Self-organisation, integration and curriculum in the complex world of medical education

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CONTEXT The world of medical education is more complex than ever and there seems to be no end in sight. Complexity science is particularly relevant as medical education embraces a movement towards more authentic curricula focusing on integration, interactive small-group learning, and early and sustained clinical and community experiences.

DISCUSSION A medical school as a whole, and the expression of its curriculum through the interactions, exchanges and learning that take place within and outside of it, is a complex system. Complexity science, a derivative of the natural sciences, is the study of the dynamics, conditions and consequences of interactions. It addresses the nature of the conditions favourable to change and transformation (learning).

CONCLUSIONS The core process of complexity, self-organisation, requires a system that is open and far from equilibrium, with ill-defined boundaries and a large number of non-linear interactions involving short-loop feedback. In such a system, knowledge does not exist objectively 'out there'; rather, it exists as a result of the exchange between participants, an action that becomes knowing. Understanding is placed between participants rather than being contained in one or the other. Knowledge is not constructed separately in the mind of the knower, but, rather, it emerges; it is co-created during the exchange in an authentic recursive transactive process. Learning and knowing become adaptive responses to continuously evolving circumstances. An approach to curriculum based on self-organisation is characterised as rich, recursive, relational and rigorous and it illuminates how a curriculum can be understood as a complex adaptive system. The perspective of complexity applied to medical education broadens and enriches research questions relevant to health professions education. It focuses our attention onto how we are together as human beings. How we respond to and frame the issues of learning and understanding that challenge contemporary medicine and, by extension, medical education, in a complex and rapidly changing world can have profound effects on the preparedness of tomorrow's health professionals and their impact on society.

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'The physicist Richard Feynman once described how aliens from outer space looking at the Earth would, to their astonishment, see a thin vertical line of millions of people brushing their teeth that rotated around the Earth every 24 hours. This line of tooth brushers, just on the bright side of the line of dawn that separates day and night, is not created by a single tyrant that orders each of those people to brush their teeth at just the right moment. Rather it is formed by the individual actions of millions of people who had independently decided to brush their teeth in the morning. Nobody has ordered them to form a line, yet, each acting independently has generated a distinctive pattern in space and time. This line and its motions around the Earth is an example of ''self-organisation'', that is, when a global pattern emerges from the rules that govern a large number of individual units … there can be many different types of individual units. The rules that control them can be mathematical rules, physical laws, or biological behaviours.'[1]

INTRODUCTION

What can we learn from a global line of tooth-brushers, just on the bright side of the dawn, that is relevant to medical education? The event Feynman describes is complex because it consists of many interacting agents (variables) with ill-defined boundaries that together form a dynamic whole. It is complex because the whole cannot be understood by reducing it to its component parts, nor can it be described by simple linear equations. The behaviour emerging from the multiple interactions of individual agents cannot be predicted from the circumstances prior to their interactions. It is a system that is open to the outside world and is continuously exchanging energy with its surroundings. It is affected by and, in turn, affects its environment. A medical school as a whole, and the expression of its curriculum through the interactions, exchanges and learning that take place within and outside of the school, is a complex system.[2] Other examples of complex systems include health and illness, the organisation, conduct and management of health care systems, hospitals, clinics, classrooms, people and the nervous system. Complexity science, a derivative of the natural sciences, is the study of the dynamics, conditions and consequences of interactions in complex systems.[3–7] It is a relatively new and diverse field that has many different interpretations and is still finding its way into the health professions. It focuses on the nature of and conditions that lead to change and transformation under particular conditions.[5]

A recent description of American medical education included the statement: 'Medical education appears to be in a state of perpetual unrest.'[8] Currently, it exists in a state of tension between the tendency to fall back into traditional teacher-centred pedagogies and the urge to reach forward to newer, more interactive, authentic, integrative and transformative approaches to learning and teaching. There have been calls for the re-examination of existing paradigms in medical education, many of which have become fragmented and remain rooted in Cartesian reductionism and Newtonian principles of linear causality.[9,10] A realisation is emerging that what is needed are approaches that embrace and recognise the dynamic nature of the interaction between health and the social determinants of disease in order to promote capability[11–14] as a goal for the preparation of future health professionals who must address the evolving priority health needs of society.[8,15–18] How we respond to and frame the issues of learning and understanding that challenge contemporary medicine[19] and, by extension, medical education, in a complex and rapidly changing world will have profound effects on the preparedness of tomorrow's health professionals and their impact on society. Complexity science contributes to an explanation of and insight into the process of adaptation to changing circumstances at the macro level of medical school curricula and at the meso and micro levels of teaching and learning.[13,20–23]

Complexity concepts have appeared in the medical education literature.[10,24,25] However, they have not yet taken hold of the collective consciousness of medical educators. The purpose of the present paper is to introduce further and relate key concepts of complexity science to contemporary medical education to stimulate discussion, to '*re-view*' and reframe approaches to integration in curricula and the teaching–learning dynamic that is fundamental to what we do as medical educators and as learners.

Imagine that a diverse group of people, including teachers from clinical and basic science departments, students, community and patient representatives, and other stakeholders, have been asked to work together as a committee during the coming year to review and recommend revisions to the curriculum at a medical school. Their goal is to propose a curriculum that will prepare graduates to be responsive to regional health needs and that will optimise the talents and abilities of all concerned. You are the chair of this committee. It is clear to you that it is not possible to predict accurately what will finally

happen and that over the course of many meetings your interactions with members of the committee will evolve as information is exchanged, points of view and values are put forward, and data are reviewed and applied to the challenges faced by the committee. The committee functions as a complex adaptive system: '…a collection of individuals (agents) with freedom to act in ways that are not always totally predictable, and whose actions are interconnected so that one agent's actions change the context for other agents.'[26] The curriculum committee, like other complex adaptive systems, will learn from its experience and adapt to changing circumstances as it pursues its task over time. Each person on the committee is also a member of other complex adaptive systems that are nested one within the other at different levels of interaction,[27] such as departments nested within the school, the school nested in the community and individuals nested in social groups outside the school, such as families, etc. As Capra writes in *The Web of Life: a New Scientific Understanding of Living Systems*, 'A system is an integrated whole whose essential properties arise in the relationship between its parts…'[4] The committee is not static. There is a constant flow of people and information into and out of it. It is open to the exchange of different forms of information and activity that keep it in a state of flux, energetically far from equilibrium.[10,26,28] Members are simultaneously involved in different systems and the committee receives new information and resources, while it, in turn, provides information and resources to other groups in the school and community in the form of periodic reports, updates and informal discussions. The committee's boundaries, beliefs and rules are defined, yet are imprecise and fuzzy.[6] Initially, the discussion could go in any one of many possible directions. Over time, as the members of the group interact and exchange views and differences, the group tends to settle into (is attracted to) a particular rhythm and pattern as it works through various possible approaches to its tasks and as it begins to shape the outlines of a proposed curriculum. Each time there is a question, a disagreement, or the composition of the group varies and new information is added to the discussion, the dynamics of the group are disturbed. The group tends either to return to its previous pattern or configuration of understanding (stability) or to change and reconfigure itself (to undergo spontaneous self-organisation) to arrive at some new state of understanding (i.e. a new pattern).[7,20,28] The final pattern, the committee's proposed new curriculum, will emerge from and reflect its integrated collective thinking, experience and interaction over time. Capra says: 'A pattern of organisation is a configuration of relationships characteristic of a particular system.'[4] Configurations of patterns are fundamental to understanding, in general, and to understanding how integration and learning occur individually and in groups. The same complex process the curriculum committee goes through, although with different details, will happen among teachers when they come together to interpret, respond and adapt to the curriculum committee's recommendations. Similarly, when teachers implement their understanding of the recommendations (boundaries, contexts and rules) at various levels of detail, the same adaptive process of self-organisation will take place. When students and teachers respond to the boundaries placed on them by sets of outcomes, objectives and deadlines, they too will respond with a process of self-organisation. The details will vary in each setting, yet a similar process occurs at each level of organisation (scale-free self-similarity).[29] The planning process of the curriculum committee, the process by which teachers organise courses, modules or units and the process students go through when interacting with teachers, materials, patients and problems, etc. in their day-to-day learning are similar, yet different. Each group experiences multiple interactions among its members (agents) with frequent short-loop feedback. The underlying process by which complex adaptive systems organise themselves, adapt to changing circumstances, and achieve integration, learning and understanding, is called self-organisation.[4,7,10]

SELF-ORGANISATION

Self-organisation refers to the process by which new structures, patterns or properties arise spontaneously and are characterised by multiple feedback loops involving non-linear dynamics.[4,30] A classic example often used to illustrate self-organisation refers to the formation of Bénard cells[31] (Fig. 1). A thin layer of liquid in a pan is heated slowly. The bottom layer becomes hotter until a critical temperature is reached and the liquid takes on a structure of thermal conductivity. Its temperature, density and pressure vary between the top and bottom planes, leading to the formation of unexpected patterns, Bénard cells. Temperature gradients in the liquid create a non-equilibrium-based structure, which, when viewed from above, appears as square patterns as a result of the self-organisation of the liquid molecules. The system literally reconfigures itself to adapt to changing conditions and assumes an optimal structure in response to the heat gradient. Merely putting things in proximity, by itself, does not necessarily lead to the

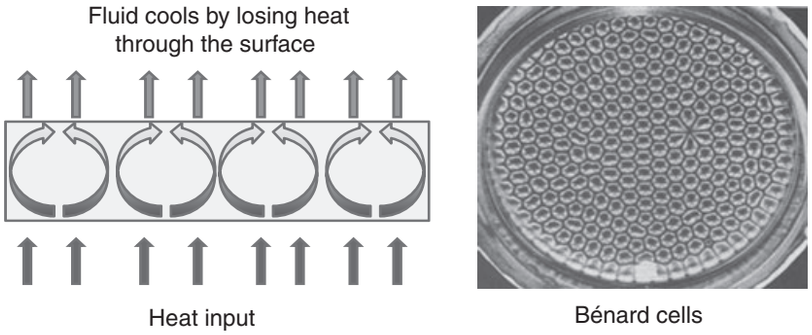

Figure 1 Bénard cell formation is an example of self-organisation. (a) A thin layer of liquid is heated slowly. The bottom layer becomes hotter until a critical temperature is reached and the liquid overcomes its viscosity and takes on a structure of thermal conductivity. Its temperature, density and pressure vary linearly between the top and bottom and the liquid undergoes bulk motion leading to (b) the formation of unexpected patterns, Bénard cells

emergence of new patterns and self-organisation. An external gradient, in this case, of heat, is necessary. The emergence of the new pattern is a function of the characteristics of the molecules (agents) themselves.

There is no '*self*' in self-organisation, nor is there a predetermined endpoint that is purposeful in a teleological sense.[7] It is an open-ended process in which the past and present provide a basis for the future without limiting and controlling it.[7] What emerges from self-organisation is fully integrated and whole. It is different from and not the sum of the parts that led to the new pattern. The same principles and process of self-organisation operate among the agents and variables that constitute the reality of medical schools, curricula and learning. The new patterns that form from self-organisation are said to emerge. Emergence can be long and continuous or rapid. The emergent pattern (the proposed new curriculum in the example given) depends on what came just before and at the same time influences what will come next.[29] Dewey believed that the ends emerged from within the process itself.[32] Bruner[33] emphasised learning as being about the relationships between things. Creative play, interaction and exploration are a necessary part of learning.[34] Fuzzy (ill-defined) boundaries, context and history function as liberating constraints in that they provide a stable structure within which change can occur. Being playful with variations of a situation is part of deliberate practice and reflection, and incorporating feedback promotes the development of expertise as a self-organising process.[35,36] Learning is a continuously emergent property of self-organisation.[29,37] A summary of conditions that promote self-organisation are listed in Table 1.

Teachers, learners and curriculum planners promote conditions for self-organisation (integration) through dialogue, stories, problems, unresolved situations, questions and incomplete understandings, all of which serve to disturb the status quo (like heat in the Bénard cell example) and stimulate curiosity, interaction and exchange. They create discrepancies between what is and what could or will be, which represent gradients and gaps in information and understanding among learners that result in a need to know, to act. Feedback and reflection function as non-linear recursive loops that promote conditions favourable to self-organisation.[7,13,26,29]

A group of people beginning to work together experience multiple non-linear, recursive interactions that initially serve to destabilise the group and move it though a variety of possible patterns or states until its members reorganise themselves and a shared understanding emerges in the form of a group decision about learning objectives or an agreed-upon action or explanation.[9,25] Other medical education examples that involve change through the process of self-organisation include individual and group reflection, formative and summative assessment, various forms of case discussions and community-based education, to name a few.

TEACHING, INTEGRATION AND SELF-ORGANISATION

Integration refers to the dynamic interconnectedness that emerges from recursive interactions at multiple levels. Putting things in sequence and proximity is necessary, but not sufficient for integration. Integration is more about the nature and quality of interactions over time and how they lead to the

Table 1 Conditions for self-organisation, with medical education, clinical and biological examples

Conditions for self-organisation	Medical education examples	Clinical and biological examples
Open to the outside, far from equilibrium	Students and teachers are free to come and go; students encounter new information and new experiences daily; patients come and go in clinics and hospitals; agents are changing constantly	Biological systems are open and exchange energy with the outside world (e.g. the respiratory system, the gastrointestinal system). Global epidemics like H1N1, SARS and HIV AIDS arise from the openness, fluidity, flow and mobility of people and infectious agents
Large number of interacting elements, multiple short feedback loops	Many students, teachers, patients; continuous exchange of information among different agents	Many patients, workers and staff in the hospital or community clinic change as a result of their interactions
Fuzzy boundaries	Boundaries that are ill-defined and permeable hold agents together to promote interactions; context can serve as a fuzzy boundary; boundaries can be physical, biological or conceptual; examples include ground rules for small-group discussions, curriculum general learning outcomes, rules of ethics and professionalism	Semi-permeable cell membranes frame cellular interactions; groups of health workers may have varying roles depending on conditions; an emergency room has defined space yet extends to other units in a hospital
Agents change through multiple non-linear local interactions	Feedback and formative assessment; self, peer and group; the exchange of ideas in groups affects outcomes and data; a patient's history influences the doctor's approach, sequence of questions and actions which, in turn, affect the patient, who in turn, affects the doctor	Small changes in clotting factors make big differences in haemodynamics; large expenditures in health care do not necessarily result in greater health indices

formation of new patterns that are fluid and whole. Curriculum design, integration and learning are about the conditions under which new patterns emerge from interactions.[9] The student experiences transitions (phase shifts, in the language of dynamic systems[6]) during which body systems self-organise and new patterns of understanding emerge (learning).[37–39] Reflection is a recursive process that facilitates self-organisation.[6,35] Recursion refers to the end of one event which becomes the beginning of the next, unlike repetition where the next event is the same as the previous one. Teachers help students learn (self-organise) by designing curricula and learning experiences that are contextually rich, recursive (iterative variations with reflection) and relational.[9,20] Anything that serves to disturb the status quo of a complex adaptive system (i.e. a variable outside or inside the system), to which the system is sensitive and which helps move it through different states (towards self-organisation), is called a control parameter.[6] Curriculum outcomes and guides function as control parameters that orient learners, yet do not decree the specific path taken by the learner.[40,41] The problem in problem-based learning (PBL),[25] the patient in your office, the particular approach a teacher takes in a given moment, and a well-framed question can all be control parameters.[6,29]

Curriculum activities and teaching methods differ in their richness and in the extent to which they promote interactivity (i.e. their potential to disturb the status quo and stimulate self-organisation, or learning). The more interactive the curriculum and the teaching and learning experiences, the greater the degree of disturbance and the greater the

likelihood that self-organisation will occur.[20] Interactive collaborative inquiry and PBL are more interactive than team-based learning, which is more interactive than lectures. One of the many strengths of communities of practice is the high degree of rich interaction at multiple levels of experiential learning.[42] In this context, it is interesting to observe that the trends in medical education over the past three decades have been towards more diversity, richness and authenticity in curriculum design, learning and assessment methods,[18] which students identify as helpful to their learning.[43]

The nature of the relationship between teacher and student, and doctor and patient, influences what happens and what emerges. The roles of the teacher as knower and the student as learner exist in a complex system in which both are transformed by questioning and by seeking understanding. In *A Post-Modern Perspective on Curriculum*, Doll, writes: 'In a reflective relationship between teacher and student, the teacher does not ask the student to accept the teacher's authority; rather, the teacher asks the student *to suspend their disbelief in that authority*, to join with the teacher in inquiry, into that which the student is experiencing. The teacher agrees to help the student understand the meaning of the advice given, to be readily confrontable by the student, and to work with the student in reflecting on the tacit understanding each has.'[9] The teacher and student suspend power differences and enter into a reciprocal relationship-centred approach that enriches learning for both.[37,44] Relationship-centred care between the doctor and patient is a complex responsive process[45] of relating in which patterns of meaning emerge through the reciprocal recursive exchange of gesture and language.[46] *Knowing* is understood to emerge from the continual flow of interaction between knower and known, from transactions in the space between two people, a student and teacher, and a doctor and patient.[9] The richness of the learning context[47] and activity[48] are part of the interaction that is involved in the self-organisation process. Learning in a self-organising curriculum allows teachers and students to co-evolve, so that each participant in the local exchange is changed as a result of his or her interactions. For example, think of a situation in which two students in different PBL groups are discussing their experiences. They make gestures with their hands and faces as they talk.

Student A says, 'Our group makes learning objectives at the end of the session. I'm not sure that's the best way to do it. What happens in your group?'

Student B replies, 'In my group, we make learning objectives throughout the discussion as the need arises and then at the end we select the most important ones for study.'

Student A says, 'I see. I think I'll suggest that to my group.'

Student B asks, 'I wonder if it will make a difference?'

Student A replies, 'It might. It's worth trying.'

Both students are simultaneously product and process. Understanding is placed between them, not contained in one or the other. It emerges from the opening up of new spaces of possibility from the exploration of current spaces.[9] The distinction between object and subject evaporates because both are co-determinates of one and the other. Learning exists as the exchange between participants, an action that becomes knowing. Knowledge is not constructed separately in the mind of the knower; rather, it emerges as knowing; co-created during an exchange in an authentic, recursive, transactive process, an adaptive response to continuously evolving circumstances.

INTEGRATION AND SELF-ORGANISATION

National and international agencies[49–54] and medical schools[55] have responded to the call for social accountability to priority health needs by defining a set of outcomes and competencies, framed as knowledge, skills and attitudes, that graduates must demonstrate.[51,56] Competencies and outcomes are broad statements meant to organise and frame overall teaching, learning and assessment strategies and can function as fuzzy boundaries within which self-organising learning occurs. Competency-based curricula have been criticised as being too 'top-down' and at risk for constraining teachers' and students' freedom to learn.[57–59] Traditionally, the burden of integration has fallen locally upon the shoulders of the individual learner.[60] Integration, as applied in curricula, has been primarily about the proximity and sequence of content,[41] and the learning venues and processes by which it is thought to be achieved.[40,41] Self-organised learning is a 'bottom-up' process that takes place through local recursive interactions among learners and between learners and learning resources in a rich context.[61] Top-down curriculum planning and bottom-up learning are complementary and, ideally, should both come into play at the same time to achieve dynamic and

sustainable integration in the planning, implementation, learning and evaluation of health professions education. Integration through self-organisation binds top-down planning and bottom-up learning together. Understanding, the new patterns and ideas that form through self-organisation, emerges whole and fully integrated. It is not constructed from the sum of the parts.

CURRICULUM AND SELF-ORGANISATION

How can a curriculum be self-organising? Many patterns in nature are the same or similar when viewed at different scales or orders of magnitude. An individual fern leaf has the same shape as that of the whole fern and the shape of each part of each fern leaf is a miniature of the whole leaf. This is referred to as scale-free self-similarity in which organisation is characterised across networks by adherence to a common set of guiding principles.[62] The branching pattern of Purkinje fibres in the heart, heart rate variability over time[63] and the dendritic spines on cerebellar cells[64] are other examples of scale-free self-similarity. Self-similarity provides a way to think about designing an integrated curriculum in which defined outcomes and generative themes such as health and illness and the health of society can occur over different time-scales in a self-similar way (6 years or 4 years, 1 year, 1 month, 1 week; planning for less than 1 week increases the risk of fragmentation and loss of coherence in the learning experience). Figure 2 illustrates how self-similarity can be translated into curriculum planning by defining competence in medical education in terms of observable and measurable performance that remains whole and intact at every level or scale of the curriculum.[65,66] The same overall outcomes are described in each year of the curriculum. What varies is the capacity to express the competence at the level of understanding the learner has at a given time. A painting viewed by a first-year art student is understood and appreciated to the full extent of that student's ability. A sixth-year student differs in that he or she has learned more and is able to understand and appreciate colour composition, brush strokes and the perspective of the artist in the same painting. Authenticity in medical education is usually defined in terms of the final desired outcomes. In a complex self-organising curriculum, authenticity can also be understood in the context of the learner's capability at any given moment. What the learner knows, knows how, shows how and does[67] can be assessed at each level (year) as his or her authentic learning and understanding.

Curriculum design based on self-organisation has been characterised by Doll as rich, recursive, relational and rigorous[9] and it illuminates how a curriculum can be understood as a complex adaptive system. *Richness* refers to the depth of the curriculum, its layers of meaning and its different possible interpretations. Curriculum needs to be '… provocatively generative without losing form or shape… it needs disturbing qualities, perturbations, to provide richness'.[9] *Richness* comes from negotiating passages between various interpretations of situations, data and experiences. An example is the study of the principles that underlie shortness of breath in different contexts, such as in a 25-pack per year smoker, a newborn baby and an 85-year-old woman, which can occur in every year of the curriculum. *Recursion* is

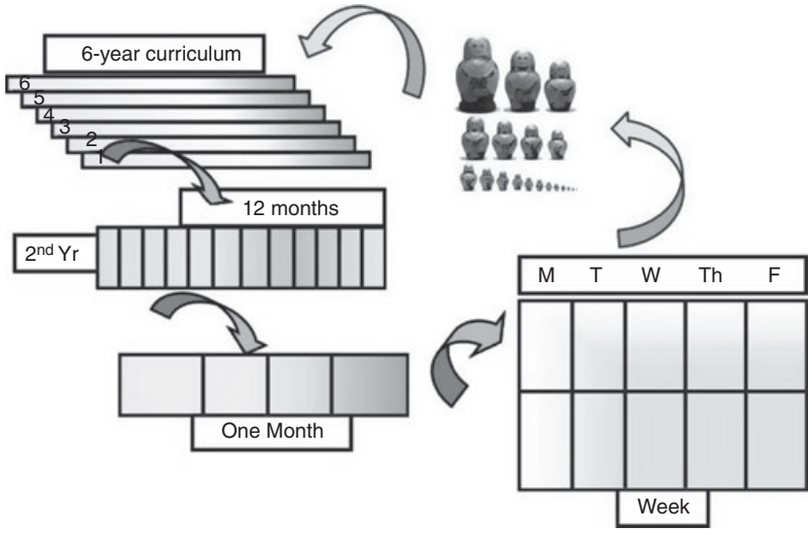

Figure 2 Curriculum self-similarity illustrating that a general theme or concept can be represented in each temporal level. The concept retains its form at different scales, like Russian dolls, while being implemented during different time-frames

about looping thoughts on thoughts in reflective interaction with the environment and with culture as an essential part of transformation. Formative assessment, such as a mini-clinical examination (mini-CEX), and reflection about community-based education in a portfolio are two examples. In recursion '…there is both stability and change … in an orderly but often unpredictable manner'.[9] Thus, the educational structure is stable as the learner changes. Complexity science advocates for spiral curricula[40] that are recursive, developmental and comprehensive with tests, practicals, portfolios and other completions that become the beginning of the next part of the learning process.[9] Reflection conceived as recursion is helpful in developing competence and promoting inquiry. In *A Post-Modern Perspective on Curriculum*, Doll writes: '…without reflection engendered by dialogue, recursion becomes shallow not transformative; it is not reflective recursion, it is only repetition.'[9] *Relations* are constantly changing and it becomes important to seek the connections between different things. An integrated learning experience values human relationships as an essential aspect of explanations about interactions: 'What becomes important are the connections with people, with the environment and the culture … our local perspectives integrate into a larger cultural, ecological, cosmic matrix…'[9] *Rigour* is important in a transformational curriculum. It means 'purposely looking for different alternatives, relations, connections...' or looking for and uncovering the assumptions that underlie our understanding.[9] In the rapidly changing world of the health professions, it refers to the capability[11] of learners to frame new questions, define problems and seek understanding in new situations.

COMPLEXITY AND RESEARCH IN MEDICAL EDUCATION

The role of research is to offer explanation, description and prediction based on a systematic approach to inquiry. The goal is to be able to make predictions about outcomes in order to improve education. According to Radford: 'Nobody would deny that schools are complicated but the concept of complexity brings a further dimension to the ways in which we see them functioning… whereas complicated systems are understood to be relatively contained and limited in terms of their interacting variables, complex systems are open and subject to potentially unlimited variables. Complicated systems tend to be understood in terms of measurable variables that remain relatively stable in terms of strength and patterns of interaction. In complex systems, the influence of the particular factors is variable according to the relationships that they enjoy with others at any moment in time… Within the context of interaction between the elements new variables or characteristics may emerge that cannot be accounted for within the context of the interacting components but only in that of the interactive process itself.'[13] Research in medical education often seeks unsuccessfully to reduce complex systems to their component parts, searching for regular and predictable patterns of interaction. The study and comparison of curriculum interventions such as PBL has 'invariably confounded attempts to seek cause–effect relationships, and simple experimental strategies like randomisation will hardly remedy the situation'.[68] Complex systems, such as schools, are resistant to reductive methods of prediction and control.[13] As complexity science enters the lexicon of medical education, we will need to find new ways to study systems in which multiple variables are interacting simultaneously.[69] One promising approach, structural equations modelling, has already appeared in medical education.[70,71]

Thinking of medical schools as complex adaptive systems raises new questions. What are the key elements, structures and learning events in medical schools that contribute to their self-organisation? How can existing and new emergent structures that are important for self-organisation and emergence in learning be identified in schools? How does approaching schools as complex adaptive systems alter leadership and management practices? How can the fitness of the schools to cope with change, flexibility and adaptability be studied? What are the conditions for emergence in a medical school and how can they be identified, developed, supported and sustained? How can learning in medical schools become more humanistic and person-centred? If the past is a prologue, the future will continue to increase in complexity. The application of complexity science to medical education will help us to cope with and understand these challenges.

CONCLUSIONS

Embracing the perspective of complexity and self-organisation affects how we formulate research questions, and plan and conduct curricula. It affects how we understand learning as transformation that emerges from self-organisation. It focuses us more intently on the quality of human relationships and exchanges that affect the quality of learning at all levels. Relationship-centred teaching becomes the focus of learning in a complex curriculum. Knowing

emerges in the space between participants. It focuses our attention more closely on how we are together as human beings. Teaching, learning and assessing become co-evolutionary events framed by fuzzy boundaries in open dynamic systems. Learning is understood as transactive and transformative. Integrated curricula are based on the self-similarity of generative themes at all levels.

How can faculty develop habits of co-evolution with students? How can teachers be part of the knowing and learning process rather than giving or transferring knowledge to students? It is time for medical education to embrace learning as self-organising and emergent in a complex curriculum '...where no one owns the truth and everyone has the right to be understood'.[9] One hundred years ago, Flexner changed the paradigm for medical education. The next hundred years may well see the emergence of new paradigms in which complexity science becomes an important perspective in our understanding of health professions education and health care systems.

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