Complexity Theory and Staff Development

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Abstract: In understanding the effectiveness of staff development in schools, conventional reductionist methodologies may not explain sufficiently the complex and indirect relationships between inputs and outcomes. Uncertainty supersedes proportionally – linearly – predictable outcomes of designed inputs; transplanting good practice from one organization into another context may not work. Complexity theory both advocates, and offers explanations of, non-linear relationships, suggesting how staff development can prepare schools and teachers for the challenges of internally and externally changing environments. Connectedness, free-flowing communication and information, voice, rich feedback and collegiality, promoting self-learning and self-organization, and creating conditions for non-linear emergence and diversity, are central features of complexity-based staff development. Staff development is an input to, and medium and outcome of, complexity-driven change. Networking and openness, corollaries of complexity theory, can reduce the isolation and 'balkanization' of teachers and increase their abilities to handle internal and external change. Empowering staff within learning organizations, enable schools both to lead, and react to, change. Some limitations of complexity theory are suggested, including issues of power and decision-making in schools.
Keywords: complexity theory; staff development; schooling; education; learning organization

Introduction

Schools face great pressures as they are expected to provide younger generations with quality education, preparing all students for future challenges which we may not have dreamed of, and equipping them with life-long learning skills to keep pace with global and local development. Many schools, however, are run as large-scale industrial-age organizations (Senge *et al*., 2000: 43), which are divided into parts and each person does his or her specialized job as in a machine; control is the heart of such a school system—teachers control the students and, themselves, are controlled by the administrators; students, who are provided with fragmented (subject-separated) knowledge, may overlook or ignore life's interdependencies, have great difficulty in viewing the interrelationships of reality, and may not be capable of addressing complex issues (*ibid.*: 43-6). Industrial-age schools may not sufficiently develop students to be competent future citizens, and many slower learners, who cannot meet the prescribed quality standards, may be sacrificed in Procrustean, one-size-fits-all educational systems.

To keep up with the new demands, changes and challenges, educational reforms have been carried out worldwide, targeting the promotion of lifelong learning to prepare students for their future development (Cheng, 2000; DfES, 2002; UNESCO, 2005). However neatly the aim and objectives of any educational reform may be presented, it is not uncommon for them to encounter resistance from teaching staff. Therefore, it is important to study how to develop teachers as learners and agents for change, who are able to facilitate their own learning and contribute to organizational development.

No one can avoid change. Schools have been facing many challenges: from the rapid demographic downturn in some countries to the accountability polices imposed by compulsory educational systems; from the uncertainty emerging with rapid social

development to concerns about the quality of education being given to the next generation. The challenges of internally and externally changing environments bring great impact on schools' sustainable development. This paper focuses on the situation in many of Macau's schools, and uses that as a vehicle for examining the contribution that complexity theory can make to the enhancement of staff development.

In many of Macau's secondary schools, students (as in other countries) are not always motivated to learn, as that which they learn is not always of immediate relevance to their daily life; they do not find their learning preparing them for their future challenges. Teachers find that their authority is challenged (Doll, 1993: 3-4), and students show little interest in learning. Students' learning styles are changing; they are capable of using diverse sources to acquire knowledge. If schools are not preparing themselves to address rapid changes in the external environment, students may not gain relevant learning experiences and knowledge which can prepare them for upcoming challenges; their graduates may be unemployable. Parents may not feel satisfied with the education provided by these schools and they enrol their children elsewhere. As a result, the schools with little social recognition will be eliminated by 'natural selection'. This, of course, is the policy of 'magnet' and 'sink' schools: good schools attract students and survive; poor schools wither and die.

Staff development as a lever to change

Staff development is one of the ways of improving school effectiveness and responding to changes (Miles, 1983; Gall and Renchler, 1985; Fullan, 1991; Butler, 1992; Dalin, 1998). However, to date, many staff development programmes in Macau are comprised of having teachers follow courses, workshops or conferences. The impact of these traditional approaches to staff development is short-lived and quickly dissipated (U.S. Department of Education, 1999). Fullan (1991) indicates that traditional staff development approaches are unlikely to have long-lasting impact on teacher development and student outcomes. From one-shot workshops lasting only one or two days, teachers, even if they acquire new ideas and learn some effective practices, may encounter difficulties in applying their learning in their workplace, especially they if gain little support or limited ongoing follow up. In Macau, primary and secondary teachers, for example, who have followed English language teaching courses, have returned to school only to encounter opposition from the school principal and, indeed parents, to the new ideas, and so they have reverted to the previous outworn, and often ineffective, practices.

New ideas and practices may not be easily accepted by colleagues or merged into the cultures of their schools. Embedded behaviours are not easily changed, and old practices are often great obstacles to new ones. In other words, the existing structures and patterns of schools may exert a negative impact on, and resistance to, changes.

Staff development is a learning process, through which staff increase their capacity to respond to changing environments. Fullan (*ibid*.: 326) defines professional development as learning experiences teachers gaining formally and informally throughout their career. Dalin (1998: 151) points out teachers develop while going through a process, in which they change their understanding, behaviours and attitudes. Throughout the lifelong learning process of staff development, staff change and become more capable of keeping pace with the challenges from internally and externally changing environments. Furthermore, although teachers usually comprise the majority of school staff and are the focus of most of the staff development, administrators and support staff are not excluded from staff development. All school members carry knowledge of the situations and environment, as Stacey (2001: 70)

claims: knowledge is stored in individuals and lies in the relational patterns between people. Staff as agents at schools learn from others while reciprocally enhancing others' learning.

Inputting new ideas and transplanting good practice from one space to another space may not bring in-depth changes. Using benchmark examinations to test teachers may improve teachers' subject knowledge but may not necessarily improve school effectiveness, which needs profound reforms and transformation to systems to cope with rapidly changing environments (e.g. Fullan, 2005). This is where complexity theory may have a role to play.

Complexity theory is a theory of adaptation and development (Morrison, 2002). This paper will suggest how components of complexity theory can help schools to develop and to be complex adaptive organizations, and how staff development is used to facilitate complexity-driven change. This paper argues that staff learning through mutual interaction and working collaboratively helps school staff sense and respond to their environments, which changes the environments and in turn brings staff development. The rapidly changing environments press the staff to learn and gain new knowledge, and staff development continuously change the environments. Staff development can thus be used as a lever to initiate continuous and recursive changes in and of systems. The educational implications of complexity theory argue that all the staff can be learners, who carry knowledge, information and have potential and capacity for further development; schools can be structured as networks, which facilitate staff learning and flexible restructuring.

Paradigm shift: from mechanistic to complexity methodologies

Isaac Newton succeeded in providing a unified framework in which to describe and explain physical phenomena. Inspired by his accomplishment, there arose a sense of assurance that the scientific method was the only valid means for studying and explaining 'human affairs and natural phenomena' (Burns *et al*., 1984: 637). This mechanistic worldview, adopting Newton's 'clockwork' perspective, had come to dominate Western thought in the 1800s, and has insinuated itself into our beliefs, assumptions, scientific principles and everyday practices (Youngblood, 1997: 4). This mechanistic view has been applied to understand and learn about the universe by a process of reductionism/atomization, breaking systems and organizations into parts, with a belief that such reductionist methodologies help one to understand how the whole works (Lewin and Regine, 2002: 21-22; Fuchs, 2003). Though such reductionist approaches may have been working well for some time, more recently they are being replaced by more fitting paradigms for the present situation of constant change. Complexity theory is one such new paradigm.

In complexity theory there are unpredictable and nonlinear relationships between causes and effects; small changes can cause large effects and vice versa (Cilliers, 1998; Morrison, 2002). The mechanism of dominance, command and control, which is often unable to respond quickly and flexibly to changing environments, may not help in addressing effectively emerging problems in complex situations of the rapidly changing world. Youngblood (1997: 7) indicates that the environment we inhabit is complex and globally interdependent. Several writers (Youngblood, 1997; Gharajedaghi, 1999; Fuchs, 2003; Morrison, 2003) report that Newtonian mechanistic systems, which are based on linearity and predictability, are unable to cope with today's complex environments and rapid changes.

Morrison (2002: 8) indicates some key components of complexity theory as nonlinearity, diversity, open systems, uncertainty and unpredictability. Lewin and Regine (2002) describe complex systems as nonlinear systems often with uncontrollable and unpredictable behaviour.

The feedback and interactions among the agents create unpredictable effects, producing an unpredictable whole which is different from the sum of its parts (*ibid*.: 22; Youngblood, 1997: 38). There are no linear cause-and-effect relationships; the outcomes cannot be predicted simply or accurately from inputs.

The Newtonian mechanistic view has merged into school management model and largely predominated in schools' everyday operations. Students are grouped into cohorts and seated in classrooms; many teachers transmit contents to students with traditional pedagogies, and seldom do they actively respond to emergent problems. Principals are regarded as leaders; schools are run under strict hierarchical management systems. This conventional mechanistic view has treated teachers as cogs or screws in a machine; they seldom work with colleagues in a collaborative way, thus not knowing their students' workload and development holistically. This is the balkanization of teaching, where the whole is less than the sum of the parts (Hargreaves, 1994), discussed later. Students are designed to gain the same quantity of knowledge after going through the same processes of schooling. However, in reality, students (and, indeed teachers) do not learn at identical speeds and in the same order. The ways of delivering factual knowledge may demotivate students' interest in learning, creating difficulties in their forming lifelong learning habits.

As they move towards stable equilibrium, schools have reduced their capacity for sufficient and quick responses to dynamic changes and competitions. Stacey (1992: 43) argues that excellence has been accepted and interpreted as 'consistency in performance', i.e. as reliability. With this possibly mechanistic assumption, people equate instability with failure, and try to remove irregularities in their control systems. Hierarchical school management systems that emphasize control may prevent school staff from communicating and interacting with colleagues; the structures and patterns of hierarchical schools do not encourage teachers to work collaboratively and plan together (Hargreaves, 1994). Teachers working in these schools have not always broken the old mindset: the boss is still the leader.

Senge (2002) argues that people are prevented from taking effective and rapid actions if they believe that it is always the case that the 'boss is leader', which implies that they do not think they will take the leading role. This phenomenon is often seen in traditional schools; teachers are waiting for instructions from the principals or senior managers. Teachers, in strict hierarchically structured organizations, may struggle to fulfil given requirements. Teachers are dehumanized and mechanistically manufacturing 'products' (Dalin, 1998: 174) describes students as products of the school system, which are protected and monitored by teachers and adults. Teachers act as parts of a mechanistic organization, keeping the products on the right track; their creativity is limited. This working model structures stable working environments, which moves towards unchanging equilibrium, which, for complexity theorists, is the stability of the cemetery (e.g. Kelly, 1994: 92). However, staff in a highly hierarchical organization are not empowered to react to rapidly changing environments and thus may be incapable of responding efficiently and effectively to internal and external changes.

Mathematicians and natural scientists have discovered a great deal from living complex systems. Complexity systems have adaptability and learning capacity (Davis and Sumara, 2005). Where schools have succeeded in keeping their stability and efficiency with mechanistic approaches, they have reduced the ability to adapt and learn in changing environments (Youngblood, 1997: 132; Lewin, 1999: 15; Coppieters, 2005: 137). Complexity theory provides a way of interpreting the nonlinearity, unpredictability and

diversity of systems and organizations. Complexity-based staff development helps prepare teachers and schools for the challenges of internally and externally changing environments. Understanding that there is no definitive way of predicting the future, we should find ways of creating it (Tasaka, 2002: 135).

The emergence of order in self-organizing systems at the edge of chaos

Doll (1993: 3-4) suggests a non-traditional educational order emerging in a complex and unpredictable network or system, which is always in process and transforming itself. The new form of order arises in a state, at the 'edge of chaos', which is at the point just before collapsing into chaos, a state between 'mechanistic predictability and complete unpredictability' (Morrison, 2002: 23). Youngblood (1997: 29) and Morrison (2002: 23-24) suggest that complex adaptive systems balance having too much structure (which is too inflexible to respond to constant environmental challenges) and too little structure (which is too sensitive to environmental disruptions and easily slips into chaos). When natural systems reach the point which is sufficiently far from equilibrium but not tipping over into chaos, they spontaneously evolve and move towards higher degree of complexity, through self-organization towards the 'edge of chaos' (*ibid*.: 23). The 'edge of chaos' is a state with high levels of self-organized order (rather than control), where the living systems have the greatest creativity, diversity, flexibility and novelty. In this state, small causes may produce great effects, just as one single grain drops and causes the collapse of a pyramid of sand at the point just before the pyramid falls down (Bak, 1996).

Order emerging through self-organization and constant adjustment to the system is one of the main features of complex adaptive systems, e.g. heating ice makes it self-organize into water spontaneously (Morrison, 2002: 14). Order can be achieved in natural systems through self-organization (*ibid*.: 14; Schultz, 2002: 19; Morrison, 2006: 3). Order need not be imposed; rather it emerges spontaneously in the interactive process between the organism and its environment (*ibid*.: 2-3), as Kauffman (1995) says: 'order is for free' (see also Lewin, 1999: 25). Order and self-organization arise in complex adaptive systems to keep up with external environments with free-flowing feedback and communication (Prigogine, 1996; Lewin, 1999; Morrison, 2002). In complex adaptive systems, central control, which is imposed externally, is equated with extinction, as it is a feature of closed, mechanistic systems (Youngblood, 1997: 29); the rigid systems and organizations are controlled and inflexible to adjust and reorganize themselves to cope with rapidly changing environments.

Stacey (1992: 55) uses the notions of 'bounded' or 'limited instability' in describing complexity, as a state of paradox in which stability and instability co-exist. This potential contradiction creates great tension in successful organizations, which encourages continual dialogue between contradictory viewpoints. This is perhaps an echo of the commonplace Hegelian philosophy of dialectics, in which thesis and antithesis lead to a new synthesis. In this state, old attitudes and perceptions are shattered, and standardized and inflexible cultures are unable to develop (*ibid*: 81). It is the state which has much greater diversity and flexibility than mechanistic systems for behaviours to be changed.

As there are no linear relationships in complex systems—outcomes cannot be predicted based on the amount of inputs—it is often impossible to predict with any certainty outcomes from inputs. In complexity theory, a system is comprised of its interacting elements and is seen holistically (Morrison, 2002: 7). The connectivity, interactions and interrelationships of the system's basic elements may cause new structures of the systems, with each element influences, and is influenced by, other elements (*ibid.:* 12). These interconnections between

agents create new patterns and structures of the organizations, which, in turn, influence the behaviours of the agents; agents and systems co-evolve. Changes are not simply designed or imposed by any specific agents; rather, the innovative patterns emerge (Lissack, 2002, 54-56). For example, in Macau, the booming gaming industry attracts students, who leave schools prematurely, and schools and staff have to adapt to cope with the impacts brought by this new economic situation.

Stacey (1992: 183-4) indicates that self-organization, from a management perspective, is a process in which self-directed teams are spontaneously formed to address issues around the self-organizing networks work and that these run against over-hierarchical, bureaucratic management systems. Morrison (2002: 42-43) argues that teamwork, with a group of people having positive relations and commitments, contributes to networking. The interaction of agents working in teams helps create self-organizing patterns and behaviours in the systems. An effective team experiences satisfaction and may feel proud of its achievement; the team members usually do not mind how much effort they have paid in order to finish a task perfectly (Hastings *et al.*, 1986: 10-12). It is not the procedures, job descriptions and duties but good relationships that make people work excellently, and, as Fullan (2005) remarks, it is not *too much* work to which people may object, but too much *negative* work. Complexity science lays emphasis on human relations, and interactions among agents are regarded as the source of creativity and adaptability (Lewin and Regine, 2002: 27). Team members interact, eliciting spontaneous self-organization and reacting dynamically to changes in environments.

Stacey (2001: 71) characterizes a complex adaptive system as being comprised of large numbers of individual agents. The agents interact endlessly with others, following organizing principles and interacting iteratively and non-linearly with each other (*ibid*: 71). These interactions follow a set of rules which determines how each agent interacts with others. Youngblood (1997: 48) suggests that every agent in the system shares a few 'organizing principles' created by nature. It implies that there may not need a large number of 'top-down' instructions to guide each agent's behaviours; a few key rules 'located at the level of the agent' (Stacey, 2001: 71) facilitate agents' interactions, enabling them to adapt to each other and cope with their environments. Guided by the simple rules, which give rise to emergent complexity through agents' interaction, staff work together and bring advantages and advancement to the whole system; the agents are not guided strictly but they interact and create with freedom. (An experiment demonstrating the self-organizing behaviour of a flight of birds by using a computer program is 'Boids', which shows that only three universal rules determine and reproduce the flocking strategy of a flight of birds (Waldrop, 1992: 241-242; Youngblood, 1997: 48; Morrison, 2002: 10).) Staff, in complexity-driven staff development, can perform self-organizing behaviours through their dynamic interactions.

Complex adaptive systems have agents interacting to adjust the systems internally in order to cope with changing external environments (Morrison, 2006: 2). Effective self-organization increases the adaptability, learning capacity and degree of communication flow of the systems. The structures of the systems are therefore impermanent, allowing fast re-patterning, re-structuring and self-organization to keep up with challenges of internally and externally changing environments. Sharing knowledge is one of the elements to facilitate self-organization (Stacey, 2001; Morrison, 2002).

Complexity theory is helpful in explaining and suggesting why some kinds of staff development programmes may contribute positively to the whole system, and why some programmes may have limited impact on individuals and the whole organization. We can see

what kinds of organizational structuring may facilitate agent development as well as the organizational development. Complexity theory inspires us that, although we cannot create changes, we can create *conditions* for changes to emerge, in self-organizing systems at the edge of chaos.

Creating conditions for complexity-driven change through staff development

Changes are inevitable. Complexity theory suggests that what needs to be done is preparing staff for changes and transforming them into interactive agents to cope with emergent problems and issues. Staff as adaptive agents in complex systems are also the medium of information and knowledge transmission, and their individual learning can bring organizational development and increase its capacity for dealing with challenges of internally and externally changing environments.

Creating *conditions* for complexity-driven changes at a school involves staff members in the networks**,** activating them to be interactive agents and creating networks for interdependence, which is the main feature of self-organizing organization (Morrison, 2002: 41). Therefore, complexity-driven staff development is to create networks rich in interrelationships, interaction and connectivity, which provides space for information transmission, knowledge sharing, individual learning and organizational development. Staff development is a process of staff learning, and the networks inside schools are created through teachers working together with positive communication and rich feedback.

At schools, teachers are often not closely networked and many teachers work in isolation or 'balkanization' (Hargreaves, 1994). Teachers work individually because of the cellular 'egg-crate' structure of schools; they are limited in the classrooms and have little developed interaction with other agents. To encourage teachers to work collaboratively, schools may divide teachers into teams, faculties and departments. This strategy has been planned to group teachers together and have them work together. However, if teachers are isolated in their own sub-groups and control mentalities dominate, this can create boundaries, blocking teachers' interactions, limiting free-flow communication and hindering networking.

Balkanized cultures have several characteristics:

(1) balkanized teachers work individually or in their own sub-groups and their learning mostly occur within the groups;
(2) few teachers move between groups and their membership is rather stable;
(3) teachers have stable personal identification and it limits communication between staff; and
(4) balkanized teachers distribute power and interest largely through their membership in the sub-groups (Hargreaves, 1994: 213-5).

Balkanization does not create collaborative cultures within which teachers and their colleagues work spontaneously, voluntarily and unpredictably, with self-commitment and flexible schedules (*ibid*: 192-3). Rather, balkanized patterns of work are characterized by strong boundaries between different parts of the organization and individuals, and imbalances of power and identification structures that prevent teachers from developing professional learning, thus not equipping them for quick responsiveness to the changing needs in the community (*ibid*: 235). Networking and openness, corollaries of complexity theory, can reduce the isolation and balkanization of teachers.

Networking of agents can increase the flow of information and encourages agents' interaction. Throughout interaction, agents increase the flow of information and gain rich feedback. The high degree of communication flow can stimulate personal learning and organizational development, and increase creativity and change. Knowles (2001: 120) indicates that people self-organize, form teams and address problems together whenever they have enough information, are well involved and understand what is to be accomplished. During the process, they learn how to share ideas, insights and listen to each other; they learn how to trust and inter-depend on each other. Trusting relationships and interdependence, through the high degree of information flow, contribute greatly to self-organization.

Lewin and Regine (2002: 28) argue that 'people are agents and relationships are interactions'. Human relations are thus interactions between agents; warm personal relations can increase the speed of communication and decrease misunderstanding. However, the close relations embedded in some power structures can also reduce some people's opportunities for networking, e.g. experienced teachers forming an informal group block the opinions and changes initiated by newcomers.

Personal relationships are often essential for closely-connected networks, as agents within the system need strong connectivity for sharing and communication (Fullan, 2001; Morrison, 2002). How successful a complex adaptive system is depends on the interaction between the parts of the system. Agents within the system interact with each other, and the success and failure of the organization strongly depends on the relationships between agents, as Fullan (1999) writes: people and relationships are critical for an organization's long-term success. Senge *et al*. (2000: 19) indicate that studying how people think and interact contributes to the improvement of a school system. Hargreaves (1994) also emphasizes the importance of close human relationships:

> Warm human relationships of mutual respect and understanding combined with the toleration and even encouragement of debate, discussion and disagreement create flexibility, risk-taking and continuous improvement among the staff which in turn lead to positive results among the students, and positive attitudes among the staff to changes and innovations which might benefit those students. (Hargreaves, 1994: 239)

Teachers, in many educational systems which strongly emphasize accountability and responsibility, may be embedded in mechanistic organizational structures and treated as parts of a machine. This can block information and knowledge sharing, thus limiting the flow of information. Teachers need opportunities to develop interdependent and trusting relationships and to learn from each other. Complexity-driven staff development should focus on building personal relationships through networking and creating collaborative working patterns. It not only reduces isolation and balkanization through close human relationships but also increases the capacity (in teachers and, more widely, in schools and amongst leaders) for taking risks, and for innovation and change. Questioning, discussion, dialogue and disagreement between agents facilitate the adaptation of new information and the application of new ideas.

Collaboration, which allows sharing successful practices and the giving of mutual support (Fullan, 1991), provides understanding and a safe environment in which mistakes may be seen as learning opportunities rather than matters of blame, and it encourages risk-taking throughout the process of change. Wideen *et al.* (1996: 200-1) recommend a team working

collaboratively to change and to accept the unpredictable outcomes of innovations. Working in collaborative teams facilitates the networking of agents through rich feedback and close human relations.

In complexity theory, agents work together to respond to, and change, the environments. Working in teams also facilitates staff learning from each other. Through dialogue, communication and rich feedback, staff keep ongoing learning through working together and from the process of addressing schools' key issues. The process contributes to their learning, organization's development and closer human relationships. Staff learn how to respect others and link to other colleagues when working together. Teachers who have good relationships trust and depend on each other; they know where to get advice, support and resources; they have mutual respect and therefore may be more willing to take risks. Complexity-driven staff development can lie in collaborative working teams, which have flexible structure to respond to environments.

Learning is also essential for creating conditions of self-organization. Not only does the individual learn, but the whole organization also learns. Without individual learning, organizational learning does not occur (Senge, *et al*., 2000: 25). Personal mastery, shared vision, mental models, team learning and systems thinking, the five disciplines proposed by Senge (1990) are regarded as essential for developing learning organizations. The disciplines can be applied to encourage individual and organizational learning.

Personal Mastery keeps people continually expanding their capacity to achieve what they truly want. It keeps people learning. True *Shared Vision* may embrace individuals' visions. People truly sharing a vision are closely connected by committing themselves to creating it. There is power coming from their common caring; shared vision is important for learning organization as it provides the focus for people to strive for.

Having *Mental Models* helps people understand attitudes and perceptions; it influences how we see the world and how to take action. *Team Learning* can occur through dialogue and group interaction; team learning develops what members want by aligning and developing the capacity of a team.

Systems Thinking puts emphasis on seeing wholes, interrelationships, patterns rather than parts. It provides a way of viewing the system as a whole. In complexity theory a system is seen as a whole, and Senge's disciplines help understand how to view a system holistically, with encouraging individuals to interact and learn from others.

These five disciplines encourage people to explore new ideas, using different ways to think, interacting with, and connecting to, internal and external environments. These principles are conditions for complexity-driven staff development, which promote continually changing and ongoing learning in the process, and contribute to the creation of knowledge and information through networks and interrelationships.

Complexity theory suggests that behaviour be influenced by the structure of the living system itself (Stacey, 1992: 33). Coppieters (2005: 137) argues that a school is a complex dynamic system, and it is unrealistic to expect linear cause-and-effect relationships happening in a stable equilibrium state. To pursue complexity-driven change, and the order emerging spontaneously at the edge of chaos, we cannot only change one individual component or agent. Complexity theory suggests looking at the system as a whole and facilitating the self-

organization of the whole system; the whole is greater than the sum of the parts. Hence the networking of the staff help agents work collaboratively as a whole, thereby creating conditions for non-linear emergence and diversity, and reducing the isolation and balkanization of teachers. Staff are the medium in the networks, transmitting information and facilitating free-flow communication. The dynamic structuring allows staff to interact, act and create interdependently, creating conditions for agents' behavioural changes, and bringing advancement and welfare to the whole system.

Staff development, inspired by complexity theory, has to connect staff in order to facilitate networking, communication, feedback, and increase collaboration, flexibility and diversity. These are the conditions for development that are suggested by complexity theory. It is a process of empowering teachers and energizing them into active and interactive agents. In the post-modern world, roles and boundaries in the organizations are blurred; decision-making is decentralized and the organizational structures are flatter (Hargreaves, 1994: 9). Top-down management model may be too hierarchical to respond effectively to unpredictable and successive problems, changes and chances (Fullan, 1999: 27; Senge, et al., 382). Schools running as mechanistic systems face great difficulties in dealing with emergent problems and challenges.

Hargreaves (1994) argues that the integration of bottom-up and top-down strategies in planning is more effective than top-down or bottom-up alone. To address complexity and uncertainty, teachers are empowered and work collaboratively within networks with decentralized structure (Dalin, 1998), thus increasing their effective responsiveness to the internal and external changes. Complexity-based staff development is a *process*, creating networks, strengthening connectivity, activating teachers to learn and developing them as interactive agents. This process may elicit self-organization of internal systems to cope with external environments.

Schools can operate as complex adaptive systems, with networking, organizational learning, connectedness, communication, and relationships as their main features. Schools can be very traditional, resisting and responding slowly to emergent internal and external changes. In Macau, most schools are strongly hierarchical and hierarchically controlled. Macau's sustainable development is at great risk as schools are not capable of preparing students for unexpected challenges and rapid changes. Complexity-driven staff development proposes a way for Macau's schools to create conditions that are needed to address emergent issues and cope in changing environments.

Leaders' tasks, informed by complexity theory, become leading staff in networked learning, sustaining self-organization, and catalyzing development (Morrison, 2002: 35). Without the support and understanding from the school leaders, it is hard to initiate self-organization of individuals and organizational learning in order to cope with changes. In many cases, little energy is spent in school innovation and change; more emphasis is put on maintaining the existent school operations and structures (Dalin, 1978: 15). Complexity-driven staff development can be used as a lever to activate staff interaction and the restructuring of the organizations.

Limitation of complexity theory in staff development

Complexity theory helps people to handle and prepare for changes. When applying this theory to staff development, multiple agents are involved and they become interactive learners, facilitating their own learning and organizational learning. Ongoing learning and

flexible networking within schools help coping with challenges and addressing problems emerging in the changing environments. However, complexity theory has some limitations, which need to be considered when approaching complexity-based staff development.

We can learn from nature, but the amount of information in complex systems may be overwhelming. Staff at schools, who are used to understanding their systems by adopting (consciously or otherwise) simple mechanistic perspectives, may not think complexity theory can help them in running schools effectively. No one can predict what is going to happen, and flexibility, diversity and uncertainty are not their expected outcomes. They may feel incapable and deskilled as they have lost control over situations.

Stable school structures create comfortable environments in which teachers can accomplish their everyday tasks, regardless of how these tasks may or may not relate to, or bring benefit to, student learning, staff development and school improvement. Complexity-driven staff development forces teachers to jump out of traditional school structures and face the constant challenges from the internally and externally changing environments. Thus, it would be unsurprising if it were not to encounter resistance from the staff (Dalin, 1978).

Furthermore, hierarchical structures of schools keep power in hands of traditional school leaders, and, indeed, this may facilitate some kinds of change, particularly with stagnant schools and staff, as it can cut to the heart of mandated change. Further, some senior school staff may not wish to empower teachers, as changes are not predictable and they feel that they lose power when staff make decisions. The flatter school structure, different from the mechanistic paradigm, may make them uncomfortable. They may not want to create conditions for complexity-driven changes to occur. Without senior staff's intervention and support, the old structures may be reproduced or remain unaltered; networks are not created and conditions for self-organization do not exist. This suggests that hierarchy and complexity theory are not mutually exclusive (see also Stacey, 2001); it is the stultifying reach of hierarchy that is inimical to complexity theory. Too much hierarchy can stifle change; control has to be replaced with order.

Ideas of collaboration may be used to prevent staff development, i.e. to use the micropolitics of organizations to inhibit proposed changes (Hoyle, 1986). Teachers may be forced to work collaboratively for others' goals, such collaboration may be forced or contrived (i.e. not serving any real purpose other than being, of itself, a 'good thing') (Hargreaves, 1994) and they may not share the similar vision. It does not activate teachers to network and address immediate issues for individual and holistic advantages.

Further, even though the paper regards staff development through the lens of complexity theory, in fact it is advocating matters that are familiar to school management and leadership. For example, networking, collaboration and collegiality, trust and mutual respect, risk-taking, feedback, teamworking and communication are the staple diet of management texts. In this regard one can ask how much complexity theory actually advances our thinking and practice of staff development over and above commonplace management thinking and effective practice. What else does complexity theory offer that these do not? This is an important question that complexity theory has to engage.

Conclusion

Complexity theory gives us an insight why communication, feedback, human relations, collaboration, mutual respect and support, lifelong learning, teamwork and interaction are

important for complexity-driven changes. With this insight, we can see how to facilitate and plan complexity-based staff development; it requires mutual support and respect, together with positive human interrelationships. Networking is essential (Morrison, 2002: 41) and the development of collaboration between teams can increase the degree of interaction and the free flow of communication; these contribute to positive human relations in turn and facilitate networking. Staff change and adapt themselves to respond to the challenges through self-organization, and thus changing the environments, and changing themselves recursively and iteratively.

Complexity theory helps to understand and, therefore, prepare for change. Rigid organizational structures applying mechanistic paradigm may be useful for control and predictability, but they may have little to offer for keeping up with internal and external changes. As Macau's booming economic development creates unpredictable challenges, schools have to consider whether their staff, their students and schools themselves are ready for the rapid changes. If they are not, then complexity-driven staff development is a lever to initiate the changing process at schools, thus preparing staff and schools for the unpredictable internal and external changes.

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