CHAPTER 10

Complexity Theory and Emergence: Contributions to ESD

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An Introduction to Complexity Theory

How to approach Education for Sustainable Development (ESD) is a challenging issue for teachers who are often called upon to embed it into their practice. We are faced with demanding ecological and social problems, often with apparently competing claims, such as poverty eradication and environmental protection. These can seem contradictory if we only consider these claims through current knowledge frameworks. New ways of thinking, doing and being are needed if we are to live harmoniously as part of nature now and in the future. Huebner (1999, p.403) uses the idea of 'the call of moreness' to articulate this. We need to have hope that we can draw on past and present knowledge, identify our current limitations and seek to go beyond them. Complexity theory offers a way to approach this challenge.

So, What Is Complexity Theory?

Complexity theory argues that environments, organisations or systems can be 'complex' if:

> large numbers of constituent elements or agents are connected to and interacting with each other in many different ways. This interaction causes organisation and reorganisation and if sufficient or critical level complex

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> interactions are allowed to develop, new and sometimes surprising patterns and structures can emerge which are more than a sum of their parts. It is this notion of emergence, and the conditions required for it to take place, which is of central interest to complexity theorists. (Mason 2008a, p.119)

Educational settings *do* have the potential to be places which are 'complex'. Emergence of the new is possible (although not certain) if, as educators, we create opportunities for numerous connections and interactions to take place between many constituent elements. For example, students could be encouraged to interact with each other, the tutor and the wider community, as well as exploring ideas from formal and informal curriculum sources. Allowing the emergence of different patterns and structures emphasises the importance of listening to new and unexpected ideas and including them in what is deemed to be valid. Such an approach does not have to occupy all of one's practice—although it could! It is possible to identify and build on 'moments of complexity' when they 'interrupt' (Biesta 2013, p.1) more standard practice. Indeed, many practitioners already encourage and value such moments without necessarily knowing about complexity theory!

Potential Advantages and Possible Issues with Complexity-informed Approaches

Since what emerges is more than the sum of inputs, complexity theory allows for the possibility that education can be about 'enlarging the space of the possible' rather than 'replicating the existing possible' (Davis et al. 2004, p.4). However, a focus on the emergence of new ways of knowing or being in the world raises the important issue of ethics. If the 'radically new' (namely new ways of knowing or being in the world which could not be predicted in advance from our existing way of knowing or being [Osberg in press]) is allowed to emerge from a free play of ideas, what if this 'radically new' is deemed unethical and who decides this? This is particularly relevant to ESD which openly proposes that certain ways of living are better than others. We will need to develop ethical frameworks alongside emerging new ways of doing things, as, for example, we are seeing with new communication technologies. We must also include different perspectives in this process. All these factors are challenging and risky, but continuing in the current way and supressing the possibility of the new could also be unethical.

Recognising the Value of 'Messiness'

Osberg and Biesta (2008, p.324) point out that an educational approach informed by complexity theory:

> introduces a language of education in which the messiness of classroom practice and the unpredictability of learning can be made more central to understandings and justifications of teaching practices, so that it is no longer necessary to hide it away as something 'that all good teachers know but that they nonetheless cannot speak of'.

Messiness (the unplanned and uncontrollable aspects of the teaching and learning process) is not all that is important in education! Learning existing knowledge and skills is also important. However, recognition of the inevitability and value of some messiness enables us to ask whether rigid curricula and teaching practices leave any time or opportunity for unpredictability and emergence of the new.

Educationalists working with complexity theory include Osberg (in press), Biesta (2013), Davis and Sumara (2006) and Doll (1993). It is important to note they are not proposing complexity theory as a 'grand narrative': a solution to all our problems or to replace existing theories. Indeed, educationalists working with these ideas propose using them to 'perturb' existing theories and practices. Perturbation, in this sense, means to agitate or 'stir up' and is valuable since it creates the possibility of living in new ways and doing education differently. Many of the characteristics of complexity-informed approaches discussed so far can be identified with approaches to education which encourage participation. A key difference with complexity-informed approaches, however, is that what emerges from the participation has not been decided in advance. This is not the case with all participatory methods.

Critics of complexity theory in education (e.g. Hunter and Benson 1997) argue that ideas cannot be simply transferred from science and mathematics to the social sciences. However, Kuhn (2008, p.184) suggests that to think ideas develop in compartmentalised disciplines is too narrow and that a simultaneous awareness across disciplines of the need to understand the world in different ways has occurred. There has been a move within many disciplines from an understanding of the world as a finite machine to a more complex understanding of an emerging world where the parts that make it up are changing and evolving. This matters

for education since it means that knowledge is not simply something to be transferred or discovered, it also has the potential to be something *created* through the process of educational interaction.

Complexity as Metaphor or Actual Process

A question often posed regarding complexity thinking in education is whether it is being used as a metaphor or a literal description of actual processes. Turner (2005) suggests that rather than see these positions as opposites, it is possible to see them as positions on a spectrum which attempts to understand and describe the world. What is important are the insights that complexity theory can bring to understanding what is happening in the 'messy' places that educational settings can be.

Another related question is, which part of the educational process is being referred to as a complex system? Is it the societal or school level; the level of the classroom as a complex system or the learning process in the brain of each individual? Davis and Sumara (2006) suggest this question can be addressed by the concept of nested complex systems, with smaller or local systems nested within a larger system, like the parts of a Russian doll. Each part of the educational process can be a complex system nested within, and interacting with a larger one.

Box 10.1:

1. To what extent can you identify with the ideas of complexity theory and emergence? What do you see as the advantages and also possible problems with the theory and its uses in educational settings?
2. Does your classroom allow for messiness, for interactions, for the emergence of new ideas not anticipated in advance by you or the students?
3. What are the barriers to such emergence?
4. Do you think it is more appropriate to think of complexity and emergence as a metaphor or as an actual process? Does this distinction matter to you?

A Framework for Action

Doll's (1993) *4 Rs Approach*

A commonly recognised approach to curriculum development is that based around

Tyler's (1949) model of education geared to meeting the needs of an industrial society. Tyler identified four steps for successful instruction which probably seem very familiar to teachers in further education. The stages are: deciding on what needs to be achieved and stating this as learning objectives, identifying teaching methods which can most effectively achieve these objectives, organising the process and, finally, evaluating achievement of the objectives and the process used to achieve them.

One can argue there is something to be said for such a structured approach, sometimes, for some topics, but it is not *all* that education is or can be. The problem with the Tylerian approach is that what is to be learnt and the process for achieving it have already been decided in advance by the teacher and/or curriculum-setting body. Biesta (2013, p.1) points out that such a technocratic approach tries to take away the 'risk' inherent in the educational process. He reminds us, 'education is about lighting fires as well as filling buckets' and lighting fires is inherently risky. It is to encourage such open and interacting 'risky' settings in which the new can emerge (key features of complexity), that Doll proposes in his 4 Rs approach.

R is for richness: Richness refers to a curriculum's depth, to its layers of meaning and multiple possibilities or interpretations. Doll (1993, p.176) suggests a curriculum needs to have sufficient indeterminacy, anomaly, inefficiency, chaos, disequilibrium and lived experience to be provocatively generative so that new ideas can 'self-organise' and emerge, but not be so chaotic that they completely lose form or shape. What is 'sufficient' or the right amount cannot be determined in advance but needs to be negotiated and renegotiated in the learning process. Richness could be exploring patterns in mathematics, looking at text from a variety of standpoints in literature or considering different scientific interpretations. Practical and vocational subjects can also explore richness in the curriculum. For example, in plumbing, students can explore different interpretations of which power generators are 'carbon neutral' and why such decisions can be hard to make. Use of handheld devices (tablets, smartphones, etc.) can bring richness into classrooms and workshops. Indeed, it is often 'surreptitious' use of such devices that leads students to challenge or perturb the existing

wisdom put forward by the teacher. Teachers already do work with these tensions. Complexity-informed approaches do not necessarily introduce something new or strange; rather, they value and encourage the richness already apparent in educational practice. Complexity theory can enable teachers to feel more confident to explain to students that whilst the existing wisdom is important (especially for a multiple-choice test!) the tutor also values alternative and new viewpoints and is prepared to discuss what these could mean for future practices.

R is for Recursion: Doll (1993) differentiates between repetition and recursion. In repetition, the emphasis is negative—identify what you did wrong and then keep repeating the task until you 'get it right'. What is 'right' has already been determined. Recursion is positive—it explores what could be learnt from each iteration (activity) and incorporated into the next. The result of one experience informs the next and the way forward cannot be decided, or predicted, in advance. Some curricula require things to be done to a very particular standard and in a set way. In such situations it is still possible to reflect on some of the wider issues involved in the process. For example, in carpentry, even if the methods and end products are defined by an awarding body, one can reflect on the source of the wood, or what happens to offcuts. Moreover, most curricula do have more open aspects, such as modules on environmental protection, new developments in an industry and self-development units. As a further education teacher, it *is* possible to pay attention to such opportunities. It is also important to develop the reflective skills that students will need once in the workplace. Reflection needs to involve others in an open dialogue to bring about the richness that different perspectives can bring. It is also important to remember that reflecting in itself is not recursive if it is only used to identify and correct deviation from the 'right way'. In recursion, 'moving the goal posts' about what is 'right' is seen as a positive!

R is for Relations: How ideas and properties interrelate is a very important part of complexity thinking (Mason 2008b, p.48). Doll (1993) identifies two ways in which such relations are important in a transformative curriculum: pedagogical—the networks within the delivery of the curriculum—and cultural—how the curriculum relates to its wider environment. These occur simultaneously and intermingle.

Pedagogical and cultural relations between aspects of the curricula are explored through reflection and the exploration of the richness within subjects. There is no set knowledge to master, as though a single set knowledge exists 'out there', separate from us. Rather, ways of knowing, being

and doing are understood as emerging. What we do and discover becomes part of knowledge and such knowing cannot be undone. Furthermore, our contributions affect existing knowledge since there is now something in the world which was not there before (Osberg and Biesta 2008). For example, in IT, the programming that was developed to track the ownership of Bitcoin (a virtual money system—see https://bitcoin.org/en/) is now being used to track ownership of other assets—a technique which has been used to reduce corruption. Students in hairdressing can identify a new technique for reducing use of chemicals, and this can then be shared by the tutor with the wider industry via their professional body.

To encourage such exploration of pedagogical relations, Doll (1993) uses reading within the curriculum. With higher-level courses he details readings for initial weeks. In later weeks he asks students to choose readings and then report back to the group. However, this is not in the format of a résumé of content, but rather how the new readings relate to the earlier readings. With other groups he encourages students to engage with texts and ideas by reconsidering them in 'what if' scenarios, or from a first-person perspective. For example: 'Imagine if you were a customer wanting to install a new boiler/fitted kitchen. What safety considerations would you want to check out?'

Cultural relations—how our curricula relate to the wider world—can be explored through questioning our interpretation of knowledge and current ways we do things. It is through reflecting on how our understandings are influenced by, and interact with, local and wider conditions that we begin to develop new ways to live in the world. Cook (2004) has developed the website followthethings.com to explore such interactions. This mirrors a shopping site and students have uploaded articles about how products are made and transported and the impact of these on society and the environment. The emphasis is on our relationship with the makers of the products and the wider natural world rather than seeing products and services as somehow disembodied. There has been success in developing such approaches in schools and there is scope for developing such approaches within vocational curricula.

R is for Rigour: Doll (1993) suggests that rigour is essential to ensure that a transformative curriculum does not descend into 'rampant relativism' (anything goes) or sentimental solipsism (extreme preoccupation with, and indulgence of, one's feelings, desires, etc.). Rigour is not about using appropriate scientific methods and proof; rather, it is about purposefully and critically exploring sources, strengths, assumptions and

pitfalls of certain viewpoints and looking for connections. Doll (1993) does not claim that rigour understood in this way is unique to complexity theory. Rather, he emphasises that rigour has an important role within a complexity-informed approach.

Box 10.2:

Doll's (193) 4 Rs model encourages 'a large number of constituent elements to connect and interact in many different ways' with the hope that 'new and surprising patterns and structures will emerge.' (Mason 2008a, p.119)

1. What do you think are the strengths of his ideas? Would you like to try them out in parts of your own curriculum?
2. What are some drawbacks with the approach?
3. How could some of the drawbacks be overcome?
4. How do some of these ideas build on other models of education you have explored and how are they different?
5. Identify ways that you already incorporate these ideas into your practice and areas where they could be introduced or extended.

Democratic Approaches to ESD

Adapting Heron and Reason's (2001) co-operative inquiry approach to research, with its emphasis on researching *with* people rather than *on* people, offers a way to introduce a democratic approach into exploring 'what' is allowed to emerge in educational settings, since decisions about curricula are made with learners. Indeed Heron and Reason (2001, p.185) show awareness of complexity theory and emergence when they state that, in adopting co-operative inquiry:

> a mental mind-set is needed which allows for the interdependence of chaos and order, of nascence and knowing, an attitude which tolerates and undergoes, without premature closure, inquiry phases which are messy. These phases tend, in their own good time, to convert into new levels of order. But since there is no guarantee that they will do so, they are risky and edgy. Tidying them up prematurely out of anxiety leads to pseudo-knowledge. Of

> course, there can be no guarantee that chaos will occur; certainly one cannot plan it. But the group can be prepared for it, tolerate it, and wait until there is a real sense of creative resolution.

However, when we consider the issue of democracy the question of 'who' as well as 'what' is allowed to emerge becomes important. An 'open' attitude (i.e. not decided in advance by the tutor, the student, parents and society) to what constitutes a 'successful' learner or ultimately a successful adult creates a possibility that different ways of being and interacting with others in the world can emerge.

Case Study

The following case study discusses an ESD module using a complexity-informed approach with nine part-time in-service student teachers in the UK Further Education and Skills sector. The module drew on Doll's 4 Rs and Heron and Reason's (2001) co-operative inquiry model to encourage democratic emergence. In the first session, students were initially resistant to a module on ESD, anticipating they might be 'preached to' or burdened with yet more tasks. They vocalised this in the session and their discussions were written on the interactive whiteboard and posted to the group's virtual learning site. The student teachers also reflected on this experience in their personal learning records. Then, one challenged the tutor, saying, 'How can we expect students to care about taking responsibility for the world when they can't even take responsibility for bringing a pen to their lessons?' A definite pause occurred—and from the body language this appeared to the tutor (the author of this chapter) to be a thoughtful pause. Rather than countering this challenge, the tutor suggested the group might like to explore this. The group decided to take this 'interrupting question' as a starting point for the module.

The student teachers took the issue of responsibility back to their vocational students, who devised projects. These all had a connection to 'taking responsibility' ranging from reducing cyberbullying to taking responsibility for development of new values in addiction and substance abuse settings, mechanical engineering of a swing bridge which enabled regeneration, taking responsibility both for our own studies and for attending to the needs of our fellow classmates and music literacy as a way for young people to have a voice (Chave 2015). This initial process encouraged richness and reflective pedagogical and wider cultural relations.

Since these are not 'usual' sustainability topics, the student teachers were concerned as to whether the module moderator would accept them. The tutor contacted the moderator who confirmed their acceptability and provided this useful UNESCO (2005) definition of ESD as learning which aims to:

- respect, value and preserve the achievements of the past;
- appreciate the wonders and the peoples of the Earth;
- live in a world where all people have sufficient food for a healthy and productive life;
- assess, care for and restore the state of our Planet;
- create and enjoy a better, safer, more just world;
- be caring citizens who exercise their rights and responsibilities locally, nationally and globally.

During their weekly sessions, the student teachers chose activities and spontaneously offered to share areas of interest and expertise—again encouraging richness and pedagogical relations. Topics explored included the Milgram experiment (1963) and how this relates to taking responsibility for self and others; responsibility and sustainable construction; Rokeach (1973) on human values and Miller and Rollnick's (2002) motivational interviewing technique to encourage behaviour change. The emphasis was on reflective exploration of different ideas. These were written on interactive whiteboards, posted to virtual learning sites, and reflected upon in the student teachers' professional development records. They also tried out, reflected on and then retried teaching and learning methods (recursion) which could allow their learners to take responsibility. Approaches included: supporting the development of time management skills; peer teaching and work in action learning sets (students define problems and work on solutions with support from relevant others); case studies and project work; allowing time for students to develop trust in themselves, tutors and peers; use of technologies which enable learners to identify and research issues of concern to them; and avoiding 'spoon feeding' by the tutor.

The approach was chaotic at times, and it was necessary to provide some reassurance to the student teachers. One concern was whether they would 'pass' the module. The group solution to this was to devise a framework of headings for writing up their assessment—providing reassurance that order

could emerge from the 'generative chaos'. The tutor also brought along materials they had requested, for example, Biesta's (2003) discussion on responsibility in 'Learning from Levinas'. The students also requested some more 'standard' input on sustainability such as the 'linkingthinking' *resource* (Sterling et al. 2005) and Jensen and Schnack's (1997) action competence model. All nine students finished the module which was assessed by a teaching observation (the tutor commented on ESD aspects, including the 'taking responsibility' theme adopted), an informal presentation and a short written assignment. The module assessment was both rich and rigorous.

The evaluation of the unit was rigorous and included ongoing and final reflection by participants and tutor and external quality assurance which provided triangulation of the views expressed. Further quality assurance carried out included observation by the course leader of a session led by the tutor, moderation of the assignments including their professional development plans and comments from the student teachers to the quality assurance committee. Their comments indicated they both enjoyed and benefited from the approach and that it was 'provocatively generative' overall. They did comment that they felt anxious until they had reassurance from the moderator and had also devised their written assessment framework. Whilst it could prematurely close down the process to introduce this framework earlier into the module, the fact that it was a possibility could be explained earlier.

In the post-module review submitted to the moderator, the tutor reflected that the module worked well with the group as they were in the latter part of their programme and were comfortable and trusted each other and the tutor. Also they were ready for a different approach by this stage in the programme. This group of nine was small and the technique would need careful handling in a larger group. For example, 'fluid' subgroups could be established which could then report back to the whole group. The tutor needs to be confident with a more chaotic feel in the classroom and have the ability to *allow* students to run with ideas. Since the role of the tutor is to provide support and further information as requested—as well as sometimes challenging (or 'interrupting' [Biesta 2013])—the tutor needs to have time to respond to, and be skilled in, dealing with these requests and situations. Did new ideas emerge? Was the approach more democratic? The richness of issues discussed did encourage the student teachers and their students to explore sustainability and

find means to address the issue in ways that were meaningful to them. These were often original—emerging from *within* them rather than from external imposition. The range of topics, approaches and possible solutions explored helped everyone involved in the project to consider how sustainability is a complex, interconnected issue with no easy or one-size-fits-all solution.

Closing Thoughts

This chapter has explored complexity thinking, ways that emergence of the new can be encouraged and what this can contribute to ESD. It recognises that complexity approaches are already present in many educational practices. Knowledge of complexity theory can give tutors and students confidence not to be afraid and to value those messy, unexpected moments when new ideas and attitudes can emerge. It emphasises the importance of *allowing* opportunities for students to bring new and unexpected ideas into the educational process.

Much of what has been discussed relates to educational ideas and processes in general. This is valid. If we are to live more sustainably in the world, rather than see ESD as a bolt-on to an unchanged approach to the curriculum, we need to do education differently. Complexity thinking can contribute to this challenge.

Box 10.3: Areas for development

1. Use ideas from Doll's (1993) 4 Rs model and the case study to enhance an area of your curriculum. Reflect on these changes with your colleagues/peers and students.
2. Select a further reading idea from the list below. Identify how it enhances your understanding of the issues explored in this chapter and use these ideas to redesign part of your curriculum. Discuss why you have made these changes with colleagues.
3. Reflect on the issue of democracy in your teaching approach. How can you expand what and who are allowed to appear? Discuss your ideas with your peers/colleagues.
4. Visit the followthethings.com website. Reflect on how this could help you to redesign part of your curriculum.

References

Biesta, G. (2003). Learning from Levinas: A response. *Studies in Philosophy and Education, 22*(1), 61–68.

Biesta, G. (2013). *The beautiful risk of education.* Boulder, CL: Paradigm.

Chave, S. (2015). Toward temporal conceptions of education *as* sustainability: Contributions from complexity and process thinking. In W. Leal-Fihlo (Ed.), *Transformative approaches to sustainable development at Universities: Working across disciplines.* Springer International: Cham, Switzerland.

Cook, I. (2004). Follow the thing: Papaya. *Antipode, 36*(4), 557–785.

Davis, B., Phelps, R., & Wells, K. (2004). Complicity: An introduction and a welcome. *Complicity: An International Journal of Complexity and Education, 1*(1), 1–7.

Davis, B., & Sumara, D. (2006). *Complexity and education: Inquiries into learning and research.* New York: Routledge.

Doll, W. (1993). *A post-modern perspective on curriculum.* New York: Teachers College Press.

Heron, J., & Reason, P. (2001). The practice of co-operative inquiry: Research "with rather than "on" people. In P. Reason & H. Bradbury (Eds.), *Handbook of action research* (pp. 179–188). London: Sage.

Huebner, D. (1999). *The Lure of the Transcendent.* Mahweh, NJ: Erbaum.

Hunter, J. W., & Benson, G. D. (1997). Arrows in time: The misapplication of Chaos Theory to education. *Journal of Curriculum Studies, 29*(1), 87–100.

Jensen, B., & Schnack, K. (1997). The action competence approach in environmental education. *Environmental Education Research, 3*(2), 163–178.

Kuhn, L. (2008). Complexity and educational research: A critical reflection. *Educational Philosophy and Theory, 40*(1), 177–189.

Mason, M. (2008a). Making educational development and change sustainable: Insights from complexity theory. *International Journal of Educational Development, 29*(2), 117–124.

Mason, M. (2008b). What is complexity theory and what are its implications for educational change? *International Journal of Educational Development, 40*(1), 35–49.

Milgram, S. (1963). Behavioural study of obedience. *Journal of Abnormal and Social Psychology, 67*(4), 371–378.

Miller, W. R., & Rollnick, S. (2002). *Motivational interviewing: Preparing people to change* (2nd ed.). New York: Guilford Press.

Osberg, D. (in press). Learning, complexity and emergent (irreversible) change. *Sage Handbook of Learning.* London: Sage.

Osberg, D., & Biesta, G. (2008). The emergent curriculum: Navigating a complex course between unguided learning and planned enculturation. *Journal of Curriculum Studies., 40*(3), 313–328.

Rittel, H., & Webber, M. (1973). Dilemmas in a general theory of planning. *Policy Sciences, 4*, 155–169.

Rokeach, M. (1973). *The nature of human values*. New York: The Free Press.
Sterling, S., Irving, D., Maiteny, P., & Salter. J. (2005) *Linkingthinking: New perspectives on thinking and learning for sustainability*. Aberfeldy: WWF Scotland. RetrievedJune 29, 2015, from http://www.eauc.org.uk/wwf_linking_thinking_new_perspectives_on_thinking_
Turner, D. (2005). *The theory of education*. London: Continuum.
Tyler, R. W. (1949). *Basic principles of curriculum and instruction*. Chicago: The University of Chicago Press.
United Nations. (2005). *World Summit Outcome Document*, September 15, 2005. Retrieved May 9, 2011, from http://www.who.int/hiv/universalaccess2010/worldsummit.pdf

Further Reading

Doll (1993) provides, introduces, the possibilities offered by complexity-informed approaches to education and connects these to the work of theorists such as Piaget and Dewey.

Davis and Sumara (2006) provides a straightforward introduction to complexity thinking and education.

The *Journal of Educational Philosophy and Theory* published a special volume in 2008 (Vol. 40 No. 1) exploring complexity theory and educational research. It provides articles on: complexity theory and education (Mason 2008a and b), complexity and truth (Radford 2008), Foucault 'as a complexity theorist' (Olssen 2008), human research and complexity theory (Horn 2008) and the student as subject (Osberg and Biesta 2008).

Biesta (2013) provides a challenging discussion of democratic possibilities of adopting complexity thinking in education.