Paper Presented at the AARE Annual
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AARE 2008   Complex curriculum and pedagogy   1

Complexity Theory: Supporting Curriculum & Pedagogy Developments in Scottish Physical Education

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Abstract

This paper describes how complexity theory principles relating to self-emergence and connectivity have been employed to inform our recent developmental work in Scottish physical education. We suggest that these complexity principles have purchase in postmodern times characterised by uncertainty, multiplicity, and contradiction (Fernandez-Balboa, 1997). We cite examples from the development and delivery of a Developmental Physical Education Programme in Scotland to assert that complex learning principles (Light, 2008; Morrison, 2008) can be employed to structure curriculum and pedagogy endeavours. These examples from practice highlight the ways in which a complexity-oriented learning approach provides a challenge to hierarchical, reductionist, and behaviourist notions of learning which have long held a strong foothold in the field of physical education (Light, 2008). At the same time, we pay attention to critical questions which have been raised regarding the practicality of structuring educational practice with emerging theories such as complexity theory (Davis & Sumara, 2006).

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Introduction

The purpose of this paper is to describe how several complexity theory principles relating to self-emergence and connectivity, have been increasingly drawn on to underpin the curriculum and pedagogy efforts of the Developmental Physical Education Group (DPEG) at the University of Edinburgh. Using examples from practice, we highlight the ways in which a complexity-oriented learning approach challenges hierarchical, reductionist, and behaviourist notions of learning which have long held purchase in the field of physical education (Light, 2008). In so doing, we acknowledge some of the critical questions which have been raised regarding the implementation of complexity theory to structure educational practice (Davis & Sumara, 2006; Morrison, 2008). We propose that complexity theory is an appropriate framework to conceptualise our contributions to the field of physical education in an era that has been characterised as postmodern. Wright (2004) proposes that "we live in times characterised by profound social and cultural changes"; this means that "ways of understanding health and the values and meanings associated with physical activity and sport" are not static and fixed (p.3). Kirk (1997) similarly suggests that physical education is undergoing major changes due to the prevailing worldview which sees a range of critical postmodern theories replacing long-held modernist views of knowledge and the self. The conditions of postmodernity have necessitated that those involved in physical education negotiate the values of uncertainty, multiplicity, and contradiction (Fernandez-Balboa, 1997).

Following on, we cite examples from our endeavours to create a Developmental Physical Education Programme in Scotland to closely consider how these postmodern values might find sympathy with complex notions of learning. Indeed, Morrison (2008) suggests that the primary tenets of complexity theory, including "distributed control, self-organization………open systems, unpredictability" are integrally linked with "a postmodern world" (p. 30). However, it is important we declare early in this paper that, although we strongly support a complexity view of education, and will contrast this viewpoint with notions of modernism and behaviourism throughout the paper, it is not our intention to present education as a dichotomous, polarised endeavour in which complexity approaches to curriculum and pedagogy are portrayed as 'good' and behaviourist approaches as 'bad'. We propose, however, that there is an urgent need for a *shift in emphasis* from more traditional notions of learning and knowledge to conceptions that are broader and more contemporary. From this perspective, we highlight examples from our curriculum and pedagogy efforts to speculate about the role of complexity theory in supporting and even enhancing a postmodern critique of modernist approaches to physical education.

A recent body of work has highlighted the ways in which schools can be conceptualised as complex systems. Morrison (2008), for instance, suggests that schools are "dynamical and unpredictable, non-linear organizations operating in unpredictable and changing external environments" (p.22). He further reminds us that "schools both shape and adapt to macro- and micro-societal change, organizing themselves, responding to, and shaping their communities and society" (p.22). Davis and Sumara (2006) similarly describe self-organisation and adaptation as qualities inherent to complex educational systems such as schools. This view of schools suggests that knowledge is not static and centrally held, but is instead "dispersed, shared and circulated throughout the system" (Morrison, 2008, p. 21). Osberg, Biesta, and Cilliers (2008) describe this distributive and collaborative understanding of knowledge as "emergentist"; it is imagined that students learn by engaging and responding to the shifting and diverse knowledges found in the curriculum. They suggest that these engagements with content are "dynamic, self-renewing and creative" and bring forth "new worlds" (p.225).

The notion that schools can operate as adaptive and self-organising systems which support students' active and collaborative learning has clear implications for physical education practice. We suggest that a complex learning approach challenges the modernist educational tradition which is based on linear and behaviourist models of learning. Historically situated within this modernist paradigm, physical education has been pre-occupied with the teaching of seemingly fixed knowledges surrounding the body, movement, and physical activity. Kirk (2004) describes this project as "schooling for docility-utility" (p.201)   He contends that a behaviourist learning approach has been traditionally implemented to produce physically educated pupils who can assume and reproduce specified knowledges, which have tended to be "decontextualized and abstracted" elements from sport (p.202). Light (2008) similarly argues that behaviourist approaches to teaching physical education typically involve "a 'training' approach to teaching" and "requires a highly structured and technical pedagogical approach" (p.23).

In response to the provision of "fixed and specialist skills" which renders both physical education teachers and pupils "docile", Wright (2004) argues that curricular and pedagogical practices should instead develop pupils who can grasp and "deal with the uncertainty of conflicting and changing knowledge" (p.6). Similarly, a complexity-informed perspective suggests that "greater degrees of complexity, change and adaptability…..in changing environments" requires that educational practitioners approach learning in terms of "self-organization, towards the 'edge of chaos' (Kauffman, 1995)" (Morrison, 2008, p.21). Morrison (2008) argues that positioning education at the "edge of chaos" serves to bring about "behaviours, ideas, and practices of individuals and systems" in ways that can be characterised as "creative, open-ended, imaginative, diverse, and rich"; furthermore, the

conditions of "chaos" support greater "connectivity, networking and information sharing" amongst students and teachers (p.22). Following on, we argue that complexity theory can underpin the teaching and learning of physical education relative to uncertain and changing knowledges. This complex approach challenges behaviourist and narrow outcome-driven approaches to physical education and advances a more collaborative, reflective, and constructivist learning model (Rovegno, 2006; Light, 2008). Indeed, Rovegno and Dolly (2006) acknowledge that young people actively construct knowledge by collaborating in social contexts; they suggest that an effective physical education programme is one in which students "learn to solve problems, make decisions, and think critically and creatively through constructivist-related teaching techniques" (p.407). Additionally, as part of highlighting a complex learning agenda we pay attention to the dynamic and non-linear nature of young people's movement development by taking into account recent advances in ecological (Bronfenbrenneer, 1979; Newell, 1986; Rogoff, Turkanis & Bartlett, 2001) and dynamical systems (Thelen & Smith, 1994) theories. We argue that these theories are aligned with complex principles because they demonstrate how young people learn to move by actively exploring different movement possibilities and consequently choosing which patterns work best for them. This perspective resonates with the notion of self-organisation and highlights the complex and dynamic interaction between an individual's present capabilities and attributes, the task being attempted, and environmental constraints (Newell, 1986). This perspective is concerned with variability and therefore diverges considerably from the traditional approach to teaching movement in physical education which emphasises linearity and regularity as part of the acquisition of ideal/mature movement patterns.

Using complexity theory to envision educational practice

Kuhn (2008) proposes that complexity theory highlights the dynamic and emergent processes by which humans come to make sense of and interact with an ever-changing world. At an epistemological level, "human beings are depicted as essentially self-referential and reflexive, and human enterprise as inescapably responsive and participative (p. 182). In this view, the world is considered as being "self-organising" and "non-linear" (p.182). This complex ontological and epistemological approach has implications for education at both individual and institutional levels. In the following quote, Kuhn (2008) outlines the ways in which educational structures, practices, and participants can all be understood in complex ways:

> Complexity and education may be brought together because in the language of complexity, such human cultural settings, productions and institutions as educational endeavour are complex and dynamic. Individual human beings (learners, educators, and administrators),

various associations of individuals (classes, schools, universities, educational associations) and human endeavour (such as educational research) are multi-dimensional, non-linear, interconnected, far from equilibrium and unpredictable" (p.182).

Morrison (2008) suggests that this complex view of education has significant implications for learning. From a complexity perspective, learning is a collaborative and constructivist endeavour involving students, teachers, and their institutions. The individual learns in an emergent manner, as both the individual and knowledge are considered shifting, dynamic, and diverse:

> Learning is a process of emergence and co-evolution of the individual, the social group and the wider society. Emphasis is placed on the relationship between elements, rather than the elements themselves, and the human mind is regarded as a complex adaptive system. This argues against the "empty vessel" theory of learning; rather, knowledge is emergent and the mind is emergent and developing. Our minds are not static; each new event is met and learned by a new mind—it is not the same mind as it was moments before (p. 25).

This description of complex educational structures, practices, and learning processes signals a break from simplistic notions of cause-effect and linear predictability which have long held currency in education. A complex perspective involves the replacement of these principles with a logic that views pupils, teachers, head teachers and administrators as being inextricably linked with classes and schools in the context of a dynamic and multi-faceted complex system. Schools can thus be characterised as being collectives "that exceed the summed traits and capacities of individual agents" (ref?); in this way, schools support "a collection of unities and a component of a greater unity" (Davis & Sumara, 2001, p.85). Complex systems do not have an inbuilt pre-planned arrangement as the parts flexibly interact internally as well as with the external environment (Prigogine & Stengers, 1985); these "rich" yet unpredictable interactions (Cillier, 1998) allow systems to adapt and develop in response to the ever-changing demands of the environment (Morrison, 2003), leading to the emergence of "new patterns of activities and new rules of behaviour" (ref?, p.5). In the next section we detail the ways in which this complex educational perspective might serve to underpin curriculum and pedagogy strategies in a physical education context. In particular, we pay attention to the ways in which complexity theory affords a means of structuring educational conditions which privilege emergent, connected, and self-organising behaviours and learning practices.

Conceptualising the Complex Physical Education Curriculum

In this section we illustrate the value of complexity theory in envisioning and structuring physical educational practice. First, we consider how the key features of complexity and behaviourist (modernist) viewpoints can be used to present different approaches to curriculum before giving consideration to the impact these different approaches are likely to have on our related pedagogy.

Key Features of a Complex Curriculum	Key Features of a Modernist/Behaviourist Curriculum
• Emergent responses	• Predictable responses
• Uncertain outcomes	• Certain outcomes
• Self-organising	• Externally Controlled
• Process-driven	• Product-driven
• Non-linear	• Linear
• Organic	• Mechanistic
• Diverse	• Standardised
• On-Going	• Time constrained
• Edge of chaos	• Stable
• Adaptable	• Pre-determined
• Creative	• Fixed
• Flexible	• Inflexible

Table 1   **Characteristics of Complex and Modernist/Behaviourist Curricula (adapted from Morrison 2003)**

With its foundation in emergence and uncertainty, a complex curriculum differs from the predictable certainty of a behaviourist curriculum (see Table 1). Consequently, the content, practices and behaviours which illustrate these perspectives are quite different. For instance, because a complexity perspective sets up the conditions whereby learning outcomes are considered uncertain, curriculum content itself must be flexible and will accordingly facilitate behaviours and practices which are non-linear and on-going. In contrast, behaviourist notions of certainty lead to fixed curriculum content resulting in the standardising of pupils' and teachers' behaviours and practices. This behaviourist curriculum is thus concerned with predetermined outcomes, as well as the mechanistic delivery of material to pupils who are considered to be on linear learning trajectories.

We suggest, however, that complex values of uncertainty and diversity can underpin curriculum practices which provide for self-organisation, adaptation, and creativity; as mentioned previously, these values are crucial to the physical education of pupils in a postmodern time. This non-linear and organic curriculum regularly results in learning trajectories that approach the "edge of chaos". However, these complex learning systems are not governed by an 'anything goes' mentality but one which is neither entirely "fixed nor chaotic" (p.149) but has "sufficient coherence based on a sufficiently constrained domain … (and) an openness to randomness in order to allow for the emergence of unanticipated possibilities…" (Davis and Sumara, 2006 p.149, our parentheses). Complex learning systems therefore operate at the "edge of chaos", where change and unpredictability are considered crucial elements of participants' learning behaviours and practices.

Further, viewing curriculum as a complex, emergent and self-organising phenomenon not only has important implications for the relationship between teacher and pupil but also between the different layers of the education system in terms of its pupils, teachers, schools, communities, local authorities and governments. As such, relationships across this complex ecological system (Bronfenbrenner, 1979) differ when viewed from a complexity or a behaviourist perspective (see Table 2) leading to different pedagogical approaches by teachers and different management approaches be head teachers. (Our recent professional development work which has been reported and discussed elsewhere reflects and supports these points (Dewar, 2007; Jess & Dewar 2008; Jess & Atencio, 2008; Thorburn, Jess & Atencio, under review?).

The Complex Connective System	The Behaviourist Hierarchical System
• Developmental (bottom-up)	• Top-down
• Shared vision	• Absolutist vision
• Nested	• Unrelated
• Collaborative	• Solitary
• Negotiation	• Prescription
• Networks	• Bureaucracy
• Deep learning	• Surface learning

Table 2   Viewing Behaviour Interactions as Connective or Hierarchical

Whereas traditional behaviourist pedagogies are controlled hierarchically by a "leader" whose centralised and singular vision is transmitted in a prescriptive and top-down manner, the connectivity

within a complex context results in a collaborative, negotiated, nested and bottom-up venture from which a shared version of learning emerges (Table 3). Traditional behaviourist pedagogical approaches are often characterised by pupil isolation where learning often becomes superficial (Table 3); comparatively, a connective pedagogical approach supports the creation of communities of practice (or learning communities) (Wenger, 1998) which engender interpersonal relations, shared knowledge, mutual engagement, and "deeper" levels of learning. Wenger suggest that these learning communities "hold the key to real transformation- the kind that has real effects on people's lives" (p.85).

Complex Pedagogy	Behaviourist Pedagogy
• Active participation	• Passive participation
• Self-determined action	• Received action
• Collaborative experiences	• Individualised experiences
• Edge of chaos expectations	• Stable expectations
• Open environment	• Closed environment
• Situated/authentic experiences	• De-contextualised experiences
• Formative feedback	• Summative feedback
• Reflective Evaluation	• Superficial Evaluation
• Scaffold experiences	• Fragment experiences
• Connected experiences	• Compartmentalised experiences

Table 3   Complex and Behaviourist Pedagogy (adapted from Morrison 2003)

Complex physical education pedagogy thus promotes collaborative participation within learning communities which are open, situated and authentic (Wenger, 1998; Rovegno, 2006) and which are supported by formative feedback and reflective evaluation. Central to this situated learning perspective is the implication that knowledge is socially constructed in ways that reflect the children's culture (Vygotsky, 1978); from this perspective, it is argued that school-based physical education needs to substantially reflect how these learning experiences are employed outside of school and in broader learning communities. Subsequently, there is a need for physical education to provide children with learning contexts which offer authentic, meaningful and "rich" tasks (Macdonald, 2004; Rovegno, 2006). Furthermore, we would suggest that regular engagement in this situated, authentic physical education learning community will encourage a self-determined, or self-organising, learning trajectory which passes though periods of stability and chaos, with the periods of chaos likely to be highly collaborative, diverse, creative and rich (Morrison, 2008).

Conversely, a behaviourist pedagogy which focuses on notions of hierarchy and certainty results in a more individualized and passive engagement by the physical education pupil and entertains expectations of a linear and stable learning curve (Table 3). In addition, the behaviourist pedagogical environment is more likely to be closed and de-contextualised with support from more summative feedback and more superficial evaluation. Thus, while the complex physical education context scaffolds and connects children's learning experiences and leads to deep learning, a behaviourist approach predominantly promotes surface learning due to the fragmented and compartmentalised nature of the learning experiences in de-contextualised and closed contexts.

The Implementation of Complexity Principles in the Scottish Physical Education Context

We now turn to describe the complexity-informed curricular and pedagogical practices which underpin the various projects associated with the Developmental Physical Education Group (DPEG) at the University of Edinburgh. In this discussion, we specifically focus on the key complexity principles of emergence and connectivity and the importance of scaffolding, and "edge of chaos" experiences in facilitating learning in these complex contexts.

The original curriculum and pedagogy endeavours of the DPEG were not specifically informed by complexity principles, although they were shaped by the perceived shortcomings of a fragmented and compartmentalised curriculum model which articulates with the behaviourist features discussed earlier. Specifically, these efforts emerged as a reaction to the traditional physical education curriculum oriented towards a multi-activity curriculum model, which Kirk (2004) describes as:

> characterised by short units of activity (six to ten lessons), minimal opportunities for sustained instruction, little accountability for learning, weak or non-existent transfer of learning across lessons, units and year levels, few policies to equalise participation between boys and girls (in co-ed) and high-low skilled players, and a student social system that undermines teacher authority. (p.203)

In addition, while this multi-activity model claims to support notions of lifelong physical activity, Kirk (2004) suggests that this assertion has not been substantiated by research.

Initial attempts to disrupt these behaviourist physical education practices centred around the development and delivery of the Basic Moves programme (Jess, Dewar & Fraser, 2004), which aims to impact on the early physical education experiences of young people (e.g. children aged 5-7 years) as

these years are considered crucial to fostering a lifelong approach to physical activity (Gallahue & Ozmun, 1999). Basic Moves was developed to help all children acquire a level of basic movement competence to support their current physical activity engagement and also scaffold future physical activity participation. Basic movement competence is defined as the ability to consistently perform core basic movements in a technically mature, adaptable, and creative manner, along with the ability to apply these movements effectively in increasingly more complex, authentic, and situated contexts. This perspective was used to design a programme which pays attention to the scaffolded and connective ways children transfer core basic movements to the more complex physical activity situations inherent to their non-school lives and their future physical activity participation.

The framework for Basic Moves was originally adapted from the work of two North American physical educators (Gallahue, 1982; Graham, Holt/Hale & Parker et al, 1980) who had attempted to synthesise reductionist biomechanical motor development descriptions of "mature" movement patterns (Wickstrom, 1977; Seefeldt & Haubenstricker, 1982; Roberton & Halverson, 1984) with the constructivist and emergent notions of movement education which had held sway with many physical educationists in the 1960s and 1970s (Morrison, 1969; North, 1973; Briggs, 1974). The framework includes movements from three inter-connected movement categories that underpin and scaffold participation in activities throughout the lifespan (i.e. travelling movements; object control movements; and balance movements). In addition, cognitive, social, and emotional movement concepts, adapted from the work of Laban (Laban & Lawerence, 1947), have been included to assist children's adaptability and creativity relative to space (e.g. where the body moves), effort (e.g. how the body moves, in terms of speed, force and flow of movements), and relationships (e.g. with whom or what the body moves) (Jess, 2004).

Although these emergent notions of adaptability and creativity are acknowledged as key features of Basic Moves, there has been a tendency for non-specialist teachers, in particular, to focus on the specific criteria of the movement descriptions and, subsequently, employ a more traditional behaviourist pedagogical approach. Recently, however, our curriculum and pedagogy work has become increasingly informed by ecological (Newell, 1986; Bronfenbrenneer, 1979), dynamical systems (Thelen & Smith, 1994) and social constructivist (Vygotsky, 1978) thinking, all of which intertwine and reflect many of the complexity principles discussed earlier. These ecological and dynamical systems approaches challenge traditional maturational theories of motor development which have long held sway and support a belief that movement development is pre-programmed and "just happens" (Gessell, 1928). By proposing that movement emerges from a complex mix of children's active exploration of different movement patterns, their maturation and the opportunities

they encounter, contemporary motor development theory articulates more closely with notions of constructivism and self-organisation. Further, these theories posit that different facilitating and restricting factors (i.e. constraints) provide a "best fit" for each child as a result of the complex interaction of the individual's current capabilities and attributes, the task being attempted, and the environmental conditions present (Newell, 1986). This "best fit" of inter-connected constraints facilitates an on-going self-organising process which results in the emergence of different movement patterns which, over time, create a non-linear developmental pathway characterised by periods of stable and unstable (i.e. "edge of chaos") behaviour. From this perspective, no two children show the same developmental path when it comes to learning how to move (Adolph, 2008; Vereijken & Bongaardt, 1999; Thelen, 1995). Furthermore, each child's learning of movement is not indicative of gradual and linear improvement but is usually characterised by unpredictable advances, and even periods of regression, at unpredictable points in the developmental process. This perspective suggests that children learn to move in erratic and "messy" ways. Children may pick up one skill easily, but another skill is learned much more slowly; this perspective reflects the variability within the individual. Also, it may take various children a different amount of time and effort to learn a particular skill, which points to the considerable variability which exists between children. Thus, in contrast to the notion of fixed regularity used to support a behaviourist physical education model, we argue that a more complex approach is necessary to address the "local" variability which exists within and between children in the movement learning process.

From a pedagogy perspective, as we reflect on Basic Moves as a complex endeavour, we are now concentrate on developing ways in which teachers and children can modify individual, task and environmental factors to improve basic movement learning in physical education contexts (Gagen & Getchell, 2006). We are increasingly encouraging teachers to facilitate self-emergence and self-organising by offering children the opportunity to explore a range of open-ended tasks and different environmental settings. From this self-organising starting point, teachers can guide, or nudge, children's emergent responses in directions that will consolidate and extend their adaptability, creativity and efficiency of these movement patterns. In addition, we are conscious that there is also a need to take children to the "edge of chaos" by consciously disrupting their movement patterns to create periods of instability which, with supportive guidance, assist the creation of a range of more adaptable, creative and mature movement patterns. More behaviourist directed verbal guidance (e.g. "You should bend your knees more", "Watch me and do what I'm doing!") and summative feedback ("Your legs are not in the correct position"), on the other hand, are less in evidence and are being replaced by teachers constructing learning contexts in which children are actively engaged in their own learning and become motivated to find their own solutions within specific environmental and task

AARE 2008   Complex curriculum and pedagogy   12

Paper Presented at the AARE Annual
Conference, Brisbane 2008
Australian Association
for Research in Education

constraints. Over time, and with appropriate support and formative feedback, children are being helped to develop a personalised basic movement foundation through an active learning approach.

This complex ecological and dynamical systems approach is also a highly collaborative, social constructivist venture as it increasingly engages the children in conversation with their teachers, their peers and their parents to reflect upon movement performance, movement understanding and future learning directions. Subsequently, by encouraging teachers to employ more complex and constructivist techniques to actively engage the children in the development of their own understanding of Basic Moves, more emphasis is now being placed on teachers to implement pedagogical strategies which involve the sharing of learning intentions with children, posing of problems, encouragement of dialogue and critique, use of guided discovery, and other forms of questioning. The classroom climate is also being constructed to acknowledge and support children's "edge of chaos" explorations around movement and the body, and come to view "mistakes" as a celebrated part of the movement learning process. Critically, these developments emphasise the importance of "rich" authentic interactions and provides a context for diverse and transferable movement learning outcomes. Doll (2008) suggests that this collaborative or social constructivist approach is highly resonant with the "webbed" nature of complex learning interactions:

> … students—individually or in groups—work on various texts which web together into a frame that combines closure with openness, a modest rigidity with a structured flexibility. As students work on these various texts, the aim is not for all to be on the same page at the same time but, contrarily, for groups within the web to be on different pages, in different texts, at the same time. Embracing complexity, the aim is for a process of crossfertilization, pollination, catalyzation of ideas. Over time… a network of connections and interconnections becomes more and more webbed. (p.202)

As our work on the Developmental Physical Education Programme progresses beyond Basic Moves into the Upper Primary and Early Secondary Years (ages 8-14), we increasingly recognise the influence, and importance, of children's core psychomotor, cognitive, socio-cultural and emotional learning on their participation in physical education (COPEC, 1992; Bailey et al, in press; Jess, Haydn-Davis & Pickup, 2007) (see Table 4). Children's transference of this core learning into the progressively more complex and diverse contexts they are likely to encounter as they grow older is both a scaffolded and a connected process. We acknowledge much of what we identify as core learning is included in the multi-activity physical education model although we strongly argue that the fragmented and compartmentalised "short block, specific activity" nature of this traditional curriculum

model results in core learning being marginalised and rarely developed within a situated and authentic context. As such, this de-contextualised and isolated approach leads to transient and superficial learning experiences which do not reach "rich" or "deep" levels of learning. Therefore, we propose that core learning has a central role in the developmental physical education curriculum *as long as* transferability and connectivity is facilitated through situated and authentic learning contexts.

Accordingly, we have designed our curriculum to include a core learning session each week so that children engage in experiences which focus on core learning and then have the opportunity to transfer and apply this learning into more applied and authentic contexts (Penney, Jess & Thorburn, 2006; Jess, Haydn-Davis & Pickup, 2007)). Towards this end, we have been building on existing examples of authentic curriculum projects in Teaching Games for Understanding (Thorpe, Bunker, and Almond, 1986), and Sport Education (Siedentop, 1995) and have also been commissioning and working with colleagues from a range of activity specific backgrounds to develop a more authentic, but scaffolded and connected, upper primary early secondary curriculum based on complexity principles (Beams & Atencio, 2008; Dewar & Irvine, 2006; Inchley, Kirkby & Currie 2008; Irvine & Timmons, 2007; Thomson, 2007). This approach deliberately provides children with opportunities to identify connections between core learning and the authentic applications they encounter and emphasises "a constructivist view of knowledge" (Light, 2008, p.23). In supporting this scaffolding process, we emphasise that these activities involve "complex, dynamic, unpredictable, and even chaotic" (Light, 2008, p.30) behaviours and practices and, as such, teachers need to be creative and adaptable in their pedagogy, as there are no set outcomes or linear models of delivery. Furthermore, even as we propose four broad categories of core learning relating to the psychomotor, cognitive, socio-cultural, and emotional domains, we accept that the knowledges underpinning these four dimensions are indivisible, diverse and shifting. Following Doll (2008), then, we also attempt to refrain from "using too rigid a syllabus", and instead emphasise the "problematics" (p. 202) inherent to curricular knowledges and practices.

Psychomotor (Movement & Physical Activity)	• Basic Movement Combinations like catching and throwing; running and turning • Health-related Components: aerobic, strength, flexibility etc • Performance-related Components: Speed, strength, agility etc • Physical activity lifestyle: tracking
Cognitive (Knowledge and Understanding)	• Introduce lifelong physical activity dimensions • Understanding adaptability & creativity • Principles of performance and practice • Physical Activity Health issues • Behavioural and decision making skills • Importance of physical play • Etiquette
Affective (Social Skils and Socio-cultural Understanding)	• Individual and team behaviours • Cooperation/competition • Winning/losing • Inclusion issues
Affective (Emotional)	• Task and ego behaviours • Self-determination • Etiquette • Social responsibility • Physical identity

Table 4: Examples of Core Learning in the UPES Physical Education Curriculum

Discussion

In this paper we have highlighted the importance of employing complexity principles to support constructivist and ecological models which have recently been employed to inform contemporary physical education curriculum and pedagogy. Through this discussion we have demonstrated some of the significant problems inherent in traditional physical education particularly when a solely behaviourist model is employed. According to Morrison (2008), teachers and pupils are members of an adaptive and self-organising system; as such, they "create, share and shape their own and each other's meanings" (p.27). A complex approach to learning thus emphasises the "constructivist" learner who "produces and reproduces knowledge evolutionarily and actively" (p.27). This perspective implies that physical education teachers are not experts, but instead facilitate, co-learn, and co-construct knowledges and meanings (Morrison, 2008) around physical education. Pedagogy from this complex perspective involves teachers working as "transformative facilitators who implement "discussion-based" and "problem-solving activities" in order to promote "free and freed thinking" (Morrison, 2008, p.26). In response to the dominant paradigm within physical education which views learning as a "linear and measurable process of internalizing knowledge" (Light, 2008, p.22), we argue that the physical education of children and young people is actually quite a "complex phenomena" (Kuhn, 2008, p.177). A complex learning perspective suggests that physical education needs to accommodate for self-organising, connected, adaptive, and flexible curricular and pedagogical practices. As noted by Wright (2004), these aspects are crucial to underpinning a physical education programme that is relevant to young people who live in a complex society with continuous changing priorities and multiple demands.

A complex learning agenda challenges the traditional modernist curriculum, which is "tightly prescribed" with "programmed and controlled curricula and formats for teaching and learning, and standardised rates of progression" (Morrison, 2008, p. 26). Yet, in advocating for a complex vision of physical education which holds purchase in a postmodern physical education context, we also acknowledge that notions of modernist curriculum with behaviourist pedagogies also have a role to play. Thus, as noted earlier, although we strongly support a complex view of learning, we don't wish to present a complexity as "good" and behaviourism as simply "bad". We propose, however, that there is an urgent need for a shift in emphasis from more traditional behaviourist notions of learning and knowledge to conceptions that emphasise uncertainty and non-linearity. We have sympathy with Wilson and Paterson's (2006) view that teachers need multiple theories so they can makes sense of learning in both cognitive and behavioural terms (Wilson 2003). Wilson and Paterson argue that teachers need to be well-informed and critical "consumers of "new" educational ideas or reigning

theories" (Hirsch 1996; Phillips 1995, 2000; Sfard 1998), so that they may " interpret, adapt, and combine those theories as they use them in practice…Students need opportunities to learn in multiple ways, and teachers need to have a pedagogical repertoire that draws from myriad learning theorists" (p.12).   Subsequently, the teacher's role increasingly becomes one of diagnosing children's understanding of their physical education experiences and then helping them adapt and develop their interpretations further (Wilson & Paterson, 2006).

In summary, although we share Morrison's (2008) view that education in a complex and changing world should be conceived of as being "dynamic, emergent, rich, relational, autocatalytic, self-organized, open, existentially realized by the participants, connected and recursive (e.g. Doll, 1993)" (p.25), we also believe there is no single or "correct" way to teach effectively.   Like Rovengo & Dolly (2006) we do not support the view that "anything goes" but instead insist that teachers need to be able to draw from several pedagogical strategies ranging from more traditional behaviourist pedagogy to more collaborative and open-ended approaches.   Teachers cannot expect to employ the same pedagogy for all children every day in the gymnasium because different children learn in different ways and will be at different places in their learning.   This complex perspective, which finds sympathy with both constructivst, ecological and dynamical systems theories, perhaps ironically means there are instances when the children or the context mean that behaviourist methodology is not only desirable e.g. passing information to a large group in a short time frame but also necessary e.g. safety.   However, we propose that teachers must increasingly engage with notions of emergence, connectivity, self-organisation and the "edge of chaos", even as they may sometimes employ behaviourist pedagogies, in order to develop a rich repertoire of pedagogy strategies to respond effectively to the different contexts in which they work and the diverse nature of children.   Our argument is therefore one of a shifting emphasis not a wholesale rejection or acceptance of one particular ideology or methodology (O'Sullivan, 2007).

Conclusions

Light (2008) proposes that a complex learning approach is a promising means of understanding "the body's role in learning" (p.34) across the "embodied, cultural, and social learning, and human development" (p.29) domains. However, we also acknowledge that the deployment of complexity theory in education is a very recent phenomenon and therefore requires further clarification (Davis & Sumara, 2006; Morrison, 2008).   In advocating the need for a complex physical education perspective, then, we also contend that enacting this framework is fraught with challenges.   Morrison (2008), for instance, has suggested that educationalists need to be very specific about the ways in which complexity theory better articulates and thus "adds value" to the many socio-critical educational

principles (e.g. self-organisation, adaptation, non-linearity) which have recently gained currency in physical education. While we have attempted to provide examples from our work in the Scottish physical education landscape to illustrate how key complexity principles resonate with and even expand upon existing postmodern critiques, we suggest that further research is needed to indeed articulate the "added value" of using complexity theory in physical education. Future research might serve to flesh out a prominent role for complexity theory as an analytical approach which supports curricular and pedagogical practices in physical education. Light (2008) raises this possibility in the following quote:

> … research on physical education and sport informed by complex learning theory can assist in better understanding the diverse range of learning that is possible through young people's experiences of physical activity. This, in turn, can assist in the ongoing development of teaching in physical education that can begin to realize its potential as a learning medium beyond the restrictions currently imposed by largely outdated conceptions of teaching and learning. (p.31)

Indeed, we will take up this perspective in developing future research efforts structured according to complexity theory principles. At this time, we can only speculate about the role of complexity theory relative to the evolving story of a physical education programme that has been very active in the Scottish landscape since 2001. As this programme continues to emerge, self-organise, and approach the "edge of chaos" in the future, we feel strongly that we will be able to create more open-ended, relevant, and connective physical education conditions for teachers and students. Our attempt at grappling with complexity theory has been instructive in the sense that we can map out how our work has already been marked by complexity values; we suggest that this complex journey represents a potential way forward for physical education in the in the context of "new times".

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