Curriculum: Developing a Systems Theory Perspective

Andy Begg
The Open University, England
<a.j.c.begg@open.ac.uk>

I am exploring general system theory as a framework for work-in-progress on curriculum and development. This paper outlines the influences that led me to general system theory, discusses some examples of systems, and concludes with related ideas about curriculum.

My research is concerned with curriculum and the development process in the context of mathematics. I see these as problematic because of the numerous influences on them: the people involved; the power struggles between them; the aims espoused by different participants; the changing nature of mathematics; the roles of different development activity, policy, research, and practice; and historical, cultural, and international trends.

I rejected a mechanistic/behavioural *research-development-dissemination* model as a framework for my study as in my experience it had often not worked in the intended way. Rather than building relations between process participants, the model often did the opposite: groups were separated and isolated, researchers' views were imposed on the developers, their views were imposed on disseminators, and so on to teachers.

From reading and listening to colleagues a number of influences impacted on my thinking: Cartesian dichotomies, biological ideas about learning, enactivism, ideas from phenomenology, the role of *unformulated* knowing, and complexity. An emerging theme with these was *systems*; by this I mean a shift to a new way of looking at things. Hence I began to explore system theory as a possible framework. The word *system* is common: educational systems, school systems, and examination systems. This usage fits with

> … a complex whole, a set of things working together as a mechanism or interconnecting network, an organized scheme or method, and the prevailing order (Pearsall, 2001).

This describes mechanical systems with Newtonian or cause-and-effect relationships, and ones where the interactions between the things are complex or emergent. In education these meanings are not separated, but it is the complex one that I am exploring.

Some Influences

There are a number of Cartesian dichotomies such as self/non-self, or self/world, which lead to others: subject/object, mind/body, and knower/known. They once formed the cornerstone of Western philosophy but have become problematic. Damasio (1994) refers to these as Descartes' error. While Descartes' ideas provided a new way of seeing the world, they also caused us to rely on reason rather than our senses and have led us to focus on building better representations of reality (Davis, 1996). These dichotomies come from the traditions of individualism in Aristotelian philosophy and Judaic and Christian religions.

A systems perspective sees the elements of these dichotomies as interrelated and influencing each other, rather than separated, and reason and sensory input are seen as contributing to a person's view of reality. From a curriculum perspective an awareness of these past dichotomies implies a need for a greater consideration of the role of the body, of the environment, and of the learner in the design of learning tasks.

Biology and Learning

Within biological studies of the mind the evolutionary metaphors of Darwin rather than the analytic and reductionist models of Descartes are gaining acceptance (Dennett, 1995). These ideas are not new in education. Plotkin (1998) claims that although William James embraced the ideas of Darwin in his early work in psychology these were not taken up by his colleagues. Piaget, with a background in biology, was also sympathetic to notions of evolution, and his idea of *fit* in constructivism is evidence of this. I am attracted to Maturana and Varela's work on learning that has been discussed by Capra (1996). He sees it as underpinned by Bertlanffy's (1928/1968) general system theory, the work of other biologists and ecologists, Gestalt psychology from the 30s, cybernetics, and the idea of self-organizing systems. In discussing their work Capra (1996) uses the metaphor of a *web* to explain the interrelatedness within and between living systems. He says

> In the emerging theory of living systems mind is not a thing, but a process. It is cognition, the process of knowing, and it is identified with the process of life itself. This is the essence of the Santiago theory of cognition, proposed by Humberto Maturana and Francisco Varela (p. 257).

Capra (1996, p. 95) describes Maturana's early work as focussing on two questions: "What is the organization of the living?" and "What takes place in the phenomenon of perception?" The breakthrough was seeing these as intimately connected. Capra asserts that Maturana sees a living system as self-organizing and self-referring, and perception and cognition as not representing an external reality, but specifying one through the nervous system's organizational process. In exploring these ideas Maturana (1970) saw humans as autopoietic (self-producing) systems with nervous systems structurally coupled to bodies and through this to the environment. That is, he saw the body and the nervous system as structure-determined systems, which means that the changes they undergo depend on their prior structure. Thus, within the process of coordinating with the environment, external influences can trigger but not determine any changes.

This perspective that equates living and learning implies continuous learning. One consequence of this is that a school curriculum needs to be envisaged as part of a total learning programme that must accommodate learning that is evolving from other sources.

Enactivism

My interest in enactivism developed from Maturana and Varela's work (Maturana & Varela, 1980, 1987; Varela, 1987, 1999; Varela, Thompson, & Rosch, 1991) together with interpretations from Davis (1996) and Davis, Sumara, & Luce-Kapler (2000). The theory regards the person as a living/learning system; the individual and their environment as linked; and knowing, doing, and being as inseparable. Instead of seeing learning as *coming to know*, one envisages the learner and the learned, the knower and the known, the self and the other, as co-evolving and being co-implicated. In this situation "context" is not a setting for a learning activity or a place where the student is. The student is literally part of the context. With enactivism the complexity of learning is emphasised:

> … learning should not be understood in terms of a sequence of actions, but in terms of an ongoing structural dance—a complex choreography—of events which, even in retrospect, cannot be fully disentangled and understood, let alone reproduced (Davis, Sumara, & Kieren, 1996, p. 153)

While enactivism can be seen as a variation of constructivism, it contrasts with it by emphasizing knowing rather than knowledge, and knowing in more than the usual sensori-motor and reflective modes. As I with colleagues (Begg, Davis, & Bramald, 2003), have written, two key conceptual shifts with enactivist theory are:

> (i) an enlargement of the notion of cognitive (or learning) systems, and
> (ii) the combining together of knowledge, activity, and identity.
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> On the first concept, a *learning system* is seen as any complex form that can adapt itself to changing circumstances. Examples include a stock market as it adjusts to unexpected economic news, an ecosystem as it establishes a new balance when the climate changes, a child who accommodates to the demands of a new classroom … such systems are dynamic and robust, able to change and adapt efficiently. Inherent in this notion is the broader definition of cognition as "coming to know", which includes traditional rational thinking and other forms of learning.
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> From such a perspective *learning* refers to transformations, those that expand the learner's potential range of action—and it is here that the second major concept fits into place. The suggestion that learning is a *transformation* is a reference to the physical character of a learning system. Upon learning, a system's patterns of activity and its associations—internal and external, with and in other systems—undergo physical change. … learning affects the entire web of being, and it follows that what one knows, what one does, and who or what one is cannot be separated. (p. 593)

Enactivism for me moves the focus of curriculum from knowledge external to the learner, to a range of possibilities that *evolve* as learners and knowledge co-emerge.

Phenomenology

Phenomenology is concerned with "that which appears and the manner in which it appears", and "attempts to get beyond immediately experienced meanings in order to articulate the pre-reflective level of lived meanings, to make the invisible visible" (Kvale, 1996). In this, Merleau-Ponty (1962) sought an alternative to dichotomous thinking; he rejected rational/empirical ways of knowing and claimed that "the body renders mind and world inseparable" with the body being "our means of belonging to our world". Such embodied views of knowing are not new. Dewey had a similar problem with Cartesian philosophy, took what is called a post-Darwinian or embodied view, and did not accept the mind/body or subject/external world splits (Boisvert, 1998). Maturana's ideas are similar to those of Husserl and Heidegger (Winograd & Flores, 1987), but he does not reference them. However, Varela, Thompson, and Rosch (1991) have elaborated on Merleau-Ponty's phenomenology, and claim that biological and historical interactions influence the mind.

Capra (2002, p. 45–46) describes how Varela has developed phenomenology into what is termed *neurophenomenology*. Within this, three approaches are used for first-person experience—introspection, as advocated by William James, phenomenology as developed by Husserl and followers, and meditative practices from within the Buddhist traditions.

These notions of embodiment and the complexity of interrelationships link with complexity theory and dynamic systems, and the ways of knowing which involve *being-in-the-world* or *knowledge-in-action* fit with the idea of unformulated knowing in enactivism. From a curriculum perspective phenomenology suggests to me the desirability of accepting personal introspection, awareness, and reflection-on-action as legitimate learning activity.

Unformulated Knowledge

Much of what we do, we are not conscious of doing, and this is termed *unformulated* knowing. Earlier theories did not explain the learning of unformulated knowledge; perhaps because we have seen the cognising agent as separate from the world (Davis, 1996). Davis talks about what we think and say (formulated) and what we do without conscious thought (unformulated), and how it is through both forms of coming to know that we learn. He sees formulated and unformulated knowledge as complementary and inseparable. This fits with meditative practices where one cultivates an awareness of body and thought and an awareness of relationships between them. Enactivism accounts for unformulated knowing because "every act is an act of cognition" and "we are not separate from, but coupled to, our situation/context". Davis summarises this with Maturana and Varela's (1987) phrase, *to live is to know*. In this context *cognition* means *to know* rather than *to think*, it includes unformulated knowledge and assumes action is equivalent to conscious knowing. Davis (1996) sees learning as resolving tensions between tacit and explicit knowledge, between emotional and reasoned actions, and between intuitive and calculated responses. He sees: understanding implying sympathy, meaning implying intent, and meaning having an affective dimension that is often ignored because of the Cartesian knowing/feeling split.

Unformulated knowledge can be interpreted as describing the knowledge that Piaget called motor-sensory (rather than reflective), and that Vico termed poetic, which included emotional, intuitional, and mystic knowledge—although Vico claimed that this could only be known by metaphor (von Glasersfeld, 2000, personal communication). While unformulated knowledge may be accepted within some arts subjects, I assume that it needs to be considered more broadly. While some educators, for example Vergnaud (1981) in mathematics education with his theorems-in-action, have done this to some extent, the existence of such knowledge needs to be recognised in curriculum. In addition, the place of the "informal" curriculum alongside the school one needs to be recognised.

Complexity

Four terms commonly used with complex systems are chaos, complexity, holistic, and ecological. Chaos and complexity are used synonymously by Gleick (1987) and Cohen and Stewart (1994), while others, like Hoban (2002) separate them. I think of the two words as synonyms but prefer complexity as it implies a structure underpinning apparent chaos. In such a system the outcome is unpredictable as one cannot control unpredictability, but one can seek to influence/manage it. Capra (1996, p6) used holistic to mean "seeing the world as an integrated rather than a dissociated collection of parts". Ecological is sometimes used for holistic, but, as Capra (1996, p. 6) claims, it has connotations of "the fundamental interdependence of all phenomena and the fact that, as individuals and societies, we are all embedded in (and ultimately dependent on) the cyclical processes of nature".

An acknowledgment of the interrelationship of influences within the learning process and within the way we see knowledge implies consideration of an integrated curriculum.

System Theory

In considering systems theory I have drawn on the work of Bertalanffy (1968, 1969), Laszlo (1996), Luhmann (1984/1995), and Foerster (2002). Other contributions are from Maturana and Varela with commentaries and interpretations by Capra.

Systems are not new: Aristotle observed that the whole is greater than the sum of its parts. Ecosystems have been taught in biology for many years. Piaget "related his conceptions to the general system theory of Bertalanffy" (Hahn, 1967). And Steiner (1984, p. 293) organised a topic group at ICME 5 to discuss theories of mathematics education and in his sub-title spoke of the need for "a comprehensive approach to basic problems in the orientation, foundation, methodology and organisation of mathematics education as an interactive system comprising research, development and practice".

Capra (1996, p. 43) claims that the work on systems began with Alexander Bogdanov who had three volumes on *Tektology* published between 1912 and 1927, though much of this work is unknown outside Russia. However, Bertalanffy is generally acknowledged as the founder of system thinking. His work started in the 1920s, although, he acknowledges,

> As "natural philosophy," we may trace it back to Leibniz; to Nicholas of Cusa with his coincidence of opposites; to the mystic medicine of Paracelsus; to Vico's and ibn-Khaldun's vision of history as a sequence of cultural entities of "systems"; to the dialectic of Marx and Hegel, to mention but a few names from a rich panoply of thinkers (Bertalanffy, 1969, p. 11).

He also saw Heinz Werner (1926) as introducing an organic-developmental approach as an early attempt to overcome the positivistic-mechanistic-behavioristic philosophy that dominated psychology. He went on to introduce his own contribution.

> In biology, I advocated an "organismic" conception, presented in *Modern Theories of Development* of 1928. In brief summary, the principles of organismic biology were, "the conception of the living system as a whole in contrast to the analytical and summative points of view; the dynamic conception in contrast to static and machine-theoretical conceptions; the conception of the organism as a primary activity in contrast to the conception of its primary reactivity". The parallelism with Werner's ideas is obvious (Bertalanffy, 1968, p. 2).

Bertalanffy's interests began in biology, but his general systems theory was broader. He was influenced by considerations of different types of systems and the mathematics of them. I do not intend to take a mathematical approach—my aim is to look at systems qualitatively and identify elements and interactions that make such a perspective appropriate for use with curriculum.

Examples of Systems and Some Links With Curriculum

Bertalanffy (1969, p. 39) saw closed systems as isolated from their environment, while open systems were not, and saw living organisms as open systems. When a system is defined as a complex of interacting elements then *general system theory* is concerned with the interactions and Bertalanffy (1968, p. 42) said that, "general systems are non-mechanistic in the sense mentioned, that is, regulative behaviour is not determined by structural or "machine" conditions but by the free interplay of forces".

Maturana and Varela introduced the notion of *autopoietic systems* that are *structurally coupled*. This property establishes the difference between the ways living and non-living systems interact with their environments. For example:

> … when you kick a stone, it will react to the kick according to a linear chain of cause and effect. Its behavior can be calculated by applying the basic laws of Newtonian mechanics. When you kick a dog, the situation is quite different. The dog will respond with structural changes according to its own nature and (nonlinear) pattern of organization. The resulting behavior is generally unpredictable. … As a living organism responds to environmental influences with structural changes, these changes will in turn alter its future behavior. In other words, a structurally coupled system is a learning system. … As it keeps interacting with its environment, a living organism will undergo a sequence of structural changes, and over time it will form its own individual pathway of structural coupling (Capra, 2002, pp. 35–36).

If I replace "dog" with "curriculum" and "kick" with "nudge from a mathematician who wants set theory introduced, a statistician who wants more statistics, or a bureaucrat who wants more assessment", then we have a complex learning/living system. In this situation "living" has an extended meaning, and learning includes evolving without consciously being aware of change as well as learning in the traditional sense.

Society is a self-producing or autopoietic system of communications (Luhmann, 1984/1995). While such communication (feedback or interaction) within a system is important, communication itself is a system—it involves interacting components, and we know from classrooms that such communication systems are not mechanical. Schools and classes have been described as knowledge-exchange systems, social systems (or sub-systems) and as open systems. A class is a system open to its environment, the school system; the school in turn is open to the educational system, which is open to society. Change in terms of curriculum, resources, assessment and professional development is itself an open system or a series of subsystems with interactions from the environment. If curriculum is thought of as a document, then it is a closed system, but if it is what is planned and implemented with children then it is a living/learning system.

Bohm (1994) considered "thought" to be a system. He said that it includes what we normally think of as thought together with feelings, states of the body, and all of society (currently and historically), and this incorporates social constructivism. He saw thought as developing, changing, evolving, and as having one systemic failure—fragmentation.

Is mathematics a system? Davis and Hersh (1981, p. 53) cite a Russian mathematician

> ... if we compare mathematics to a living organism, mathematics does not resemble conscious and purposeful activity. It is more like instinctive actions which are repeated stereotypically, directed by an external or internal stimulus ... one can say that the development of mathematics is different from the growth of a living organism which preserves its form and defines its own border as it grows. This development is much more akin to the growth of crystals or the diffusion of gas which will expand freely until it meets some outside obstacle (I. R. Shafarevitch).

I see mathematics as a subject system with interrelated parts, and school mathematics in its "intended" form as a system involving mathematics, statistics, and education. In its "implemented" form it also involves the school, the teachers and the pupils. At the same time, mathematics is part of a Western partitioning of knowledge (into sub-systems) and people from other cultures may see it only as part of a broader knowledge system.

With system thinking one looks to see structures that underlie complex situations, that is both the parts of the system and the relationships between them. Of course it can be argued, (for example by Capra, 1996, p. 37.) that "there are no parts, merely patterns of inseparable relationships". Seeing the parts is difficult with a system such as curriculum because of the complexity. Thinking of curriculum as a system means one cannot think of the relationships as causal or strongly correlative as in the past. For example, if something in a curriculum is taught in the prescribed order it does not mean that the intended learning will follow. As Laszlo (1996) suggests, we need to look at complex systems as we would look at a team rather than individual players, at a business rather than the workers, and a country rather than individual people. Laszlo wrote,

> … wholes ... cannot simply be reduced to the properties of their individual parts. ... Of course ... we could fully account for the properties of each whole if we could know the precise characteristics of all the parts and know in addition all existing relationships between them (p. 5). ... (And later) ... the characteristics of complex wholes remain irreducible to the characteristics of their parts (p. 6).

Laszlo (1996, pp. 25–58) looked at what stays the same and what changes in systems, though he accepts that most things change given enough time. He discussed how natural systems maintain themselves in changing environments (p. 30) and called these steady-state systems. He saw human beings, ecologies, and societies as examples of natural systems. He discussed how organisms slowly exchange all their parts—although a dramatic change in their environment may exceed their adaptive ability, and over time, ageing means that an organism may not be able to continue to heal and regenerate itself. But, such systems have developed ways of perpetuating themselves—reproduction. Laszlo discussed how social systems perpetuate themselves by developing rules, regulations, laws, principles, customs, habits, etc. University courses are an example of this—students complete a course, new ones come on and conserve the structure, the course may slowly evolve as a result of the students' impact and the lecturer's insight, but there is a degree of relative invariance in the midst of change.

Laszlo (p. 39) discussed how natural systems respond "to changing conditions which cannot be offset by adjustments based on the existing structure" He spoke of change as being of two forms. There is the pre-programmed kind, like ontogenesis that involves the growth and maturation of the young of self-reproducing species. And there is the evolutionary kind, which is typical of phylogenesis. Again, thinking of curriculum, this parallels the growth/development of a school subject such as mathematics, and the major changes that occur from time to time such as when the radical changes of "new math" occurred or when teachers are asked to make fundamental changes to their practice.

Laszlo (1996, pp. 40–52) discussed this evolution in terms of whether it is purposeful or whether it evolves randomly but according to some "laws". He saw variations being randomly produced with the successful ones being those that are more compatible with their environment. This leads to a slow emergence of discernible order within systems. He saw this evolution not as a smooth and continuous, and suggested that incremental improvements are seldom of fundamental importance—while they may adapt a system they are not likely to change it in a radical and lasting way. He saw complex systems as having considerable instability, and persisting by buffering out forces that threaten to radically change their structure (that is, rejection rather than accommodation or assimilation). In this situation evolution becomes more revolutionary when a system is critically destabilized and must either evolve or perish. Then there may be sudden upheavals that create fundamental (rather than incremental) change in the systems, changing not only their internal structure, but also their external relations. Thus he saw system evolution as pre-programmed but not pre-established.

Conclusion

Looking at curriculum in terms of development and implementation, I am aware of the competing and cooperating influences that influence the curriculum process. From an enactivist perspective, the aim in teaching is not to link learners' experiences to an external curriculum, but to view the curriculum as being *occasioned* by the learners' experiences in their school environment. Davis (1996) describes this as *curriculum anticipating*. In terms of change over time, curriculum does change, although usually not as intended, and this suggests the need to consider change as a non-causal system. Such issues suggest a need to redefine what we mean by curriculum, and to acknowledge its complexity. I see a systems perspective as enabling me to look at curriculum differently, but more work is needed to bring together the ideas about systems and curriculum. However, while I see curriculum as a complex system, policy makers, teachers, and parents generally prefer less complexity.

Acknowledgment

I wish to acknowledge my colleagues John Mason and Linda Haggarty for comments on earlier drafts of this paper.

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