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"Chaos rules" Revisited

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IRRODL
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Chaos Rules Revisited

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Introduction

Keywords: Instructional design; chaos and complexity theory

About 20 years ago, while lost in the midst of my PhD research, I mused over proposed titles for my thesis. I was pretty pleased with myself when I came up with *Chaos Rules* (the implied double meaning was deliberate), or more completely, *Chaos Rules: An Exploration of the Work of Instructional Designers in Distance Education*. I used the then-emerging theories of chaos and complexity to underpin my analysis. So it was with more than a little excitement that I read the call for contributions to this special issue of IRRODL. What follows is a walk-through of my thesis with an emphasis on the contribution of chaos and complexity theory.

The Thesis

The first chapter of *Chaos Rules* discussed the research problem, which was, in essence, an answer to the question, "But what do you actually do?" asked of instructional designers. The thrust of the research was therefore "an investigation of the work practices of instructional designers, with particular attention being given to the practices they adopt when working with academic staff in the preparation of distance learning materials." (Murphy, 1995, p. 3)

But what did all this have to do with chaos/complexity theory? It had been my experience that the work of instructional designers (or educational developers) bore little relation to the theories that they espoused to support their practice. New "conceptual lenses" were thus required to make sense of the theory and practice of instructional design. With a background in mathematics, I was getting excited about the emergence of chaos theory, fractal geometry, and so on, first inspired by reading James Gleick's *Chaos* (1987), and then moving on to the more challenging and lesser-known *Order out of Chaos: Man's New Dia-*

logue with Nature (Prigogine & Stengers, 1984), which was originally entitled *La Nouvelle Alliance* before translation, indicating a newfound relationship between science and the humanities.

And so the seed was sown. I kept reading and researching and found that fascinating insights were emerging from a variety of disciplines, the best at the time coming from Katherine Hayles, an academic with background in both thermodynamics (Prigogine's area of expertise, in which he was awarded a Nobel Prize) and literary theory. She describes chaos theory thus:

> Chaos theory . . . can be generally understood as the study of complex systems, in which nonlinear problems . . . are considered in their own right, rather than as inconvenient deviations from linearity. Within chaos theory, two general emphases exist. In the first, chaos is seen as order's precursor and partner, rather than as its opposite. The focus here is on the spontaneous emergence of self-organization from chaos. . . .
>
> The second branch emphasizes the hidden order that exists within chaotic systems. Chaos in this usage is distinct from true randomness, because it can be shown to contain deeply encoded structures called "strange attractors." Whereas truly random systems show no discernible pattern when they are mapped into phase space, chaotic systems contract to a confined region and trace complex patterns within it. The discovery that chaos possesses deep structures of order is all the more remarkable because of the wide range of systems that demonstrate this behavior. . . . The strange-attractor branch differs from the order-out-of-chaos paradigm in its attention to systems that remain chaotic. For them the focus is on the orderly descent into chaos rather than on the organized structures that emerge from chaos. (Hayles, 1990, pp. 9–10)

I therefore focused my analysis of and theorizing about the work of instructional designers on elements from the branch that discusses "the organized structures that emerge from chaos" and "the spontaneous emergence of self-organization from chaos."

The Chaos Literature

The origins, emergence, and development of chaos theory are at least partially found in the work of Edward Lorenz (1963), who analyzed the solutions and patterns of nonlinear differential equations in his pioneering research on weather modeling, which led to the now-famous notion of the "butterfly effect" (the term used to describe the extreme insta-

bility that can result from slight changes to initial conditions). This and other associated discoveries, developments, and theorizing led many to a different way of thinking about our world, providing a new perspective that is comfortable with the idea of turbulence, envisaging it as the natural order of things. As Hayles has succinctly surmised,

> Where the eighteenth century saw a clockwork mechanism and the nineteenth century an organic entity, the late twentieth century is likely to see a turbulent flow. The importance of chaos theory does not derive, then, solely from the new theories and techniques it offers. Rather, part of its importance comes from its re-visioning of the world as dynamic and nonlinear, yet predictable in its very unpredictability. (Hayles, 1990, p. 143)

What exactly, though, are we talking about? Chaos theory is the popular name now used to describe "the exploration of patterns emerging from apparently random events within a physical or social system" (Griffiths, Hart, & Blair, 1991, p. 432). The term was "playfully introduced into mathematics in 1968 (and earlier in the nineteenth century by Ludwig Boltzmann in the context of thermodynamics)" (Knoespel, 1991, p. 105) and, in fact, is seldom used by theorists and researchers in the physical sciences, where the designation is usually dynamical systems methods or nonlinear dynamics. At a basic level the theory claims that, "even within ostensibly stable systems (such as a swinging pendulum), chaotic behaviour can be observed, and within systems which seem chaotic, order can arise" (Murphy, 1995, p. 12).

The branch of chaos theory that particularly interested me was based on the work of Ilya Prigogine, focused on phenomena that exhibit the emergence of order from disorder, or chaos. Prigogine named such phenomena dissipative structures, defining them as self-organizing systems in conditions far from equilibrium, that transform from chaos to order through a process called bifurcation.

> We now know that far from equilibrium, new types of structures may originate spontaneously. In far-from-equilibrium conditions we may have transformation from disorder, from thermal chaos, into order. New dynamic states of matter may originate, states that reflect the interaction of a given system with its surroundings. We have called these new structures dissipative structures to emphasize the constructive role of dissipative processes in their formation. (Prigogine & Stengers, 1984, p. 12)

This notion is explained more vividly, and with a direct reference to the social sciences, in Alvin Toffler's foreword to *Order Out of Chaos*:

> Most phenomena of interest to us are . . . *open* systems, exchanging energy or matter (and, one might add, information) with their environment. Surely biological and social systems are open, which means that the attempt to understand them in mechanistic terms is doomed to failure. This suggests, moreover, that most of reality, instead of being orderly, stable, and equilibrial, is seething and bubbling with change, disorder, and process. In Prigoginian terms, all systems contain subsystems, which are continually "fluctuating." At times, a single fluctuation or a combination of them may become so powerful, as a result of positive feedback, that it shatters the preexisting organization. At this revolutionary moment—the authors call it a "singular moment" or a "bifurcation point"—it is inherently impossible to determine in advance which direction change will take: whether the system will disintegrate into "chaos" or leap to a new, more differentiated, higher level of "order" or organization, which they call a "dissipative structure." (1984, p. xv)

It was these ideas and others from chaos theory, and emerging complexity theory, that underpinned my research. I wanted to show that instructional designers worked in open rather than closed systems, that the environment was essentially chaotic (in Prigogine's sense), and that instances of order emerging from chaos could be observed. More than that, I wished to illustrate that an induced chaotic state might lead a course development team to move to a higher, more creative state. What would I see when I looked at the practice of instructional design through the conceptual lens of chaos theory?

The Instructional Design Literature

The start of my journey was an examination of instructional design theory and practice as espoused by others, from the US postwar theorists Briggs (1977) and Gagné (1979) (with others applying their successful military training techniques more generally) through to the then-emerging theory of constructivism. Not surprisingly, there was little for me to identify with in early theories because they essentially adopted a closed system approach, the antithesis of chaos and complexity. Grumbling about early theories increased in the 1980s as constructivism took hold, and mention of chaos theory with respect to instructional design was made by Jonassen (1990), who summarized its challenges as

- the assumed determinism of instructional systems design (ISD);
- the unpredictability of learners and the learning process;

- the relatively linear sequence of procedures that course designers perform in hopes of affecting learning outcomes; (and the fact that)

- information processing models frequently depict learning as an essentially linear process of short-term to long-term memory, which naturally suggests a linear instructional process. (Jonassen, 1990, p. 33)

Jonassen counseled against eliminating chaos, encouraging instructional designers to employ techniques that accommodate it. He claimed that

> we cannot conquer chaos and render the learning process completely predictable. Rather than controlling the instructional process, we should be integrating those factors, including chaos, that affect learning in our systems. Instructional systems need to be made more dynamic by accommodating or integrating the learner's intentions, political exigencies, social realities, and other chaotic fluctuations into the instructional systems, rather than trying to isolate the system from all these other factors. Technologists need to become more integrative and less analytic. Learning can never be completely predictable, but designers as integrators may make it less doubtful. (Jonassen, 1990, pp. 33–34)

Implicit in Jonassen's viewpoint was a sense that chaos is a reality we must live with; his position was one that attempted to "cope with chaos." He did not recognize that chaos might be something to celebrate because of the opportunities it presents for learning systems to move through chaotic states to higher levels. Jonassen thus ignored the dissipative structure branch of chaos theory.

More productive was the literature on how instructional designers actually did their work. The work of Gordon Rowland and Judith Riley proved to be particularly helpful to my research. Neither of them explicitly referred to chaos theory, but the way that they described the working world of instructional designers (Rowland, 1993) and the process of course design and development at the UKOU (Riley, 1984) resonated clearly with many of the fundamental tenets of chaos and complexity. As I outlined in my thesis,

> In examining the nature of the design process, Rowland contrasts designing with mathematical problem-solving, which may be extremely complex, but in general has fixed initial conditions, a single solution, and a limited number of methods by which to obtain that solution. Not so with a design problem:
>
> > A nearly infinite number of different solutions to this same problem are possible. . . Neither the initial conditions nor the most appropriate and efficient process to obtain

> a satisfactory solution are entirely clear. (Rowland, 1993, p. 83)

So the designer has to locate relevant key points from a vast array of information, some of which can help in locating the problem and in [facilitating] the process. To attempt to impose a rigid, systems engineering model on such situations

> severely restricts the designer's ability to understand the problem. They feel that . . . understanding is developed through efforts to solve the problem. The two processes are interdependent and simultaneous or cyclical, and goals are gradually uncovered in the context of solution attempts. . . . the process is thus dynamic and unpredictable. (Rowland, 1993, p. 84)

This view, known as "exploratory" design (Robinson, 1986) or "soft-systems analysis" (Holt et al., 1985) claims that not only is this an accurate reflection of the design process but [also] that it results in a clearer understanding both of the problem and its solution. Further, it also assists [in] the revealing of subproblems, perhaps unrecognised in the initial stages. It thus assists in unpacking the layers of a design problem, of locating eddies of turbulence within the larger chaotic domain. This might also be called an "open systems" viewpoint, allowing as it does for greater consideration of alternatives and other influences.

The issue of subproblems was further explored, especially as systematic methods typically attempt to solve subproblems in isolation, emphasising the parts rather than the whole and resulting in badly integrated solutions to design problems. An exploratory, or open systems view means that the designer

> balances resources and organizes the design process according to relationships between the subproblems, and a series of problem-solving cycles is implied. . . . Rather than defining all problems prior to attempting to solve any of them, the designer may await the emergence of subproblems during preliminary solution attempts, and, by focusing on subproblems as they occur, may find a more elegant solution to the whole. Again, the process implied is much more dynamic. Cycles of problem solving are derived dynamically during the design process, vary in duration and extent, and address subproblems when and in whatever forms they present themselves. Neither the subproblems nor the means to address them are felt to be completely specifiable at the beginning. (Rowland, 1993, p. 85)

The essence of these notions sits comfortably with the balance between the forces operating in open systems far from equilibrium conditions and Prigogine's self-organising systems, described earlier. Rowland proceeds to use such terms in outlining a recent conceptual description of the designer. Earlier conceptions had moved from that of a magician, with the emphasis on creativity, to the "designer as computer," with logic and rational processes reigning supreme. The conception propounded to replace these two is

> the designer as a self-organizing system. . . . Design expertise is thought to lie not only in knowledge and skill, but in the designer's ability to reflect on his or her own actions. . . . The designer must be a self-organizing system capable of controlling both rational and creative processes, knowing when to apply each and varying strategies and tactics as the situation demands. (Rowland, as cited in Murphy 1995, pp. 47–49)

Added to this was the revealing work of Riley (1984), whose focus was more specifically on distance education. As I explain in my thesis,

> The key features that Riley identified within course production, as experienced by course writers, are that the process is complex, individual and emotional. Additionally, she was critical of lists of essential tasks prepared by instructional designers for course writers, preferring a more problem-oriented approach. Riley wisely concludes that the preferred base for recommendations to course writers should be professional practice—that is, "recommendations based on what experienced and successful distance educators actually do" (Riley, 1984, p. 52).

Interestingly, what such educators "actually do," as reported by Riley, has sympathy with the notion of searching for order within chaos. As she explains concerning the drafting behaviour of a particular writer,

> In the second quotation, the Mathematician was trying to write the final words of his lesson out in full. Although he had completed two previous drafts which had been approved by his colleagues, his head was still full of a great diversity of concerns and criteria, and he kept changing his mind and seeing that one decision meant that another piece of the text had to be changed to fit. (Riley, 1984, p. 6)

The ideas of interconnectedness and iteration are also implicit in her analysis of the behaviour of those preparing distance education materials. Thus we find in her comments concerning her observations:

> When the roles are not formally separated, many experienced authors find that they change their plans as they write. As the Open University Social Scientist quoted above said, ". . . beyond a certain point, the only thing to do is start writing and see if it will work out." . . . If major new insights come during drafting, then the planning of distance education materials should not be separated from the writing stage, and putting the teaching into words cannot be seen as a subsidiary process. (Riley, 1984, p. 11)

The iterative nature of the process is explicit in the following comment, wherein Riley's notion of spiralling might well be equated with the recursive symmetries exhibited by chaotic systems.

> A common way in which experienced writers of distance lessons cope with this complexity is to adopt a strategy which I call spiralling. By this I mean that on their first attempt at a draft, they will only allow a few concerns to intrude on their search for a way of tackling their lesson. At each subsequent draft, they are able to take a few more ideas on board, until the final version has been checked against their full range of criteria. (Riley, 1984, pp. 21–22)

The outcome of these iterative cycles is movement towards far-from-equilibrium conditions, given recognition by Riley as the out-of-step phenomenon. She describes it thus:

> . . . many of the changes that the author made between one draft and another could not be traced to any comment made by his colleagues. This can be understood by reference to what I have called the out-of-step phenomenon, which adds to the complexity of receiving numerous differing reactions. When an individual goes off to work on the first draft of a lesson, he and his course team usually share several ideas about what he is trying to produce. However, as the author works on his draft, his ideas develop and he sees other ways of dealing with his topic, and other objectives that the students might be asked to achieve. When he brings his first draft back to the course team, they are bound to be out-of-step with his new thinking. Some of them may have changed their views of the role his lesson should play in the course, as a result of working on their own lessons, and some of them will have

> been so busy with their own work that they have not given his lesson another thought since the unit outline was first discussed. As a result of this divergence of opinion, the author and his commenters inevitably compare his draft with different images of what the lesson should be. (Riley, 1984, pp. 22–23)

At the same time as this divergence or disorder grows, pockets of order are apparent within the process, as the "increasingly sophisticated" efforts of individual writers produce more and more focussed drafts. This is explained by Riley as follows:

> This divergence of images will increase with every draft, for many team members cannot pay sufficient attention to each other's lessons even to catch up with the author's views at the time he wrote each draft; and they are getting more involved with the preparation of their own material, as time goes by, and so are increasingly reluctant to think about the course as a whole. . . . As the author carries on exploring the topic of his lesson and developing his expertise, the reasons for his drafting decisions become increasingly sophisticated and embedded into their subject matter context, even though the structure and argument of the lesson may be becoming clearer with each successive draft. One way of looking at this divergence is to see the lesson as a living thing, continuously growing and changing in its author's mind. At intervals he prepares a static account of this living entity, a "snapshot in time," in the form of a written draft, which he circulates for comment. (Riley, 1984, p. 24)

The notion of local rather than global theorizing is also explicit in Riley's findings. Each course is a product of particular people working at particular times in particular circumstances. Global generalizations are not viewed as helpful, as the following comments make clear.

> For it is my experience that the actual tasks done are very variable, between institutions, between teams, and between authors. It is not just a matter of whether the work is done by teams or not; there are also differences depending on the precise system of roles in use. (Riley, 1984, p. 36)

> . . . stress the importance of the individual creative role, that producing distance teaching materials cannot and

> should not be a simple technical task. I asked a question about this in my survey: "How different would a team's decisions be if, in the same context, a different set of individuals had formed the team?" Almost without exception, my informants were quite sure that individuals mattered. . . .
>
> "No, they wouldn't produce the same course, whatever the subject matter, the approach, etc. would be very different. . . . And above that you still get a lot of variation, because it grows out of interactions between people and between people and subject matter, it's an organic thing." (Riley, 1984, pp. 45–46)

The claimed resonance between Riley's work and elements of chaos theory is, of course, built on Riley's own analysis of her data, which was certainly not from a chaotic perspective. It is interesting to speculate whether examination of her original data and transcripts might reveal further congruence. (Murphy 1995, pp. 61–64)

Methodology

Based on the literature survey of both chaos and instructional design, I applied qualitative methods, underpinned by Eisner's (1991) notion of the "critical connoisseur," to investigate instructional designers at work. I used chaos theory to analyze the series of case studies that formed the empirical study.

More specifically, my aim was to

> search for evidence of patterns that reveal chaotic processes at work in the design and development of distance education courses. Are the circumstances under which instructional designers work rich in complexity? Do they have to function in open systems? Are such systems moving to far-from-equilibrium conditions? If so, how do they go about seeking order within the chaos of their working environment? Is there evidence of instructional designers using chaos and complexity to encourage creative outcomes? Can their work be categorized as a process of *becoming*, or is it simply a matter of *being*? That is, does time and its consequences have significant impact on their working environment? (Murphy 1995, p. 67)

The case studies that emerged were the outcome of the application of a modified form of participant observation, the diary–diary–interview method (Zimmerman & Wieder, 1982). The instructional designers I worked with were located in a number of institutions that provide distance teaching along with traditional classes in Australia and Hong Kong. Each participant allowed me to track his or her progress through the design and development of

one specific course, with the time periods averaging about six months. The core of the data was 26 extensive interviews I had recorded on tape, along with supplementary material comprising diary notes, letters, responses to transcripts, additional institutional material, and email messages.

Three chapters were devoted to analysis of the data. The first focussed on how the participants had come into their role as instructional designers, along with their perceptions of their role and status within their institution. The second picked up on the major emerging themes, including the "arrow of time," giving advice (also called working at the edge of chaos), and product emphasis. The third chapter detailed the participants' reflections on teaching and learning, discipline expertise, and the metaphors that were being used at that time to clarify their role (surrogate student, consultant, amicable guerilla, transformer, etc.). I concluded this chapter with the observation that

> they saw the need to be flexible in their work. The attitudes they exhibited displayed an open systems orientation, one ready to adapt to the exigencies of each project and situation, in terms of the demands of the subject, the personality and working style of those with whom they worked, and the perceived needs of the students. There was virtually no evidence of adherence to a model of instructional design or, more generally, a model of teaching. Rather, they were ready to come to terms with what often turned out to be complex and demanding design and development work, calling on them to display a wide array of skills as they charted their way through a project. (Murphy 1995, p. 189)

The Final Chapter

In the final chapter, I posited an emerging model that applied the language and concepts of chaos and complexity theory to the practice of instructional design. The following extracts (from pp. 191–193) pick up on comments from one of the participants:

> Nick: I want to stress that in this role it was like a jigsaw—you had to piece the pieces together, but you had to do the jigsaw over time. And it was like a flux jigsaw, it was changing from day to day. And not only did you have to get the pieces and stick them next to each other, link them up, the colour with the colour and the line with the line, but the jigsaw was forever changing, so that you had to put the pieces into a dynamic situation. (Interview transcript—3/3/93)

The focus, then, is on complexity and irreversibility—time, moving in one direction, is a key factor, helping to make chaos theory a science of change, or "becoming," rather than a descriptive theory of "being." Such an approach would clearly find resonance with a process like course development—Steve Worboys comment-

ed about his project at one stage that "it's in the process of becoming because it's a new environment" (Interview transcript—4/5/94). . . . time was a key issue for all the instructional designers, and influenced the projects in a complex pattern. It was not just a matter of tight deadlines, but also involved the problem of durational expectancies, producing a variety of outcomes for the designer and the distance education course materials.

One implication of this kind of work environment is the need for flexibility in instructional design. There is a sense of being ready for changes in the environment, an anticipation that, because of the open systems nature of the work, the instructional designer must be ready for anything. As Wendy Tsui commented:

> Wendy: If the author is too busy, then it will hamper the progress very much, and we can't have a schedule. Everything is upset. Then it makes the life of an instructional designer very uneasy. We can never anticipate what will happen tomorrow. . . . I think that an instructional designer needs to be very flexible, and has to be able to make decisions, rapid decisions . . . you have to make rapid decisions as to what to do. (Interview transcript—5/11/91)

Specific features of chaos theory have also found their parallels in the theory and practice of instructional design and development. Particular prominence was given in the thesis to the notion of the instructional designer as a chaotic attractor. As a chaotic attractor, the instructional designer acts as a focusing agent, maintaining the system in a state of agitation, endeavouring to find the creative balance between order and chaos.

Some examples of sensitivity to initial conditions have been mentioned. . . . Others can be identified within the experiences of the instructional designers participating in this research. Little did YL Cheung realise that, when early on he helped the writer by suggesting an activity, he would end up writing almost all of them. The pattern, once started in a small way, became an ongoing and integral component of his course design work with that writer. For Steve, the presence of a belligerent and initially uncommitted member of his development team caused him to adopt a "hands-off" approach that had significant, and seemingly positive, outcomes for the development process.

The presence of non-linearity as a feature of the projects is indicated by the quotations given above. Typically, most participants indicated periods of intense activity, such as the long meetings reported by Felicity Simmons, Wendy Tsui and Nick Little, where draft materials were examined and amended "on the spot" . . . the flow of ideas, upon which much course design work hinges, is clearly non-linear (Weissert, 1991). At the same time, patterns emerge as projects progress, developing into

iterative processes as subjects are prepared unit by unit or topic by topic. . . .

The development became slowly focussed on the iterative steps determined by the number of topics (units, chapters) into which the particular course or subject had been divided. These iterative processes invariably involved some form of feedback process, wherein the instructional designer would comment or add to drafts produced by a writer. The number of iterations would vary, depending on a number of factors, including the instructional designer's perception of the quality of the material as well as the ever-present pressure of time and scheduling.

The practice of instructional design that emerges from the case studies is thus that of "a holistic, interactive, spiralling, and dialectical form" (You, 1993, p. 26), more in line with a chaos theory approach than a traditional instructional design model. (Murphy 1995, pp. 191–193)

The Emerging Model

The final chapter of my thesis specifically addressed what a model of instructional design for course designers in distance education might look like. The following lengthy extracts from pages 196 to 201 of the thesis present the essence of an emerging model based on chaos theory.

First, there would be an acceptance of multiple world perspectives, coupled with a celebration of the complexity of the system in which instructional design operates, rather than an attempt to narrow down focus and isolate individual factors. Rejected are traditional design and planning models that stress order, predictability and linear patterns of change. The alternative requires an open systems approach (Chieuw, 1991), one in which forces acting from outside the system are viewed positively, as catalysts for change and the inspiration for new and novel views of crafting learning environments. The system is viewed, not as chaotic in the traditional sense, but [as] complex in the sense of being rich in information that has the potential for enhancing judgment and creativity. Coupled with Eisner's notions of educational connoisseurship and criticism, instructional design thus becomes the art and science of crafting effective learning environments.

In celebrating chaos, an instructional design model does not have to become complex in itself. Rather, it is based on simple iterative procedures across a range of scales within the course development system. Connected to this is the consequent ease with which instructional design can become more context-dependent, encouraging localised theorising within an overall globalised strategy.

The heart of a chaos model of instructional design is, however, the role of dissipative structures, the self-organising systems which, when far from equilibrium, transform from chaos to order through bifurcation. As was quoted in Chapter 2,

> far from equilibrium, new types of structures may

> originate spontaneously. In far-from-equilibrium conditions we may have transformation from disorder, from thermal chaos, into order. New dynamic states of matter may originate, states that reflect the interaction of a given system with its surroundings. We have called these new structures dissipative structures to emphasize the constructive role of dissipative processes in their formation. (Prigogine and Stengers, 1984, p. 12)

A clear implication of this modelling is that, rather than seeking simplicity, order and equilibrium, the instructional designer should be facilitating precisely the opposite state of affairs. That is, the early stages of design and development should be seeking complexity and disorder, pushing the system far from equilibrium to allow dissipative processes to come into effect and play their creative and constructive roles, pushing the system to a higher level of functioning. The creative forces of a team of developers will be strongest when the environment is freewheeling and open, not when the team is tied to a tightly structured, closed system approach to instructional design.

> There must be . . . a sense of indecision and indeterminacy. . . . 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. . . . 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. (Doll, 1987, pp. 19–20)

The instructional designer's role then becomes one of encouraging an open environment, using accumulated experience and influence to open up possibilities and possible new directions, not [one that limits] the group down to a set mode of functioning. Returning again to Prigogine and Stengers, the situation is, somewhat surprisingly, much like that operating in certain specialized chemical processes.

> . . . the new constituents, introduced in small quantities, lead to a new set of reactions among the system's components. This new set of reactions then enters into competition with the system's previous mode of functioning. If the system is "structurally stable" as far as

> this intrusion is concerned, the new mode of functioning will be unable to establish itself and the "innovators" will not survive. If, however, the structural fluctuation successfully imposes itself . . . the whole system will adopt a new mode of functioning: its activity will be governed by a new "syntax." (Prigogine and Stengers, 1984, pp. 189–90)

In such a scenario, it is partly the instructional designer's responsibility to encourage the team to overcome the structural stability of the system, to allow "new constituents," which may originate from multiple sources, to influence the design and development processes. The designer thus becomes a self-organising system, with the ability to control "both rational and creative processes, knowing when to apply each and varying strategies and tactics as the situation demands" (Rowland, 1993, p. 86). Further, as a reflective practitioner in complex circumstances, the instructional designer's decisions are often "triggered by features of the practice situation, undertaken on the spot, and immediately linked to action" (Schön, 1983, p. 308). Their view of the task is that of "situated designing," where "unexpected things in the path are not only obstacles to be overcome, but also opportunities for new views on the problem, and can produce new elements for the designer to use in forming the next action" (Allen, 1988, p. 12). The combined effect of these factors was, as previously quoted, well described by Rowland (1993) as he concluded:

> . . . some level of situated designing, and of reflection-in-action, is apparently necessary for designers. In a sense, reflection-in-action may describe the process of controlling situated actions . . . and the mind engaged in both is a self-organizing system. (Rowland, 1993, p. 87)

Although such features are not immediately apparent in all the case studies outlined by the participants, they do feature most strongly in that described by Steve Worboys. He found himself holding back from imposing structure and process on the team, rather allowing the team to build up its creative forces—his job was to outline possibilities and to let the team find its own solutions. As he explained, part of the job was to give "people freedom that they didn't think they might have had." It was only after they had thrashed out numerous issues to do with structuring the new course that they came to him to help with translating their ideas into reality. Similarly, Wendy Tsui saw it as part of her role to "raise questions and initiate active discussion" among the team members.

Once the process does move from the initial design to development, patterns begin to form, a feature of all the case studies. These patterns form around the individual parts into which the course of study has been subdivided. It is here that the iterative processes begin, and the contribution of appropriate feedback mechanisms

comes to the forefront. Such feedback systems are not mere corrections of mistakes (negative feedback), but the use of imbalance, deviation and error to drive the system into "becoming" an effective learning environment. As argued in Chapter 3, "errors are seen as positive stimulants for the kinds of perturbations that create disequilibrium necessary for self-reflection and conceptual restructuring" (Lebow, 1993, p. 12). Further, as You earlier expounded, the aim is

> to base our ISD models on the positive or deviation-amplifying feedback loop in order to allow the instructional system to exchange information or energy between the system and environment, to initiate appropriate system response, and thus to regulate itself. In this way ISD models can adapt to changes in their internal structures and renew themselves, and thereby survive and continue to function. Positive feedback should be designed into the ISD model in order for the instructional system to continue becoming rather than simply being. (You, 1993, p. 23)

. . . . Numerous examples of patterns of positive feedback loops can be found within the case studies. Typical was the pattern developed by Jane Hammersby with Nicole—despite the occasional clash, in general the cycle of development had Jane providing positive input and suggestions to Nicole, who put them into effect in subsequent drafts of material. YL Cheung combined his skills in preparing activities with those of the course writer to create a series of feedback loops culminating in completed course materials. Nick Little encouraged Carole to take an open, free-wheeling approach to her initial drafting of material. The key to subsequent progress, as an outcome to the deficiencies of the drafts, was effective positive feedback and a close interactive partnership in developing the course.

. . . . The matter of scale levels and their interdependence was also of concern to most participants of the study, and needs to be built into a model for the development of distance education materials. The importance of attention to different levels is well illustrated in the differing project outcomes of Nick Little and Felicity Simmons. For Nick, his project came to a premature and abrupt end due to the untimely intervention of institutional authority. It is easy to surmise and be wise in retrospect that he would have been well served to have striven harder to establish a better working relationship with his college's principal. On the other hand, foreseeing potential problems due to drifting deadlines, Felicity contacted those in control in the medical foundation for their approval.

> Felicity: The author is extremely happy. Yes, she is very pleased to have gone through this process. The [medical foundation] itself, who will be footing the bill, are very concerned because it has taken so long. But I did get in

> touch at the right moment and make them make a decision between time and quality, and they went for the quality, so that is pretty good. (Interview transcript—15/12/92)

Different scale levels within the project were thus kept in harmony, and the work was able to progress quite smoothly. The different scale levels within Felicity's project might be viewed as, first, the institutional concerns between her university and the medical foundation. Then followed the project as a whole, its general structure and aims. At a third level came the working relationship between Felicity and Susan, with the next being the drafted materials, their flow and design. At a final level came the fine-tuning of the written work, in terms of language and layout. There is strong evidence that Felicity, like other successful instructional designers, gave attention to all levels of the project, showing awareness of the dependency of scale levels. Failure at one level can have significant repercussions, and small problems, through the butterfly effect, can spread uncontrollably throughout the system. (Murphy 1995, pp. 196–201)

Afterword

I'm excited about this special issue of IRRODL. At least part of my motivation for submitting this article is that I've never really come to a conclusion about the extent to which chaos and complexity theory can be applied to the social sciences in general and to education in particular. Is chaos theory just a nice metaphor, a conceptual lens with which to view the educational enterprise? Or are educational systems and the distance education institutions within them actually complex systems that follow the "rules" and patterns of chaos and complexity theory? My suspicion is that a mathematical expert in the field would be irritated by attempts to apply the theory to education, but perhaps the other contributions in this issue will allay my fears.

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