ‘not on how systems maintain their organization intact, but rather on how they evolve in unpredictable and often highly complex ways through emergent processes’

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**Why did educational theorists in 1980 continue to privilege homeostatic self-regulation two decades after it had ceased to be generative in the field of cybernetics?**

- educators faced few compelling challenges to deeply sedimented conceptions of ‘natural’ order as stability, predictability, and equilibrium
- concepts of ‘natural’ order pervade many disciplines, including ecology

From the 1970s many ecologists repudiated Odum’s portrayal of orderly and predictable processes of ecological succession culminating in stable ecosystems; ‘balance of nature’ is contested

Pickett & White (1985): concept of ecosystem has receded in usefulness and, when used, has lost its former implications of order and equilibrium

Robert Ulanowicz (2009) emphasises that chance, disarray and randomness are necessary conditions for creative advance, emergence and autonomy in the natural world

Educational bureaucracies privilege orderly, predictable processes leading to ‘stable output’.

Educational policies and curriculum documents are homeostatic devices regulating the diverse inputs of students and teachers by bringing them within closed circuits of corrective feedback to maintain stability and equilibrium.
Complexity and complexity reduction: implications for education

- Complexity invites us to be cautious of complying with models and trends in education that assume linear thinking, control and predictability, e.g.
  - increasing emphasis on measuring educational ‘outcomes’ through national and international comparative studies – NAPLAN, TIMSS, PIRLS, PISA…
  - increasing emphasis on making education an ‘evidence-based’ practice by seeking causal links between measured educational ‘inputs’ and the measurement of outcomes

Complexity: a different way to think about ‘inputs’ and ‘outputs’

- sees educational processes as necessarily characterised by gaps between ‘inputs’ and ‘outputs’
- not gaps to be ‘filled’ but sites of emergence
Complexity: a different way to think about ‘inputs’ and ‘outputs’

- knowledge, understanding and reality *emerge* through educational processes
- individuals *emerge* in and through educational processes in unique and unpredictable ways
- education is not only about qualification and socialisation
- should also be concerned for the ‘coming into presence’ of unique, individual beings.

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Complexity reduction in Australian education

- national teacher quality standards
- standardised testing

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Who is reducing complexity for whom?
In whose interest?

Complexity reduction in education not only happens prospectively (through the reduction of initial variables) but also retrospectively (through backwards selection of particular trajectories). One of the most explicit examples of retrospective complexity reduction in education is assessment, because assessment validates some learning trajectories and invalidates others but always does so ‘after the event.’ Because education is a recursive system, the anticipation of assessment also reduces complexity. In this way assessment also functions prospectively in the reduction of complexity (Gert Biesta 2008).

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Retrospective complexity reduction:
identifying ‘learning’

If we say
• ‘Matilda has learned how to waltz’ or
• ‘Matilda has learned how to use the EwE (Ecopath with Ecosim) ecological/ecosystem modelling software suite to predict movement and accumulation of aquatic contaminants in Lake Eppalock’

then we are making a selective retrospective judgement about the value of some more or less durable changes in Matilda that we have observed and that are not simply a result of maturation.

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Complexity reduction and ‘methodology borrowing’: some issues and implications for environmental education research

- Complexity reduction is not unique to environmental education research
- Most forms of inquiry deliberately reduce the complexity of the objects of their inquiries and/or the data they produce in one or more ways
- If our knowledge interests are in prediction and control, as in much medical science, then reducing the complexity of the object of inquiry might be defensible
- Most research reports published in JEE up to the late 1990s were modelled on experimental applied science and behaviourist psychology
- These researchers reduced the complexity of learning by limiting the variables they studied to observations of ‘objective’ behavioural change and deliberately ignoring ‘subjective’ conceptual activity

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Complexity reduction and ‘methodology borrowing’: some issues and implications for environmental education research

- caution needed when ‘borrowing’ concepts and/or methodologies from other disciplines
- objects of inquiry in environmental education research are not identical to objects of inquiry in (say) science education research and may be complex in different ways
- three cautionary tales outlining instances of complexity reduction in educational inquiry that involve ‘methodological borrowings’ from other disciplines
- these ‘borrowings’ appear in the literature of environmental education research and might even have particular appeal to environmental education researchers for a variety of reasons

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Cautionary tale 1: borrowing from constructivist science education research


• draws on conceptual change research in science education to explore students’ ‘ecological misconceptions’
• ignores post-Odum ecology – assumes ‘basic ecological concepts’ (i.e. Odum’s) are stable and enduring (even ‘natural’) rather than constantly changed and reformulated by ecologists who construct them


• Munson’s assumptions about ‘basic ecological concepts’ match Odum’s foundationalist view of stability in nature
• ignores post-Odum ecology, thus many of his ‘basic ecological concepts’ are themselves ‘misconceptions’ (ideas incompatible with *currently* accepted scientific knowledge)
• Munson’s appropriation of the conceptual change discourse of constructivist science education research is an elaborate rationale for replacing students’ ‘misconceptions’ with his own

- assumes subjectivities to be as stable as ecosystems: ‘misconceptions are stable elements of an individual’s conceptual framework and highly resistant to change’
- interprets the literature of conceptual change in science education in a way that takes reductionism to new extremes of absurdity:
  ‘If educators view misconceptions as completely individualistic, they will find the task of teaching for conceptual change overwhelming. However… some studies have found that the vast majority of individuals hold a limited number of misconceptions (Driver et al 1985). This suggests that a finite number of ecological misconceptions exist. Such a conclusion should be encouraging to environmental educators and environmental curriculum developers. (p. 34, my emphasis)

Cautionary tale 2: borrowing from the ‘evidence-based’ education discourse

- the idea that education should be an evidence-based practice is now widespread and taken-for-granted in many countries
- appeals to many environmental education researchers who are legitimately concerned with exploring ‘what works’ in producing environmentally literate (or informed, or ethical, etc.) citizens
- e.g. an evaluation of a community water education program quite rightly seeks evidence of its effectiveness in informing community members about water availability and management
Cautionary tale 2: borrowing from the ‘evidence-based’ education discourse

• seeking evidence of ‘what works’ may reduce the complexity of an issue in ways that produce simplistic, meaningless conclusions
• e.g. much research on ‘significant life experiences’ and ‘formative influences’ on the development of environmental awareness – ‘studies which aim to identify formative influences’ in the lives of ‘adults committed to environmental quality’ (Tanner)
• ‘The rationale for such research is simple: if we find that certain kinds of early experience were important in shaping such adults, perhaps environmental educators can, to the degree feasible, replicate those experiences in the education of the young’ (Tanner)

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Cautionary tale 2: borrowing from the ‘evidence-based’ education discourse

• naïve to assume that ‘what worked’ for us environmentally responsible adults could or should be replicated for our and other people’s children
• this type of research exemplifies a particularly obvious form of complexity reduction, namely, the attempt to produce ‘evidence’ of causal relationships between a particular category of inputs (‘formative influences’ in the early years) and outcomes (‘adults committed to environmental quality’).

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Cautionary tale 3: borrowing ‘triangulation’

- crusade for ‘mixed methods’ is a relatively recent development in educational inquiry
- ‘Mixed methods research is formally defined here as the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study. Philosophically, it is the “third wave” or third research movement, a movement that moves past the paradigm wars by offering a logical and practical alternative’ (Burke Johnson and Anthony Onwuegbuzie 2004)

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‘mixed methods’ and ‘triangulation’

- ‘triangulation’ seeks ‘convergence and corroboration of results from different methods and designs studying the same phenomenon’ (Johnson & Onwuegbuzie 2004)
- examples (from EER manuscripts reviewed/published recently):
  - ‘The accuracy of the coding of the drawings was triangulated by the verbal data from the interviews and group discussions’.
  - ‘The researcher shared and discussed the data and interpretation so that it could be reflected and triangulated to enhance the reliability of the data analysis process’.
  - ‘The validity of the research results can be augmented through triangulation of methods and analysis’.
  - ‘Interviews of students and teachers were used in the classic sense of triangulation’.

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‘triangulation’ critiqued

- ‘triangulation means many things to many people… none of the uses in sociology bears any resemblance to its use in surveying’ (Norman Blaikie 1991)
- ‘triangulation’ of social worlds makes sense only if the researcher adopts a ‘positivistic frame of reference which assumes a single (undefined) reality and treats accounts as multiple mappings of that reality’ (Blaikie 1991)
- Alexander Massey (1999) identifies many misleading and invalid claims (and seven common logical errors) made in the name of methodological triangulation.

Do the prior disciplinary histories of many environmental education researchers dispose them to see the triangulation metaphor as common sense?
- For example, sampling techniques such as line transects in botany reinforce the legitimacy of a surveying methodology…
Not a conclusion but…

I do not really wish to conclude and sum up, rounding off the argument so as to dump it in a nutshell on the reader. A lot more could be said about any of the topics I have touched upon… I have meant to ask the questions, to break the frame… The point is not a set of answers, but making possible a different practice (Susanne Kappeler 1986).

• How might understanding our worlds and selves as open, recursive, organic, nonlinear and emergent make ‘a different practice’ possible for environmental education research?

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