

Complexity Theory and Nursing Education in Macao

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Abstract: Nursing education faces rapid changes in advanced technology, socioeconomic factors, cultural diversity and changing global health care arenas. These can be interpreted within through complexity theory, itself a theory of evolution, development and adaptation. Nursing education must prepare nurses for extraordinary challenges and opportunities, yet many student nurses are confused about the multiple areas of learning and their relationships to practice, and they experience difficulties in completing the required nursing degree. Macao, since its handover to China in 1999, faces very many challenges and changes in nursing and nursing education in order to keep pace with external changes in the field. Nursing education in Macao has to restructure and reorganize itself. How can this be understood and approached? What influences nursing education in Macao and how can it respond to these? The paper takes nursing education in Macao as a case study of a service in a small territory, facing complex environmental and internal system changes. Using key elements of complexity theory, it identifies strategies that can be used to progress nursing education in Macao.

Keywords: complexity theory; nursing education; Macao

Introduction

As massive changes are occurring in the health care system, nursing education must adjust to this changing environment and prepare nurses to be equipped to face a whole new set of challenges. Much of the history of nursing education has been tied to the need to prepare nurses to practice in hospital settings (Dochterman and Grace, 2001). As Koh (1996) mentioned:

Nursing, as a practice discipline, demands competency in numerous psychomotor skills. The level of competency in nursing skills affects not only the trust relationship between the nurse and the patients but also affects the quality of nursing care (Koh, 1996: pp. 47-49).

Combined with the continuation of growth and development of health technology and the maintenance of quality of nursing, nursing professionals need to update quickly their knowledge and skills to meet the demands. At the same time, nursing educators continue to be challenged to develop more effective programs to prepare graduates to apply their nursing skills safely and effectively in health care. (Lee, Chen and Wang, 2002).

Traditional education and training largely focus on enhancing competence, but in today's complex world, nursing education is not merely for competence, but for capability, the ability to adapt to change, generate new knowledge, and continuously improve performance (Fraser and Greenhalgh: 2001).

Much learning takes place in the zone of complexity, where relationship between items of knowledge are not predictable or linear (Fraser and Greenhalgh, 2001). Complexity theory as a theory of change, development and evolution through relationships, raises an interesting agenda for educational change (Morrison, 2006), not least in nursing education. The evolution of nursing roles and responsibilities has created a complex profession.

Nursing education must adjust to this changing environment and prepare nurses who are equipped to face a whole new set of challenges (Dochterman and Grace, 2001). Complexity theory offers a new way of thinking about nursing education, and its notions of interconnectedness gives nursing a theoretical and philosophical underpinning for practice (Walsh, 2000).

Nursing education must prepare nurses for extraordinary challenges and opportunities, yet many student nurses are confused about the multiple areas of learning and their relationships to practice, and they experience difficulties in completing the required nursing degree. When students observe gaps between what is taught and the care practices they encounter during clinical rotations, learning can suffer and disillusionment can occur (McConnell, 2004).

Politico- and socio-economic factors and cultural diversity are phenomena of complex system in the changing world. Macao, since its handover to China in 1999, faces very many challenges and changes in nursing and nursing education in order to keep pace with external changes in the field. Nursing education in Macao has to restructure and reorganize itself.

How can this be understood and approached? What influences nursing education in Macao and how can it respond to these? The paper takes nursing education in Macao as a case study of a service in a small territory, facing complex environmental and internal system changes. Using key elements of complexity theory, it identifies strategies that can be used to progress nursing education in Macao.

The paper takes particular aspects of complexity theory and illustrates their application in nursing education in Macao. It argues that changes in nursing practices and nursing education, in a small territory of Macao, with limited human resources and expertise, have necessitated that Macao move towards increasing connectedness with the external environment, not only in training providers, but in terms of nurses themselves, and in terms of internal changes in nursing and nursing education provision in Macao. A brief review of antecedent nurse training providers in Macao shows, true to complexity theory, that those institutions which have not changed and developed, have not survived. The case is made for nursing education and nurses to move beyond simply viewing their work as the acquisition and practice of competencies, and towards the need to develop *capability*, and nursing education for capability requires service and training providers to be constantly updating themselves. Macao's nursing and nurse education provision has emerged, through self-organization, to increasing connectivity with overseas providers and to increased connectivity between nurses, nurse educators and student nurses.

Some key features of Complexity Theory

Complexity, has been called the science of the 21st century by Stephen Hawking and Edward Wilson, and is a relatively young field dedicated to studying interactions within living systems of all types and the patterns of behaviors that emerge from these interactions (Lindberg, 2005). Complexity is science's most recent attempt to explain how order and novelty emerge in the world. As such it is the intellectual successor to systems theory and chaos theory. (Lindberg, 2005). Clancy (2004) define complexity as 'phenomena demonstrated in systems characterized by nonlinear interactive components, emergent phenomena, continuous and discontinuous change, and unpredictable outcomes'. Complex systems are created by a number of diverse and interdependent agents that are constantly changing and interacting with each other. Such systems are ubiquitous. Some examples include the brain, ant colonies, hospitals, communities, families, economies, and the human

heart (e.g. Kelly, 1994). Coppieters (2005) mentions the importance of organizational learning and knowledge management for a complex system to change, and has outlined some characteristics of complex systems and their implications as follows:

- *Relationship are non-linear and contain feedback loops.* Positive and negative feedback are key ingredients. The effects of an agent's action are fed back to the agent and influences the agent's behavior in the future.
- *Complex systems are open.* Information is constantly imported and exported across system boundaries. The effect is that there is constant change and the information flow is an important element in organizational learning.
- *Complex systems are holistic.* The parts cannot contain the whole. No part can control the system.
- *Boundaries are difficult to determine.* The boundaries are determined by the interrelations between the agents (interconnectedness).
- *Inability to predict.* A complex system has a history. This history constitutes the initial conditions. The system is very sensitive to initial conditions. Not taking into account that history when making changes can have large effects as time goes on. It means that planning as accurate predictions is impossible. It means that planning has to be *seen as learning and takes the form of scenario planning.*
- *The concept of 'edge of chaos'.* Changing a variable can initially exhibit ordered behaviors and then became disordered. The region where greatest change occurs is termed the 'edge of chaos'. There are several variables which are significant in moving a system to the edge of chaos: connectivity, diversity, creativity and information. Change can be generated by increasing the flow of information. It can be achieved through the inflow of information and also by increasing information (knowledge) through learning. If there is too much stability then change is unlikely. Disequilibrium is essential for change. In human systems two other variables are important: the level of contained anxiety and the power differentials in the system.
- *A complex system demonstrates autopoiesis.* This derives from the Greek, meaning self-making. Complex systems are self-organising and transform themselves.'

(Coppieters: 2005, p.133)

Morrison (2006) suggests that:

self-organization, complex adaptive systems, non-linear change, emergence, unpredictability, diversity, differentiation and autopoiesis, networks, connectivity and relations, order without control, feedback, open-systems, collectivity, distributed knowledge, autocatalysis, holism and co-evolution as key terms of complexity theory (Morrison, 2006: 3).

Elsewhere he writes that (Morrison, 2005): 'closed systems in equilibrium die; systems need disequilibrium in order to survive. Change, disequilibrium and unpredictability are requirements for survival: a butterfly which only flies in a straight line is soon eaten' (Morrison, 2002: 13). Stable equilibrium, in this view, is a recipe for death; systems must change if they are to survive. A reform of nursing education must emerge, like the new butterfly from the chrysalis, to meet and adapt to the external changing world. Open systems and networking with external nurse training providers are needed.

Lindberg (2005) comments that, 'nurses play a central role in health care, also a complex system, it is vital for nursing scholars and leaders to plumb this new science for insights that

will enable nurses to enhance the well-being of patients'. A well designed nursing program includes advanced theories and practical skills, enhancing participants' knowledge, capability and skills, using the advanced technology as new learning styles for self-organizing and transforming themselves.

Frazer and Greenhalgh (2001) suggest that complexity concepts applicable to education and training include the views that:

- Neither the system nor its external environment are, or ever, will be constant;
- Individuals within a system are independent and creative decision makers;
- Uncertainty and paradox are inherent within the system;
- Problems that cannot be solved can nevertheless be 'moved forward';
- Effective solutions can emerge from minimum specification;
- Small changes can have big effects;
- Behaviour exhibits patterns (that can be termed 'attractors');
- Change is more easily adopted when it taps into attractor patterns'.

Similarly, Plsek. (2001) contends that coping with escalating complexity in health care requires the abandonment of simple, predictable, linear models, an acceptance of unpredictability, a respect for, and utilization of, autonomy and creativity, and flexible responses to emerging patterns and opportunities. Plsek (2001: 628) also suggested that:

The science of complex adaptive systems provides important concepts and tools for responding to the challenges of health care in the 21st century. Clinical practice, organisation, information management, research, education and professional development are interdependent and built around multiple self adjusting and interacting systems. In complex systems, unpredictability and paradox are ever present, and some things will remain unknowable. New conceptual frameworks that incorporate a dynamic, emergent, creative, and intuitive view of the world must replace traditional 'reduce and resolve' approaches to clinical care and service organization.

The world is complex. Nurses may strive to manage the complexity of their life by breaking up the experiences into manageable components that have meaning (Sell and Kalofissudis, 2002). AsPisapia (2006) suggests, the only way to make a complex system work is to begin with a small system that works, have multiple goals, strive to make good enough choices, and grow by chunking; 'chunking' here meaning that a useful approach to building complex systems is to start small. How does this apply to nursing education in Macao, a small territory experiencing dramatic complexity in political, socio-economic and cultural changes?

Macao as a small territory and its links to complexity theory

Macao, located at the Pearl River Delta at the southeastern coast of Mainland China, some 60 km southwest of Hong Kong, is a small territory some 28 km² in area, consisting of the Macao Peninsula, Taipa Island and Coloane Island. (Direcção dos Serviços de Estatística e Censos., 2006). As a Special Territory of Portugal for 450 years, it became a Special Administrative Region (SAR) of the People's Republic of China (PRC) on 20th December, 1999. Since the handover from Portugal to China, Macao is operating under the 'one country, two systems' principle, akin to the system in Hong Kong. Though more than 90% of the population is Chinese, with the influence of hundreds of years of history, Macao is a territory

painted with the cultures of the east and the west. These are reflected in the World Heritage Site status by the United Nations Educational Scientific and Cultural Organization (UNESCO).

Macao is experiencing a transition of culture, politics, socio-economic status, health care and educational changes. The population of Macao is increasing very rapidly, from around 400,000 in 1994 to 430,000 in 2000, to 488,000 in 2005; with the rise in gaming increasing numbers of westerners and people from all over the world is placing a greater premium on the need for an effective, efficient, up-to-date and world-class health care system, with a developed infrastructure of nursing service and concomitant nursing education. With increasing numbers of immigrants from the mainland and overseas entering Macao, a product of tourism and the thriving casino industry, together with health care trends to deliver some nursing services to private health care institutions, more educational reforms are necessary to meet demands.

According to the statistics shown in 2004 (Serviços de Saúde de Macau, 2004), there are 1,063 nurses in Macau; 682 nurses are working in the Macao Health Bureau, 302 nurses are working in Kiang Wu Hospital and 79 nurses work in others private institutions. The ratio of residents per nurse is 430:1 (Direcção dos Serviços de Estatística e Censur (DSEC) (2006). In 2002, a study was undertaken to identify the trends of development of the nursing professions and nursing education in the 21st century; this reported that there was a need to increase this overall number to at least 1,600 nurses in order to respond the population's need in Macao (Hong Kong Polytechnic University, 2002). Macao is facing many simultaneous external and internal changes; there is major disequilibrium and unpredictability, themselves constituting a complex system. Not only is demand increasing in Macao as a function of its increasing population, but changes in health services themselves, not least in increasingly sophisticated technology, requires upgrading of nurses and nursing education in Macao. This is reflected in the increasing levels of qualification and ongoing professional development in nursing education. How can this be understood through the lens of complexity theory?

Complexity theory and Nursing Education

In Macao, health services are mainly offered by two institutions: the Health Bureau of the Macao Government and Kiang Wu private hospital. This was not always the case: services were provided by a range of institutions, several of which have either ceased or have had to change (often through mergers), in order to survive. Nursing education in Macao started in the early twentieth century, and has moved from hospital-based training to tertiary-institution-based training since 1997.

The requirement for admission to nursing education was initiated from primary education level in the early 1960s, and was progressively upgraded to junior secondary education level (form 3) to senior secondary education level (form 6) since 1989. The curriculum of nursing education was developed from diploma to higher diploma, and upgraded to a bachelor degree program from 2002. With a joint program with Monash University of Australia and Hong Kong Polytechnic University, a Master's program and Post-Graduate Diploma have been initiated. Four nursing institutes participated totally or partly in the evolution of basic and ongoing nursing education in Macao: Midwifery and the Nursing School of Kiang Wu; the Maria Franciscans of Missionary School of Nursing; the Technical School of Health Bureau of Macao Government; and the School of Health Sciences, Macao Polytechnic Institute.

(Lam Nogueira, 2004). Basic nursing education was developed by four institutions for nursing education in Macao, described as follows according to their chronological sequence:

Midwifery and the Nursing School of Kiang Wu: founded in 1923, this is an organization belonging to the Kiang Wu Hospital Charitable Association. The school began admitting graduates of senior secondary school and received partial financial support from the government in 1991, and its academic qualifications were recognized by the government in 1994. In 1997, the Higher Diploma of Nursing Program was developed, and the institution was upgraded to a private tertiary college in November 1999, named *Kiang Wu Nursing College of Macao* (Macao government bulletin - 419/99/M, 15/11/1999). It has offered higher diploma supplementary programs in nursing since the academic year 2000-2001; subsequently it has offered a 3-year higher diploma program and certificate courses in the academic year 2000-2001; it also offered a 4-year bachelor degree program since 2002 until the present. The College also co-operates with medical organizations in China, known as Beijing Hip Vo University, with a Master's nursing program, and with Jian Nam University for a Bachelor's nursing program in Macao.

The *Maria Franciscans of Missionary School of Nursing*, established in 1939, trained nurses for the Health Bureau of the Macao government, and organized Chinese nursing programs (3 year diploma in nursing course plus 1 year Midwifery) that were recognized by the Macao government. From 1964 it offered a General Nursing Program based on the curriculum of the Health School of Portugal, and completed its mission of training nurses in 1982, with a total of 560 nurses trained.

The *Technical School of the Health Bureau of Macao Government*, a unit of the Health Bureau of the Macao government since 1947, was officially established in 1964, offering only Portuguese General Nursing and a Midwifery Program and an Auxiliary Nursing Program until 1991. From 1988, a Chinese General Nursing Program was offered. As the only nursing education institute that had ever held a Specialist Nursing Program since 1986, it was integrated into the Macao Polytechnic Institute from 1997.

The *School of Health Sciences, Macao Polytechnic Institute*, was an integration of the Technical School and the Health Bureau of the Macao government since 1997, with a continuation of basic and post basic education in Nursing. It has offered a 3 year higher diploma program in nursing and biomedical sciences program since the academic year 1999-2000. In 1998, the training for Nurses was upgraded to a Higher Education Diploma; to decrease the difference between the nurses and the new graduate nurses, a supplementary course for the nurses was initiated from May 2000. Since 2002 it has offered a 1-year bachelor degree supplementary program. A joint Master's degree in Nursing was initiated in February 2006 with Monash University of Australia, and a Postgraduate Diploma in Specialty Nurse Program was offered jointly with Hong Kong Polytechnic University, commencing in September 2006.

Nursing education in Macao has experienced evolution to adapt to a complex and changing world both within and outside Macao. The main visible changes in nursing education in Macao are witnessed in the move from hospital-based training to tertiary-institution-based training, requirements for admission to nursing education, the curricula of nursing education which developed from diploma to higher diploma and upgraded to a bachelor degree program from 2002 and now linking to external institutions to provide upgraded and upgrading programs.

As the demands placed on nursing and nursing education *per se* increase in the external environment, not least brought about by increasing technological advances, the internal environment of Macao has had to keep pace with these and change its structures and contents of nursing education. Echoing Ashby's (1964) 'law of requisite variety', the degree of internal variety, complexity, flexibility and diversity has to correspond with that found in the external environment, for nursing education to thrive in Macao.

As a small territory, Macao, in itself, does not have the resource or the size, on its own, to keep pace with changes in nursing and its supporting education requirements. This has necessitated developments in nursing education which have led Macao to establish external links and connectivity with *external* providers of nursing education. Increasing demand have led to increasing connectivity with the outside world. Similarly it has led to greater *internal* connectivity, with mergers between institutions incorporation of departments into other institutions.

Complex environmental Changes

The environment in which health service providers operate has seen increasing demand for services, significant advances in technology, faster information flow, and greater access to knowledge, with more active and discerning users (Humphris, 2002). Successful health services in the 21st century must aim not merely at change, improvement and response, but at changeability, improvability, and responsiveness (Fraser, 2000). Educators must offer an environment and process that enable individuals to develop sustainable abilities appropriate for a continuously evolving organization. (Fraser, 2001). What is being suggested here is that as the external environment, in this case that of nursing and nursing education, change and develop, often because of technological advances and credentialism, so the internal environment of nursing and nursing education in Macao has to change, linking more closely with the external service and training providers such as universities overseas. The internal and external environments not only change themselves but change each other. This echoes and embodies Stewart's (2001) notion of 'the coevolving organization' in complexity theory – the organism senses and changes the environment, and vice-versa.

Traditional education and training largely focused on enhancing competence (knowledge, skills and attitude), but in today's complex world, nursing education is not merely for *competence*, but for *capability* (the ability to adapt to change, generate new knowledge, and continuously improve performance) (Fraser, 2001). Educators are therefore challenged to enable not just competence, but also capability. As it is more than competence, capability ensures that the delivery of health care keeps up with its ever changing context.

Nursing education must adjust to this changing environment and prepare nurses who are equipped to face a whole new set of challenges (Dochterman, 2001, p. 88). Thus, it is also important to encourage the nurses, both established and newly qualified, for continuous education to adapt to the complex changing world, assure the service operators of the knowledge, skills and capability adequate to advanced technology, as well as communicate and interconnect with the new nursing generations and other professionals.

In a situation in which the external environment (i.e. outside Macao) of nursing and nursing education is changing, the internal environment of Macao, particularly as a small territory that, in itself, cannot have the resource necessary to train its own nurses in all the fields required, has to increase its connectivity with the external environment in order to keep

pace with developments, and this requires a more from simply competencies to capabilities. The former training providers in Macao have merged, adapted and, for those that have survived, have done so through increasing their connectivity with external agents. They have self-organized and, in the process, have metamorphosed into emergent new forms that involve partnerships with internal and external bodies.

Internal Systems Changes

Facing the complex environmental changes, internal system changes also emerge to meet the changes and adaptability. In this context Morrison (2003: 296) raises concerns about complexity-based curricula which need to be recognized, for example, in terms of :

- *Practicality* (e.g. class size, the need for examinations and measures in competitive environments; time; the need for minimum competencies);
- *Superficiality* (the risk of lack of in-depth study, which may require prescription and pressure as a counter);
- *Uncertainty* (curricula are unpredictable, with the risk of lowering quality in the pursuit of difference and quantity of experiences);
- *Sensitivity, threat and risk* (some new knowledge constitutes a threat to conventional curricula, pedagogy and assessment; there is a risk of unclear returns on investment in new curricula);
- *Changing mentalities* (how to manage the process of change without overload, and persuading teachers, students, parents, principals of the benefits);
- *Teacher expertise* (their capability to be polymaths, their abilities and preparedness to change, innovation fatigue and overload);
- *Resources* (how to resource many curricula, e.g. through IT; time; teachers);
- *Assessment* (e.g. how to incorporate necessary external assessments within the very different proposals for assessment in complexity theory).

Though writing about curriculum reforms in Hong Kong, these remarks can apply to the development of nursing education in Macao. Practical challenges face the development of nursing education in Macao.

Conclusion and prospect: complexity theory and its application to nursing education in Macao

Nursing education in Macao is facing complex environmental and internal system changes, and is having to restructure and reorganize itself. How can this be understood and approached? Using key elements of complexity theory, this paper has identified strategies that can be used to progress nursing education in Macao. They focus on the relationships between external environments and internal adjustment, particularly using Ashby's law of requisite variety. The developments in nursing and nursing education can be examined through the lenses of key concepts from complexity theory:

The *interaction* of individuals feeds into the wider environment which, in turn influences the individual units of the network; they co-evolve, shaping each other (Stewart, 2001), and co-evolution requires connection, cooperation and competition: competition to force development (and, in Macao, one major provider of nursing education is a private organization rather than a government-sponsored organization, and hence is acutely aware of the need for excellence in order to survive) and cooperation for mutual survival. Recent changes in nursing and nursing education in Macao's nursing education providers have also required interaction between them, simultaneously, they co-evolve, connect, cooperate

together to gain a greater force in nursing education in the society; but there also competition between them to select, train and qualify nursing students.

Emergence and self-organization are the partners of self-organization. Here the self-organization emerges of itself as the result of the interaction between the organism and its environment (Casti, 1997), and new structures emerge that could not have been envisioned initially (Merry, 1998). In nursing education in Macao, this has led to organizations themselves realizing their need to collaborate with external providers and to restructure their internal organization in order to meet demands for increasing services, not least out of a sense of Macao's acceptance that, as a tiny territory, it is impossible to meet its needs simply or solely from within itself. To increase adaptability to change a system or institution must emerge and become more self-organizing in order to better prepare itself for change. There is also the need for new and increased human resources for example with lecturers with a higher education background from Hong Kong and Mainland China, offering different nursing programs that have unique characteristic. This is evident in the following:

- (1) *Kiang Wu Nursing College of Macao* is holding a 4 year Bachelor Degree Program in Nursing;
- (2) *The School of Health Sciences, Macao Polytechnic Institute* is offering a 3 year Higher Diploma Nursing Program and a 1 year supplementary course Bachelor Degree Program (Day program) and 1.5 years supplementary course Bachelor Degree Program (Night Program) for the nurses in Macau. Recently, a Specialty Nursing Program was initiated (September, 2006), only offered by the *School of Health Sciences, Macao Polytechnic Institute*.

Connectedness: Nursing and nursing education in Macao is connected internally and externally in several ways, such as students to students, inside and outside the institutions. In Macao, this is evidenced in the links not only between internal providers of services, but also with external environments and providers, in the form of overseas universities, higher education courses for nursing lecturers, external accreditation, and the increased use of outside staff coming to Macao; teachers are linked to other teachers, other providers of education, health services, policy-making bodies, and so on..

Change and adaptability. The experience of Macao's nursing education provision has been one of the survival of the fittest. Some organizations that, previously, had provided nursing education have not survived; their demise has been matched by the need for the survivors to change themselves, often by internal reorganization and external connectivity. The experience is of survival in changing environments in which systems evolve, through self-organization, towards the edge of chaos in the sense of greater creativity and change – an imaginative linking with external providers (Kauffman, 1995). In the case of nursing education in Macao this can be seen, for example, in the linking with foreign education institutions to offer Master's degree and PgD awards for continuous education development in nursing, and also an opportunity for the long-serving and recently qualified nurses to upgrade their education level, itself facilitating greater connectivity between new generations and more experienced practitioners to ensure safety and quality in nursing care.

There are others concerns in the emergent forms of nursing education in Macao, for example: practicality, superficiality, uncertainty, sensitivity and threat, changing mentalities, teacher expertise, resources and assessment:

Practicality: class size must ensure the quality of teaching and learning, both in the theory phase and the clinical phase, for example, ideally, thirty in a class and not more than six students in each clinical practice ward. There is a need to develop a clear evaluation program of courses and nursing education programs and student progress evaluation. There is a need to define a standard set of criteria to maintain minimum competencies, and to ensure the the development of students' capabilities that build further on their competencies.

Superficiality: as nursing education expands its scope, it brings the risk of lack of in-depth study, which may require prescription and pressure as a counter; the breadth of study must also be matched with appropriate depth of study, both in overall nursing education and in terms of specialisms. Further, lecturers and students must use English as a medium of teaching and learning, not least because external connectivity to other overseas service and training providers requires the international language of English.

Uncertainty: in the complex, changing society, curricula are constantly developing, mutating and standing in need to updating and replacement, adapting to external and internal environments for institutional survival. Needs assessment, quality of provision and quality of nursing outcome remain of paramount importance.

Sensitivity, threat and risk: the need for nurses to acquire and utilise new knowledge may constitute a threat to conventional curricula, pedagogy and assessment; there is a risk of unclear returns on investment in new curricula. Perhaps the use of research and evidence-based nursing education may move towards ensuring reliable and up-to-date knowledge, competencies and capabilities in students.

Changing mentalities is another challenge to nursing education: how to manage the process of change without overload, and persuading teachers, students and stakeholders of both the needs and benefits of constant change. Direct dialogue and motivation may be required in order to change mentalities, continuous education for the teachers to acquire new knowledge and advanced technological skills, not least, for example, in the form of virtual classrooms and on-line learning.

Teacher expertise; there is a need not only to reinforce the teachers' capabilities to teach their conventional programs, but also to be polymaths and yet specialists, including their abilities in, and preparedness for change, becoming lifelong learners. On the other hand, they have to contend with innovation fatigue and overload. The nurse training institutions' policies must be planned systematically to minimize unnecessary stress on teachers.

Resources: there is a need to consider the resourcing – and new resourcing – of curricula, with advanced technology, teaching resources delivered through on-line learning, and how to maximise benefit to both students and teachers.

Assessment: as connections are developed with external providers of nursing education, not only is there a need to ensure high quality education, not least through appropriate program evaluation, but also in terms of student assessment and qualifications.

Nursing education will continue to face unpredictable problems and demands in Macao. Macao's nursing education demonstrates several key aspects of complexity theory, not least how to cope with uncertainty and paradox that inhere inhere within systems approaches to training provision. Because complex systems are nonlinear, healthcare processes are

increasingly more unpredictable, not only in terms of inputs but also in terms of processes and outcomes. Leading in a complex environment requires managers to understand new concepts, such as emergence, self-organization, strange attractors, pattern recognition, and changing parameters.

Facing a complex changing world, nursing educators, to survive, must keep pace with ongoing technological innovation, a rich network of interacting agents, and increased information flow, which combine both to streamline healthcare systems and increase complexity.

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