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Foundations for a post-modern curriculum

WILLIAM E. DOLL, Jr

> Where classical science used to emphasize permanence, we now find change and evolution; we no longer see in the skies the trajectories that filled Kant's heart with the same admiration as the moral law. We now see strange objects: quasars, pulsars, galaxies exploding and being torn apart, stars that, we are told, collapse into 'black holes', irreversibly devouring everything they manage to ensnare. (Prigogine and Stengers 1984: 214–215)

With this quote we see our vision of the universe turning from the simple, stable, eternal one of Newtonian modernism to the complex, chaotic, finite one of post-modernism.

Ilya Prigogine, the 1977 Nobel Prize winner in Chemistry, and Isabelle Stengers, professor of philosophy at the University of Chicago, begin their book, *Order Out of Chaos*, with the following statement: 'One of the greatest dates in the history of mankind is April 28, 1686' (1984: 1). This is hardly a date, just over 300 years ago, that many of us remember from our school textbooks. Yet is it a prominent date in the history of Western thought and even plays an important, although often unrecognized, role in the history of curriculum. 28 April 1686 is the day Issac Newton presented his *Principia* (*The Natural Principles of Philosophy*) to the Royal Society of London. Book III of this treatise, the one containing Newton's famous 'universal law of gravitation', is entitled 'The system of the world'. This system has, since Newton's death, become a paradigm, a paradigm which we now see began with the observations and musings of Francis Bacon, Nicholas Copernicus, Galileo Galilei and Tycho Brahe. This paradigm dominated Western scientific and intellectual thought well into the present century, and continues today, as the foundational model for the social sciences, including education. As Christopher Lucas (1985: 165) has expressed it:

> The abandonment of Newtonian mechanics as a paradigm for understanding reality is relatively well advanced. Yet, the metaphysical view of the world it once inspired has proved rather more durable. Perhaps because of cultural lag, only in recent decades have the philosophical implications of quantum physics begun to reverberate through other knowledge domains. Overall, the new image of reality unfolded by modern science portends a radical revision of how the world and human consciousness itself is to be comprehended.

The modern scientific view Lucas mentions here is more commonly called a post-modern view and, to the degree this view represents a radical revision of the world and human consciousness, so, too, does it have radical implications for education and curriculum.

It is not easy to define 'post-modern', even though the word has been hyped by popularizers and image makers. As Stephen Toulmin (1982: 254) points out, the

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modern world is behind us, but the post-modern world is so recent that it 'has not yet discovered how to define itself'. In spite of this, a definition can be started. Brent Waters says that post-modern views 'represent a critical reappraisal of modern modes of thought, religious belief and moral conviction'. Such views invite 'deepening suspicion of the rigid dichotomies modernity has created between objective reality and subjective experience, fact and imagination, secular and sacred, public and private' (Waters 1986: 113–122). Prigogine and Stengers pick up this interactionist and holistic theme when they say that through post-modern science we are 'developing a new dialogue with nature', one wherein 'our vision of nature is undergoing a radical change toward the multiple, the temporal, and the complex' (1984: xxvii) and, conversely, away from the universal, the stable, and the simple, which Newton's system posited.

The roots of this post-modern view of the world are to be found, in part, in the quantum physics debates Albert Einstein, Niels Bohr and Werner Heisenberg had in the 1920s. The systems approach of Ludwig von Bertalanffy also has been seminal, as has been the developmental biological work of C. H. Waddington and Jean Piaget. In philosophy, Alfred North Whitehead's *Process and Reality* (1929) is used as a foundational pillar. However, the person who has drawn on all of these, synthesized them, and added his own contribution is Ilya Prigogine with *From Being to Becoming* (1980) and (with Stengers) *Order Out of Chaos* (1984). In these and in his work with non-equilibrium thermodynamics Prigogine has drawn heavily on the fields of non-linear mathematics and physical chaos.

My argument is that Newtonian thought is one of the foundations on which the present-day curriculum is based. Direct correlations can be made between Madeline Hunter's or Ralph Tyler's notions of an orderly curriculum with ends pre-set and Newton's idea of a stable universe with planets rotating around the sun in perfect harmony. Harmony is definitely a modern, not a post-modern, concept, but it is the ideal goal of a Tyler–Hunter curriculum. Disturbance is not viewed here as a key, necessary, or desirable ingredient. Connections can also be made between B. F. Skinner's or James Popham's view of expressing learning in discrete, quantifiable and linear units and Newton's approach to the calculus. Both are reductionist, assume the whole to be no more than the sum of the parts, and lead to a curriculum which is cumulative rather than transformative. This connection between curriculum and the Newtonian paradigm I have explored elsewhere in greater detail (Doll 1986, 1988).

In this paper I will focus on three facets of post-modern thought – foundational assumptions, as it were – which have radical implications for curriculum. These three are (*a*) the nature of open (as opposed to closed) systems, (*b*) the structure of complexity (as opposed to simplicity) and (*c*) transformatory (as opposed to accumulative) change. Before exploring these three facets I would like to make a few comments about Ilya Prigogine and his role in post-modern thought.

Prigogine received the 1977 Nobel Prize in Chemistry for his work on dissipative or far-from-equilibrium thermodynamic structures. A far-from-equilibrium structure is one in the process of becoming, such as in a basin of water when the hot and cold are beginning to merge and blend. Structures of this sort characterize chemistry and biology. They become the very essence of living systems. They are not the physical, inert, mechanical structures Newton used in his *Principia*. Hence, in *From Being to Becoming*, Prigogine is describing chemical and biological structures, particularly those in the formative, developmental, emergent state. While the world is obviously made of both stable structures, which have settled into a state of equilibrium being, and unstable (or dissipative) structures, which are in a formative, and indeed chaotic, state of far-from-equilibrium becoming, Prigogine believes the latter to be more common than the former. On this basis, curricularists should study dissipative structures as a foundational model – albeit the model will be a difficult one to develop and evaluate. In fact, the mathematics involved in far-from-equilibrium situations is the relatively recent complex and complicated mathematics of non-linear algebra. Prigogine has been outstanding in calling upon this mathematics as he has developed his theories, just as Newton was outstanding in calling upon the linear calculus he developed for his theories. As John Briggs and David Peat point out in *Looking Glass Universe* (1984), scientists have not had, until recently, the mathematical tools to deal with far-from-equilibrium situations and so, as Waddington (1975) charges, they have either ignored developmental aspects in their research or they have assumed far-from-equilibrium situations to be but variations on equilibrium situations. Not so, says Prigogine, echoing statements made previously by both Waddington and Piaget. Far-from-equilibrium (or developing) structures have their own indigenous peculiarities – and, I would add, are useful as considerations for curriculum research and thought.

If the hot- and cold-taps in the basin described earlier are shut off, the two streams of water will mix gradually and reach an equilibrium state of being. Here there is gradual movement towards closure, and also towards stagnancy and the loss of heat-producing energy (death by entropy). If, however, the taps are not shut off there is the possibility of transformatory change: hot enough water will produce steam, cold enough water will move the basin towards the freezing point. Here the pattern is not one of gradual change, but of chaotic, turbulent, sudden change. Prigogine, speaking metaphorically, talks of combining red and blue molecules, in the manner of the hot- and cold-water taps. In an equilibrium, or near-to-equilibrium, situation one would see the red and blue molecules mixing to form a visual purple pattern or hue. But in far-from-equilibrium situations where boiling or freezing transformations are about to take place, the molecules change all at once: it is as if all the blue molecules became red without any intermediary purple step. The change is a quantum leap. Here Prigogine talks of self-organization and communication: 'To change color all at once, molecules must have a way to 'communicate'. The system has to act as a whole' (Prigogine and Stengers 1984: 148). This example is reminiscent of Waddington's 'genetic landscape', where pathways (chreods) are formed in which a gene continues until a threshold is reached when a sudden and dramatic genetic change occurs. Piaget used this concept from Waddington for his theory of transitions from one intellectual stage to another. I have discussed Waddington's and Piaget's views on this at length elsewhere (Doll 1983). Prigogine calls these far-from-equilibrium, transformative structures dissipative, because in their interaction with the environment they depend upon a certain amount of dissipation to occur for the self-organizing aspect of the structure to function. Indeed, order does literally arise out of disorder or chaos. This leads to the three facets of dissipative structures I would now like to explore.

Open vs. closed systems

In thermodynamics it is common to classify heat–energy–matter exchange systems in terms of isolated, closed or open. Isolated systems are, as their name implies, removed from their environment, exchanging nothing with it. A perpetual-motion machine is the ideal example for this. A closed system exchanges energy, but not matter, while an open system exchanges both energy and matter, and actually rejuvenates itself through this exchange. In a broader sense a closed system is one that is tightly controlled, as in a steam engine, where the variables are few, the parameters pre-set, and the predictability high. This is how a steam engine achieves efficiency. It is also the model Hunter and Tyler assume when ends are pre-set, objectives are developed in line with those ends, and closure is a return to the ends and the objectives to see they have been carried out. With its feedback loop, this is a systems view of curriculum, but not a living, open-systems view. Open systems literally 'feed on flux', using flux as the substance for their continual becoming: 'They [open systems] feed on the flux of matter and energy coming to them from the outside world'. Biological 'cells die when cut-off from their environment... they cannot be separated from the fluxes that they incessantly transform' (Prigogine and Stengers 1984: 127). The contrast here is between (*a*) a highly controlled (steam engine) system where external parameters shape interactions towards a pre-set end of efficiency, and (*b*) a fluctuating (living cell) system where external perturbations provide the system with the very means for internal transformation. Here ends are literally integrated with means. John Dewey would be pleased.

Obviously these systems are dichotomous. A closed system, like Skinner's teacher-proof machines, wants to protect itself 'from the fluxes that compose nature' (Prigogine and Stengers 1984: 128). An open system, on the other hand, needs fluxes, perturbations, anomalies, errors: these are the triggers which set-off reorganization. As Piaget (1977: 13) has said: 'It is worthwhile to note that however the nonbalance arises, it produces the driving force of development'. It is ironic that Piaget's open, living-system model of development – equilibrium disturbed by disequilibrium leading to re-equilibration – was so easily converted into a closed system, age–stage correlation. However, considering the Newtonian background assumptions which have dominated American curriculum, it is not surprising.

The curriculum implications here seem obvious – namely, curricularists should study open systems in both a metaphoric and literal sense. Metaphorically we should structure and study curriculum in such a manner that internal, autocatalytic transformations are encouraged to occur. Piaget called this process phenocopy. In our present closed-system format this concept is absurd: autocatalytic, transformative structures do not appear as part of the literature, and the 'noise' which produces them is quickly and quietly factored out. The result is that this transformative process remains more mysterious and magical than it should. At the literal level, we should study open systems wherever they occur: in biology, in chemistry, in medicine. Again to quote Piaget, on the main thesis which has guided his work: 'Life is essentially autoregulation' (1971: 26). This, he says, is a trivial, even banal, thesis, but one too often overlooked. It is not a thesis which has guided curriculum modelling or practice.

The simple (and separate) vs. the complex (and cosmological)

Newton's universe was a simple universe. The mathematics is that of lines, trajectories, areas – all simple, linear concepts. Newton assumed the universe to be one large arithmetic grid with each set of co-ordinates proportionally consistent with every other set of co-ordinates. It was a view which posited harmony, order, uniformity. One of the revolutions which came from this era, the industrial revolution, was itself based on simple mechanics. As Daniel Bell (1973: 20) points out, the mechanical inventions which made this revolution were done by 'talented tinkerers' of a practical and simple bent. However, beyond such a surface level there was what Edwin Burtt (1927: 348) calls 'the postulate of simplicity'. This principle states that Nature always works in the simplest manner, or goes by the simplest route: 'Natura semper agit per vias brevissimas' (Burtt 1927: 26). It was this principle which influenced Copernicus in his theory of a sun-centred universe, and which dominated Western thought from Plato to Einstein. Acceptance of this principle allowed Newton to posit his notion of an objective, God's-eye view of time where could be seen the past, the present and the future. In fact, the concept of objectivity we now have is based on the assumption of such a simple-ordered reality, one which allowed Laplace to state that 'Newton was the luckiest of men who ever lived, for there is but one order to the universe and he has discovered it' (quoted in Burtt 1927: 18). In its own way this statement of Laplace's captures well the curriculum activity of many fourth- fifth- and sixth-grade classrooms.

Prigogine challenges this concept of the simple with his own concept of the complex. As he and Stengers say, in the first sentence of their preface: 'Our vision of nature is undergoing a radical change toward the multiple, the temporal, and the complex' (1984: xxvii). Complexity became part of the scientific world in the early decades of this century when Einstein developed his theory of relativity and quantum physicists explored the strange world of the atom. Today complexity is a field of study in mathematics, in management, and in sociology. It is part of our daily lives. Prigogine and Stengers (1984: 209) argue that this emerging 'new science of complexity' is more characteristic of reality than is simplicity, but that we have been trained in 'terms of linear causality', and now need 'new tools of thought'. This applies very much to schoolteachers and the educational training they receive and the models of learning they are taught. Here the works of Howard Gardner (*Frames of Mind*, 1985) and Robert Sternberg (*Beyond I.Q.*, 1985) are breaths of fresh air in a stale field. Stephen J. Gould's *The Mismeasure of Man* (1981) is a fine and cautionary history of the intelligence-testing field with its strong connection to Newtonian assumptions.

Complexity assumes reality to be web-like with multiple interacting forces. We, as observers, are inside, not outside, the web. Thus, knower and known are interactively entwined. There is no God's-eye view here, and objectivity takes on a new subjective dimension. We are limited in our perceptions and evaluations by our own places in space and time, trapped, as it were, by our own historicity. This is why Prigogine makes time and 'its arrow' such an important element in his theory.

Further, with multiple interacting elements occurring in most situations it is difficult to predict their development, to know how a complex system will respond to a given change. In simple situations – those near equilibrium with few variables, easily described by linear mathematics – there is a uniform proportional relationship between cause and effect. Small perturbations cause small effects. Predictability is based on this stable relationship. In complex situations, however, this simple relationship does not hold. A small perturbation, acting among many intertwined elements, can have a multiplying, even exponential, effect. And some of these effects are of a transformative, qualitatively different nature, as in atomic reactions.

It is too early to tell what the new 'tools of thought' will be which are to help us understand how complex systems respond to given changes. Currently we are left with the frustration of the MIT scientist who coined the word 'counterintuitive' because 'the damn thing does not do what it should do' (Prigogine and Stengers 1984: 203). However, Prigogine does give examples of complex situations reaching thresholds of stability/instability and then spontaneously reorganizing themselves into newer and higher orders of complexity. This is akin to the model of human evolution Stephen Gould and his associates have been advancing under the title 'punctuated evolution' (Gould 1982). At the very least we can say that dissipative structures do not necessarily lead to entropy (gradual death by loss of heat and energy); biological evolution is a dramatic and long-term counterpoint. Some structures – intellectual, biological, chemical – do reorganize and rejuvenate themselves on a higher plane or level of complexity.

Paralleling the dichotomy between the simple and the complex is that between the separate and the cosmological. As Toulmin (1982) points out, modern, Newtonian science reacted strongly to the all-embracing cosmological views of the ancients and substituted instead a separatist, and ultimately reductionist, methodology of partitions. Descartes is famous for his separation of all being into Body (*res extensa*) or Mind (*res cognitans*). Newton followed this trend, and so did the German curriculum makers of the nineteenth century. Thus today, in schools and colleges, we study 'separate and distinct disciplines' (Toulmin 1982: 228). This sense of specialization and separation is coming under increasing challenge in a post-modern world, but the curriculum implications of a cosmological view have hardly been explored, though one notable exception to this statement is Donald Oliver and Kathleen Gershman's *Education, Modernity, and Fractured Meaning* (1989).

While the 'astrocosmological' view of the ancients is not a goal we wish to readopt, Toulmin does argue for a new cosmological perspective: one which accepts the progress and triumphs of a scientific, reductionist methodology, but places this methodology within an interactive and holistic framework. What we see depends upon where we stand in the web of space and time. Specifically, Toulmin argues for recognizing, as Dewey did, that the knower and the known are intertwined, for realizing that a science without humanity – without values, purposes, beliefs – is a false science, the false science of the spectator who always stays outside the arena of action, removed from the existential happenings of life – the 'pure' scientist as the phrase goes. This spectator view of science, of knowledge and of teaching is a thing of the past. But in curriculum its spectre still haunts us. Far too often our curriculum is reductionist, and far too often this curriculum assumes the teacher to be a spectator in the arena of learning.

To move from a curriculum based on the simple and separate to one based on the complex and cosmological requires us not only to adopt a 'new dialogue with nature' (to use Prigogine's phrase), but also to adopt a new relationship with our students, a radically new relationship. To paraphrase (and slightly alter) some fine lines from Donald Schön (1983: 296):

> In a reflective contract between teacher and student, the student does not agree to accept the teacher's authority, but to suspend disbelief in that authority. The student agrees to join the teacher in inquiry, in trying to understand what the student is experiencing, and to make that understanding accessible to both the student and the teacher.
>
> The teacher, on her part, agrees to help the student understand the meaning of the advice given and the rationale for it; to make herself readily confrontable by the student; and to reflect with the student on the tacit understandings each have.

From such a reflective relationship a transformative and post-modern curriculum can be born. Such a relationship will not be sufficient for transformation to occur, but it definitely will be a necessary factor.

Transformative vs. incremental change

By its nature, education, and the curriculum which guides it, is committed to change – directed, purposive, intentional change. Change, however, in a modern, closed system is categorically different from change in a post-modern, open system. In Newton's ideal universe, stability, not change, was the desired goal; change occurred rarely – and then was the result of a flaw in the universe which God as *Deus ex machina* put right by direct intervention. This caused Leibniz to remark that Newton's God really was neither omniscient nor perfect, since He had to readjust His handiwork. In any event, change in the Newtonian framework was looked upon negatively, not positively. While both entropy and evolution destroyed the 'perfect harmony' of Newton's system, change was still handled in a controlled, incremental way. Even in the Darwinian evolutionary thesis of 'Nature red in tooth and claw' from unbridled competition, there exists an 'invisible hand' guiding change towards a better future and a higher species. Change still exists here, incrementally, within a system maintaining order if not closure.

This view of change has carried over to the twentieth-century, which is one reason quantum physics, with its non-predictable leaps, seems so strange: it violates our normative expectations. In many ways B. F. Skinner represents the twentieth-century, modern view towards change: committed to it within certain well-defined parameters, but fearful of it lest change break those parameters. The political repercussions here are immense, as both the Marxists and the fundamental conservatives have shown. In any event, change which is associated with chaos, complexity, confusion and uncertainty is not a part of modernist thinking. Teaching machines and programmed learning control change in restrictive, incremental units, purposively designed to avoid error.

A post-modern view looks upon change in an entirely different light. Change is seen in transformative, not incremental, terms; and errors are seen as necessary actions in the process of development – the motors which drive development. Allied with this, of course, are theories of chaos, uncertainty and confusion taking ever increasing roles in the fields of management, mathematics, political science, physics and sociology. This is one reason why Prigogine's work on unstable structures has proven so popular.

Transformative change in an open system has a number of assumptions antithetical to a modernist view. It is these assumptions which make post-modern thought radically different from modern thought, even though certain curriculum practices may fit both systems. Three of these assumptions are those of internality, spontaneity and indefiniteness. Each has curriculum implications which, intertwined, produce, as Piaget realized, a change of quality not merely an increase in quantity. These changes are changes in states of being and hence become, in Prigogine's terms, becomings. Transformative change is a change in view, in perspective, in methodology. It permanently alters one's relationship to nature, to life, to the environment, to learning. It is characterized by the sort of *Gestalt* switches Piaget describes as the child or youth moves from stages of actions to those of representation, relations and systems (the pre-operational, the concrete operational, the logico-mathematical).

Internality, or internal reorganization, is a key assumption in transformative change. In a Newtonian, Darwinian, or Skinnerian modernist system, change is externally controlled or directed. Either God is directly intervening, or the environment is moulding, or the teacher is shaping by reinforcement. All these actions are performed by an active force external to the recipient, who remains passive. This is the famous spectator theory of knowledge which Dewey, Piaget and Toulmin reject so vociferously. Learning in this model occurs as the recipient receives that which is given or adapts to the external forces the environment provides. With an internalist or constructivist set of assumptions, change is the result of internal reorganization triggered either by the organism itself or by the organism reacting to external forces. In either case, internal restructuring by an active organism or learner is essential. A post-modern curriculum will accept the student's ability to organize, construct and structure, and will emphasize this ability as a focal point in the curriculum. The development of this organizational ability is as much a key to the post-modern curriculum as passive receptivity or shaping is to the modern curriculum.

Such organizational ability can be trained, as Bruner (1961, 1966) has argued in his 'Discovery' essays. However, as Piaget has argued, and as Bruner has accepted, there is still a strong element of spontaneity in the transformative process. Internal reorganization is an interactive process and, while it definitely is influenced by external forces, it does not mirror those forces. In Piaget's terms it both assimilates and accommodates them. When a transformation occurs allowing new perspectives, there is a suddenness to the transformation. As Prigogine says, 'all the red molecules turn blue'. A post-modern curriculum must allow time for this internal restructuring to take place, and must look for evidence of spontaneity about to occur. Development here, as Gould asserts, is via spurts not increments. Again, Bruner's work on the perception of incongruity is valuable here, and should be followed up with further research. While the conscious breakthrough to a new level of organization occurs suddenly and spontaneously, a long period of subconscious preparation appears to be not only important but necessary. Our modern methods of teacher–student interactions will need drastic revisions to enhance this model of learning. For one thing, teachers will need to combine supportive behaviour with challenging behaviour – equilibrium with disequilibrium – and to give students time to organize their own thoughts. In regard to this latter point, Dillon's (1987) work on questioning may prove to be a useful guide.

In a modernist perspective curriculum plans are to be well articulated, with ends clear and means precise. This is the key to the Tyler–Hunter model. In a post-modern curriculum there must be, as Dewey realized, a sense of indecision and indeterminacy to curriculum planning. The ends perceived are not so much ends as beginnings; they represent ends-in-view, or beacons, which act as guides before the curriculum implementation process begins. But once the course develops its own ethos these ends are themselves part of the transformation; they, too, along with the students, the teacher, the course material, undergo transformation. The locus of power and direction shifts from the external to the internality of the course experience. The ends more and more emerge from within the course in a conjoint fashion, the teacher more and more becomes *prima inter pares*, and the canons of inquiry and creativity more and more take over the direction and process of development. Here curriculum becomes a process of development rather than a body of knowledge to be covered or learned, ends become beacons guiding this process, and the course itself transforms the indeterminate into the determinate.

In a post-modern curriculum, then, there is a sense of both cosmology and teleology: cosmology in terms of intergral wholeness, teleology in terms of purposiveness. To this extent a post-modern curriculum is in opposition to a modern curriculum, with its separate parts, and is a throwback to the pre-modern curriculum of the Christians and the classicists. However, there is a key difference here. The pre-modern world view was externally oriented, either towards Plato's Forms, or Aquinas' God. The post-modern world view is internally oriented: forms, gods, goals emerge from interactions. Thus the cosmology and teleology are 'lesser' not 'greater'. A post-modern curriculum will combine the best of pre-modern thought with the best of modern thought, and will, like alchemies of old, transform both into a new substance or process.

Conclusion

In the preceding pages, I have endeavoured to provide a foundational framework for curricularists interested in studying the post-modern vision. Let me close by reiterating and elaborating some specific recommendations. Overall, I have argued that to break away from the modernist framework, in which the Tyler rationale is embedded, curricularists should, indeed must, study contemporary developments in the fields of biology, chemistry, cognition, literary theory, mathematics, and theology. In all these fields new models are emerging which pay attention to such issues as disequilibrium, internal structuration, pathways of development, and transformative reorganization. I am not advocating that curriculum directly borrow models from these disciplines – too often this has been counterproductive. But I am advocating that curriculum designers, researchers and theorists be inspired by new work in these fields – that they study this work with an eye towards its curriculum implications. Personally, I find such study heuristic. Let me list three illustrations.

If development is – as Gould, Piaget and Prigogine assert – punctuational and erratic, not linear and incremental, then we need a curriculum which can, interactively, both encourage and control the equilibrating forces of development. Piaget's basic model of equilibrium–disequilibrium–re-equilibration may be used as a general guideline. Here, we will envision curriculum not as a linear trajectory nor as a course (with hurdles) to be run, but as a multifaceted matrix to be explored. In this matrix, places where one begins and ends are far less important than how well one explores the myriad connections, logical and personal, inherent in the matrix. In regard to daily lesson plans the focus would be not on closure but on flexibility for alternative yet productive pathways. Lesson plans would be designed to provide just enough disequilibrium that students would develop their own alternatives and insights. Disequilibrium and re-equilibration would be intentional components of the lesson plan. Lest the daily stress of such procedures become too great, it might well be best to alternate lesson plans oriented towards closure with those seeking multiple pathways or alternatives. The 'essential tension' between these two – to borrow a phrase from Thomas Kuhn – would be left to the teacher; she or he would best know the ethos of the class. But overall the broad goal would be to combine closure with openness, performance with development, right answers with creative solutions and processes.

A second curriculum heuristic can be drawn from Waddington's and Piaget's ideas concerning the role and need of internal organization. To facilitate such organization, curriculum planning should be a two-tier or hierarchial process. The first tier would involve broad, general goals, set by the teacher as the expert in the field – or done in collaboration with other experts in the field. The second tier would emerge as the particulars of the curriculum began to take shape. This tier would vary from class to class and would involve the class – teacher and students – working as a group or community. Here ways to carry out the broad goals of the curriculum would be decided. In this manner the curriculum would have some pre-set broad goals and some emergent, particular goals. In regard to the latter, the students could be involved in choosing homework assignments, methods of evaluation, projects to be completed. Key to this shared curriculum activity would be reflection by the students on the choices made and the reasons for them. Both tiers would need to complement one another, and both would be open to reflection and scrutiny.

A third heuristic can be drawn from process theology's concern for the interrelationship among persons – expressed here in terms of the Schön quotation above. Here the teacher and the students are seen in a sharing relationship – each sharing with the other, each learning from the other. Learning, in Dewey's and Piaget's visions, becomes a by-product of inquiry, not a direct and exclusive goal in itself. Mutual inquiry, rather than the transmission of knowledge or production of specific behaviours, is the general framework in which this relationship would be placed. The process by which it is to grow and transform itself is that of dialectical interaction. In contrast to contingencies of reinforcement or mastery of predetermined techniques, dialectical interaction is, itself, the process in which learning takes place.

Examples of other heuristics could be given: those involving the development and change of pathways, or the creation of spontaneous reorganizations (teachable moments), or non-reductionist approaches to complexity. However, such heuristics will arise spontaneously as curricularists begin to study the new and exciting developments occurring in other disciplines. We need to challenge the modernist assumptions on which our present curriculum is founded and to look beyond these assumptions to new ones on which the post-modern paradigm is being built. In short, we need a re-visioning of curriculum.

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