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Becoming physical education: the ontological shift to complexity

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ABSTRACT

In this paper, we present the view that an ontological shift to complexity thinking will be significant in the future of physical education (PE). Complexity thinking not only moves PE beyond long dominant modernist approaches but also offers the opportunity to integrate many of the postmodern perspectives that currently seek to frame PE. Four interconnected complexity commonalities, becoming, lived time, self-organisation and boundaries, are presented in an overarching frame to guide future PE developments in ways that are coherent, connected and emergent. PE is subsequently viewed as a complex phenomenon that is always in a non-linear, messy and never-ending process of becoming. Students, teachers and other stakeholders are also complex as their past, present and future experiences constantly merge in a lived time unity to create lifelong and life-wide PE journeys that are both personalised and holistic. Central to these personalised journeys is each stakeholder's ability to self-organise and influence the trajectory of their pathways. Self-organisation, however, is not a relativist 'anything goes' phenomenon but a process that takes place within a multiplicity of boundaries. While boundaries may traditionally be viewed as divisive features, complexity thinking recognises that many boundaries are flexible and enable the creation of 'boundary spaces' in which 'rich' discussions can take place to develop more coherent, connected and emergent forms of PE. Transdisciplinary Inquiry (TDI) and Ecologically Informed Practice (EIP) are presented as perspectives that can help teachers, and others, create the 'boundary spaces' in which ways to plan and introduce complexity-informed forms of PE can be explored. The paper concludes by proposing that the challenge for PE in the future will be for practitioners to develop the adaptability, openness, confidence and self-organising skills that will be needed to make the most effective use of the 'rich interactions' that these 'boundary spaces' offer.

Introduction

As the world of education continues to move beyond long dominant modernist approaches (Biesta, 2020), recent developments in thinking and practice auger well for the future of physical education (PE) (Jess et al., 2022). With moves towards more holistic, integrated, inclusive and participative practices (e.g. Davis et al., 2008), a steady increase in research reporting the lifelong benefits of physical

activity (Warburton & Bredin, 2017) and a significant expansion in the stakeholders supporting physical activity development across the lifespan (Aldous & Brown, 2021), we are witnessing a contemporary context in which PE has the opportunity to move beyond its 'shadowy, marginal existence' (Ozoliņš & Stolz, 2013, p. 888). Whilst the accompanying appearance of numerous theoretical perspectives to inform PE developments may be viewed as furthering progress (e.g. Ennis, 2017), concerns have been voiced that these projects are being developed as isolated 'camps' (Tinning, 2015). With each new development, PE appears to be fragmenting and there is apprehension that this disconnection will hamper any long-term aspiration to become a more coherent and mature field of study (Evans, 2014).

With this background in mind, this paper argues that an ontological shift towards complexity thinking, currently evident across most disciplines and professions (Byrne & Callaghan, 2014), can act as a catalyst to integrate many of these recent developments and support a more integrated and coherent lifelong and life-wide vision for PE. Instead of acting to exacerbate the fragmentation of the subject area, complexity thinking provides an analytical lens to help bring a sense of cohesion to the disconnect that threatens PE's future.

### Setting the scene for the shift to complexity

The view that education and learning are complex is not new. In fact, 'the claim that learning is complex says nothing that humanity hasn't known for thousands of years.' (Davis & Sumara, 2010, p. 856). Therefore, while most physical educators may view PE as complex, the multiple meanings attributed to this complexity are founded on many different viewpoints. PE as complex subsequently will not mean the same to everyone and we are conscious that efforts to simplify complexity remain dominant in many settings. Nevertheless, while there may be multiple takes on complexity, e.g. complexity theory, complexity science, restricted complexity, soft complexity (Byrne & Callaghan, 2014), we align ourselves with the term complexity thinking. We do so because complexity thinking not only captures the broad philosophical nature of complexity but also supports the potential for complexity to represent an ontological shift and not simply a discourse that provides a more extensive set of descriptions. Complexity thinking is therefore 'a source domain that is rich with possible analogies for understanding human action, knowledge, identity and learning' (Ovens et al., 2012, p. 2) and offers the opportunity to extend beyond description and create new or different ways to view PE.

In setting out our efforts to embrace complexity, we draw on an eclectic mix of insights to create a broad framework to appeal to a wide audience and help integrate diverse viewpoints. It is not our intention to polarise thinking but to present complexity as a perspective focussed on the co-existence of phenomena that are often viewed as dualisms (Davis et al., 2008). The goal of the paper is therefore to contribute to the extant complexity-related PE literature (e.g. Ovens et al., 2012; Sanches Neto et al., 2021) by exploring the key ontological assumptions that have led us to adopt this complexity thinking lens. Inspired by extensive reading (e.g. Cilliers, 1998; Deleuze & Guattari, 1980; Morrison, 2010), we focus on four complexity commonalities (Mitchell, 2009) to make the case that PE, and its stakeholders, are complex phenomena engaged in an interrelated self-organising process of becoming that takes place within lived time and within boundaries (see Figure 1).

While we discuss these four commonalities individually, we re-iterate that they co-exist to create an overarching umbrella framework (Davis & Sumara, 2006). Accordingly, we not only use the commonalities to present a coherent vision for PE but also to support the integration of the many PE stakeholders involved in future developments.

The ontological shift to complexity: the commonalities framework

While the complexity of PE is acknowledged by many, there is some uncertainty about 'the appropriateness of the frameworks we use to make sense of the "messiness" that is inherent in complex educational settings' (Ovens et al., 2012, p. 1). In our efforts to articulate this complexity, we start by
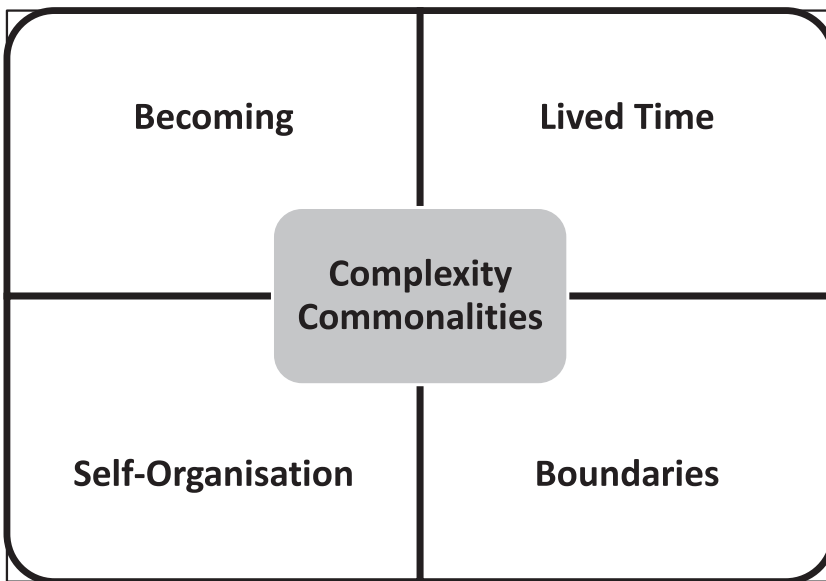
Figure 1. The four complexity commonalities.

exploring the ontological assumptions that have led us to complexity and have helped construct our view of complexity thinking. A key feature of this ontological view is that complexity is not a form of predictive theory that seeks to directly establish more coherent ways of thinking. Alternately, by acknowledging there is no certainty about what will happen in the future, the complexity framework we present seeks to help stakeholders set the conditions in which more integrated and emergent forms of thinking and practice have the potential to emerge. It is important at this early stage to provide an overview of how we have created this framework. Without this further explanation, there is a danger that readers become disorientated by our ambition to simultaneously avoid pre-scription yet support stakeholders to see new or different possibilities for PE.

We have found the work of Deleuze and Guattari (1980) a helpful guide as they present a philos-ophy that is practical and can be applied to provide a perspective on the world. This form of philos-ophy is based on constructivism and the use of concepts plays a critical role (May, 2003). Chief among these concepts is the way they connect to each other individually and in terms of how they function collectively as a set. May (2003) notes how the point of this philosophy

> … is not to tell us what the world is like – that is the point of science – but to create a perspective through which the world takes on a new significance … to engage us in the interesting, the remarkable and the important. (p. 142)

Therefore, the framework presented can be seen as a set of concepts, and a guide for diverse stake-holders to (re)use and (re)look at PE in different ways.

In agreement with Mitchell (2009, p. 295), we subsequently offer a cluster of common concepts, or commonalities, to bring coherence to our thinking. Our engagement with the complexity literature, combined with our own complexity-related writing (e.g. Jess et al., 2011), has led us to four common-alities as an overarching umbrella framework that captures the integrative potential of complexity: becoming, lived time, self-organisation and boundaries (see Figure 1). In this way, we agree with Davis and Sumara (2006) that 'the umbrella offered by complexity thinking presents a powerful means to pull together a diversity of disciplines and discourses while enabling researchers and prac-titioners to deal with the practical aspects of the formal education project.' (p. 130). Therefore, while we discuss each commonality individually, we recognise that they function *concurrently* in an inte-grated manner. To demonstrate the integrative potential of this framework, we interweave examples

from a lifelong and life-wide vision for PE that aligns with the complexity-informed view that individuals pass through a self-organising process of becoming in lived time and within boundaries.

Commonality 1: becoming

We begin with becoming because it helps to initiate the ontological shift from modernism towards complexity. Modernist thinking is based on a transcendental, reductionist notion of 'being' (Deleuze, 1968, p. 41) in which hierarchies define different beings as 'stable unities' (May, 2003, p. 143). 'Stable unities' are characterised by notions of order, predictability and certainty and are witnessed in traditional education systems when fixed forms of knowledge are transmitted to students in a top-down, linear manner. In this way, the long dominant multi-activity 'blocked' PE curriculum (Kirk, 2010) represents a pretty straightforward activity focussed on creating high degrees of similarity across learners.

While we have concerns with the overemphasis of modernism on reduction, hierarchy and certainty, we are conscious that complexity has its basis in the co-existence of elements akin to modernism like order and structure whilst also embracing more open-ended features like emergence and unpredictability. We subsequently do not suggest a complete rejection of modernism because this would lead to the polarisation we seek to avoid. In fact, as most of the deep-rooted structures in the education system have been informed by modernist thinking, a complete rejection would slow down, and perhaps even derail, the shift to complexity. Consequently, identifying, acknowledging and respecting the similarities and differences between the different ontological perspectives is a particularly important feature of the more integrated thinking that complexity seeks to develop.

With this integrated aspiration in mind, becoming is represented as a long-term, iterative and non-linear process imbued with a recognition of difference within and between individuals (Deleuze & Guattari, 1980). However, while difference may suggest some degree of disconnect the becoming process also involves some order and structure. For example, in education, while becoming may extend beyond a view of a learning process based on fixed knowledge transmitted in time-constrained units it does not suggest a move to a relativist 'anything goes' approach. As we discuss later, the becoming process is often founded on a number of simple rules that underpin a more flexible, lifelong and life-wide learning process involving more holistic, integrated and emergent forms of knowledge. Acknowledging the importance of difference within and between individuals to this becoming process subsequently recognises the need for differentiation and adaptability as key features of educational practice (May, 2005).

Becoming raises fundamental issues for PE because it challenges the traditional portrayal of a subject that is only experienced within the school timetable. While school PE may be the only context in which young people are guaranteed regular physical learning experiences, as part of this becoming process, PE is more than a narrowly defined school subject. Penney and Jess (2004) capture this becoming nature when they describe PE as ' … a lifelong endeavour, not something that can be pre-defined, pre-prescribed, or simplistically "delivered" in a specified shot' (p. 272). Further, they note that PE 'needs to be ongoing for all young people, responsive to their ever-changing life circumstances, needs and interests, and is by no means the sole concern or domain of those currently identified as PE teachers.' (Penney & Jess, 2004, p. 272). This shift to becoming extends the parameters of PE beyond the restrictions of solely being a school subject for which teachers have the sole responsibility. PE subsequently transitions into a lifelong and life-wide enterprise in which the 'concern is with a process, not a fixed product' (Penney & Jess, 2004, p. 272) and engages many others who work in other sites and at other times.

PE's transition to a lifelong process is well under way. Policy documentation often presents a lifelong goal for PE (e.g. Scottish Executive, 2004) while many authors offer support for a lifelong learning agenda (e.g. MacNamara et al., 2011). In addition, physical activity projects with lifelong aspirations have become a feature across the literature. These approaches include physical literacy (Whitehead, 2010), physical culture (Silk et al., 2017), formal and informal sport (O'Connor & Penney,

2021) and are accompanied by many inter-generational stakeholders who work in both schools and communities (Aldous & Brown, 2021). Becoming subsequently initiates a re-imagining of PE beyond the constraints of the school towards a broader lifelong and life-wide agenda.

Commonality 2: lived time

While linear time has traditionally been the 'taken for granted' view of time (Byrne & Callaghan, 2014, p. 138), complexity scholars argue that the concept of lived time should be more visible as it has a key role in the becoming process (e.g. Deleuze & Guattari, 1980). To present this case for lived time, we first consider linear and lived time before exploring the importance of their co-existence in the shift to complexity.

By quantitatively subdividing specific moments into units, e.g. months and weeks, *linear time* is infused with notions of predictability and certainty and aligns with the modernist stability of 'being'. For example, travel timetables and automated factory systems are examples of this linear time based on notions of stability and certainty. In educational institutions, linear time is used in many ways, particularly to structure term/semester and weekly timetables. This is valuable because it brings some order, structure and stability to the educational environment. However, when linear time is the only way that time is viewed, it overemphasises the modernist focus on certainty, predictability and similarity. For example, when linear timescales are allotted to the 'coverage' of specific curriculum knowledge the assumption is that knowledge is a fixed product and that learning is time-constrained. In traditional PE programmes, the content 'covered' in each physical activity 'block' is an example of these linear time assumptions. Accordingly, if linear time is the only way time is considered in PE settings, the focus will always be on developing sameness with little consideration given to the differences that exist within and between individuals.

Unlike linear time, lived time is 'complex and multi-dimensional' (Adam, 2008, p. 7) because it views time as a recursive, qualitative and non-linear process in which the past, present and future intertwine as an integrated unity (Deleuze, 1968). Within this unity, past, present and future have distinct roles with the present being the time when past and future merge (May, 2005). While this merging of past and future in the present may seem counter-intuitive, viewing lived time as an interconnected unity that evolves in a recursive manner can be explained as follows.

First, for humans, present time always interweaves with the past. This interweaving comes about as individuals' previous life histories mix with the current context in which they find themselves. In present time, therefore, while groups of individuals have many similarities (Davis et al., 2008), they are not be identical 'stable unities' but a complex amalgam of their own genetic make-ups, previous experiences and memories. In a holistic sense, present time sees individuals bring a mix of their physical, cognitive, social and emotional resources to the current situation. From a lifelong and life-wide perspective, present time is witnessed in the contrasting histories of different individuals as they find themselves in current settings (see Box 1).

Box 1. Contrasting PE histories and present time

Contrasting 5-Year-Olds
One 5-year-old child has a high level of movement development, has experienced many movement opportunities since birth and thinks movement is particularly enjoyable.
Another 5-year-old child's movement is developing more slowly and has experienced a sedentary lifestyle which has resulted in them having little interested in physical activity.
These children have different 'starting points' as they begin to attend school PE.

Contrasting 55-Year-Olds
One adult has participated in many physical activities on a regular basis throughout their life, currently takes part in physical activity most days, understands the holistic benefits of exercise and has developed many social contacts through these activities.
Another 55-year-old had negative physical activity experiences at school, has low perceptions of their physical competence, is overweight and has little motivation to be physically active on a regular basis.
As with the children, the current 'starting points' for future engagement by these 55-year-olds is very different.

This recognition that individuals have different 'starting points' in present time raises issues for PE. While different 'starting points' accentuate the limitations of a 'one-size-fits-all' approach, they also highlight the need to formatively assess the holistic similarities and differences between individuals in present time to help differentiate learning experiences in the future. On this issue of holistic developments, PE has made significant progress. While PE has traditionally been absorbed with physical learning, holistic approaches now pay attention to the cognitive, social and emotional domains (Bailey et al., 2009). Recent holistic examples include meaningful PE, strengths-based learning, physical literacy, student-designed games, non-linear pedagogy, developmentally-appropriate and models-based practices. Consequently, as more holistic approaches become features of PE, practitioners will increasingly recognise how the relationship between past and present creates different 'starting points' for learners.

Adding future time to the lived time unity adds a complication for the becoming process. Future time is critical in the turn to complexity because, as future merges with past and present, it is unclear exactly what will happen. This uncertainty lies at the heart of the non-linearity of the becoming process and challenges the linear assumptions of certainty. To understand the role that future plays in the lived time unity, it is important to recognise that present time is not a fixed entity but is constantly recreated as individuals transition from the current present to a new present as the lived experience unfolds. While future time is logically what happens between the current and new present, it is also what recursively merges with the current present to create each new present. This recursive merger with the current present sees each future period merge with past time to create the ongoing lived time unity. However, because each period of future time is difficult to pre-determine there is no guarantee what will happen in the future. This uncertainty stems from the multiplicity of factors that can influence the unfolding of each future period (Deleuze & Guattari, 1980). While individuals have some influence on each future period because of their intentions, past experiences and actions, the future is also influenced by other human and non-human factors present in the context in which future events unfold. Further, and uncomfortably for many, luck or chance can also influence the unfolding of this future period.

However, if lived time is the only way time is viewed, there would be an overemphasis on difference and the likelihood of significant disconnection, even chaos. From a complexity perspective, therefore, it is important to recognise the co-existing roles that linear and lived time play to accommodate the development of lifelong and life-wide PE in a way that is both coherent and non-linear. While linear time brings some order and structure to PE developments, lived time can help with the identification of the similarities and differences between the human and non-human factors influencing the development process. Effective co-existence therefore needs some consideration of the flexibility around the linear timescales involved in projects and also the nature of the interactions between the factors influencing the development process. Basically, too much focus on linear time will lead to too much similarity, while too much focus on lived time will lead to too much disconnect (see Davis & Sumara, 2006). With this challenge in mind, we turn to the final two complexity commonalities: self-organisation and boundaries. Together, these commonalities extend our thinking of the becoming process and support efforts to design a complexity framework that will help guide the quest for lifelong and life-wide PE.

From a complexity perspective, the multiplicity of factors influencing the future come together in different ways. At one extreme, this assemblage (Deleuze & Guattari, 1980) may merge with the current present to create a new present that is similar to the present it is replacing, e.g. walking to school the same route each day. Conversely, these multiple factors can also merge with the current present to create a new present that is different from the current present, maybe even a life-changing 'Aha' moment (Marques, 2013), e.g. a serious accident. Critically, the way this multiplicity of factors collides in lived time is not pre-programmed and can be unpredictable and even 'messy'. Lived time subsequently involves a recursive, qualitative and unpredictable process as each new present emerges from the past, present and future unity to create something similar or different for each individual.

Commonality 3: self-organisation

The final two commonalities, self-organisation and then boundaries, offer a more in-depth insight into the ways that the complexity framework can be applied to the interrelated nature of the becoming in lived time process and, in the context of this paper, support a move towards lifelong and life-wide PE. We turn to systems thinking to assist our understanding of the self-organising process. In general terms, a system is 'an interconnected set of elements … coherently organised in a way that achieves something' (Meadows, 2008, p. 11). Critically, the nature of the interactions between different elements within and beyond a system is key to the ontological difference between modernism, postmodernism and complexity. Two types of system embody different forms of social reality: the mechanical, or complicated, system that aligns with modernism and the complex system that is more aligned with postmodernism and complexity thinking.

To highlight the difference between these two systems, we first consider the more linear and ordered nature of mechanical systems before exploring complex systems and considering how they connect with the non-linear and emergent nature of the becoming process that aligns with a lifelong and life-wide vision for PE. While we present these two systems separately, we re-iterate that it is not our intention to polarise the different perspectives, so note that the order and structure inherent in mechanical systems are also a feature of complex systems.

Mechanical systems align with modernist thinking because the interactions between their different elements are pre-programmed to ensure the system functions in a linear, closed-loop manner. Mechanical systems subsequently generate outcomes that are predictable and can be repeated. Because of their closed-loop nature, mechanical systems have little, if any, relationship with the environment in which they function, e.g. traffic lights. The thinking behind mechanical systems has had a formidable influence on education systems (Morrison, 2010), particularly throughout the twentieth century but also more recently as part of neo-liberal policy agendas (Biesta, 2017). Educational institutions, as mechanical systems, are designed to implement pre-prepared curricula based on fixed knowledge that is then transmitted in a linear manner to passive learners. Assessments focussed on this fixed knowledge are then used to ascertain learning. This resonates with the notion of 'being' because it seeks to create stability and similarity and, in PE terms, aligns with the traditional multi-activity 'block' curriculum.

While complex systems are also made up of elements, the way these elements interact represents a difference from those within mechanical systems. While some interaction in a complex system function in a predictable manner like mechanical systems, other interactions lead to outcomes that are unpredictable. These different interactions come about because some elements within complex systems have the capacity to self-organise. This ability to self-organise generates 'rich interactions' (Cilliers, 1998, p. 3) that can elicit both predictable and unpredictable outcomes. These 'rich interactions' are evident when elements interact with each other, with other humans or with non-human elements in the environment (Prigogine, 1976). This self-organising ability is central to the shift to complexity because it recognises the human potential to be 'dynamic and transformational' (Byrne, 1998, p. 51) by functioning in ways that are a mix of predictability, adaptability and creativity (Davis & Sumara, 2006). This mix of self-organising behaviours emerges from the similarities and diversities across the complex system. For example, as a complex self-organising system, a successful soccer team functions with some predictability and similarity due to the rules of the game, the skills of the players and the team's tactics. However, expecting all players to play in exactly the same way leads to too much sameness and negatively impact on the team's ability to be adaptable and creative in different contexts. Fortunately, this sameness is balanced by the diversities within the team as different players play different roles, have different physical attributes and different cognitive, social and emotional skills. Too much diversity, however, leads to a lack of coherence across the team and results in too much disconnect. As such, while complexity thinking may not view humans as mechanical systems, it recognises that the transformative nature of the self-organising system is based in the

complementary and reciprocal functioning of the system's similarities that bring order and structure and the diversities that bring adaptable and creative behaviours (Jess et al., 2016).

Surprisingly, the order that emerges from this self-organising process is often governed by a small number of simple rules called order generating rules (OGRs) (Burnes, 2004). As Gell-Mann (1994) has noted, 'in an astonishing variety of contexts, apparently complex structures or behaviours emerge from systems characterised by very simple rules' (p. 10). These OGRs are important because while they bring order they also permit some degree of disconnection (Reynolds, 1987). OGRs subsequently highlight how the self-organisation process is simultaneously a simple and complex process that has 'the potential to overcome the limitations of rational, linear, top-down, strategy-driven approaches' (Burnes, 2004, p. 317). But, given the uncertainty of the future, even when appropriate OGRs appear to be present, the 'rich interactions' that occur may still lead to outcomes that are unpredictable (Burnes, 2004). In education, key skills, core skills and core learning are examples of OGRs, while, in PE, OGRs can be found in the holistic learning that underpin the foundation for lifelong and life-wide engagement. For example, a small number of fundamental movements underpin many complex physical activities (Graham et al., 1993) while cognitive, social and emotional skills can be applied and transferred across a range of activities (e.g. Gallahue & Cleland-Donnelly, 2007).

However, while this self-organising capacity may have a significant impact on the becoming process, it does not take place in a vacuum but occurs concurrently alongside a myriad of influencing factors (Deleuze & Guattari, 1980). From a self-organising perspective, therefore, the challenge is to identify, accommodate and influence this mix of factors as they come together. To do this, we now turn to the final complexity commonality: boundaries. Boundaries are important in the shift to complexity because they offer an *interrelated* framing device to support the integrative potential of the self-organising process.

Commonality 4: boundaries

Boundaries are significant in the shift to complexity because they are found everywhere and constantly influence the interrelated nature of the becoming, lived time and self-organisation processes as they unfold over time. Also termed constraints (Gibson, 1979) or borders (Evans, 2014), boundaries are holistic in nature in that they exist across the physical, social, emotional and cognitive spaces of our lives (see Khalil & Boulding, 1996). However, while boundaries have traditionally been viewed as restrictive and divisive, they are increasingly being considered for their holistic, inclusive and emergent potential. To explore this transformative potential, we first consider the difference between traditional and contemporary views of boundaries before exploring how a contemporary view recognises boundaries as key drivers for transformation change and development.

A traditional view of boundaries

Traditionally, boundaries have been viewed as fixed phenomena that are represented by the rigid lines that limit the self-organising possibilities within and between different phenomena. Fixed boundaries have been a consistent feature of modernist thinking and are commonplace in the human and non-human world. From a holistic perspective, physical boundaries are the most obvious fixed boundaries because they delineate phenomena visually by, for example, creating different countries or types of shop. Skin colour, gender and disability have often been used as physical boundaries to divide people. Other types of fixed boundaries are conceptual but are equally prevalent across the social, cognitive and emotional domains. For example, in the social sciences, symbolic boundaries (Lamont et al., 2016) are those lines that include certain individuals while excluding others, e.g. religious or political groups. Fixed cognitive boundaries are particularly apparent in the workplace as they divide academics, professionals, administration, the trades and workers

in factory settings. In addition, fixed physical, social and cognitive boundaries often align with fixed emotional boundaries and can lead to rigid axiological views about what is acceptable/not acceptable, in/out, right/wrong etc.

In traditional education settings, fixed boundaries create a high degree of similarity within institutional settings, e.g. primary or secondary schools. This similarity is useful because it brings order within defined parameters, helps individuals identify with each other and interact through shared understandings and experiences. In a similar vein, the influence of fixed boundaries is evident in the dualisms that create tightly bound and often exclusive subjects and teaching practices. As such, curricula based on fixed knowledge and pre-determined learning outcomes (Tyler, 1949) seek to create high degrees of similarity between learners. As with mechanical systems, teachers are viewed as technicians who deliver curriculum content in a linear and prescriptive manner to passive learners (Biesta, 2017). Learning is subsequently viewed as straightforward and segmented (Maton, 2009) as initial learning is consolidated through repetition within fixed boundaries and then challenged around the boundary lines (Jess, 2020).

In PE, the multi-activity approach aligns with this notion of fixed boundaries and is represented by a tightly bound curriculum focussed on high degrees of similarity in teachers' practice and student learning (Jess et al., 2011). In addition, the mind/body dualism that has long been a feature of modernist thinking has had a particularly negative impact on the positioning of PE in the school curriculum (Kirk, 2010). Fixed boundaries, however, are also evident in many of the postmodern perspectives in PE. Ironically, while many of these contemporary perspectives extol the virtues of self-organisation, e.g. constructivism and social constructivism, the relativist nature of postmodernism (Cilliers, 1998) often results in these perspectives creating divisive boundaries as they develop their own specialist language, special interest groups and specialist roles (Evans, 2014). Fixed boundaries therefore remain a feature across education and sustain practices that are rigid, exclusive and limit opportunities for integration, inclusion and emergence. In fact, if integration, inclusion or emergence does occur, they usually do so by chance or luck (Davis et al., 2008). For this reason, we now turn to consider a more contemporary view of boundaries in which a mix of fixed and flexible boundaries help to frame a process that facilitates the more integrated, inclusive and emergent approaches that lie at the heart of the shift towards a complexity-informed PE.

A contemporary view of boundaries

With technological advances leading to an exponential growth in global interactions (Urry, 2005), there has been an accompanying recognition that many issues we meet on a regular basis are complex, open-ended and 'wicked' (Head, 2019). This complexity requires novel ways of thinking and practising (Morrison, 2008) and many scholars and professionals now call for more interconnected, collaborative, inclusive and emergent ways of viewing the world (e.g. Braidotti, 2019). In this complex context, there is a growing recognition that boundaries are not only fixed and rigid but can also be flexible, even porous.

Flexible boundaries are formed by malleable boundary lines and are being increasingly seen in different contexts (Jess & McMillan, 2021). Travellers moving freely across the borders between the countries of the European Union (EU), people shopping in supermarkets offering a vast range of products and students from different backgrounds attending the same school are contemporary examples of more flexible boundaries in daily life. In each of these examples, however, fixed and flexible boundaries co-exist in the same boundary space so that individuals may travel, shop or meet more freely whilst being constrained within the boundaries of the EU, supermarket and school. From this contemporary perspective, it is the co-existence of structure and order from fixed boundaries and openness from flexible boundaries that creates the boundary spaces in which 'rich' self-organising interactions take place.

However, the boundary spaces in which these fixed and flexible boundaries co-exist are not static and uniform but are dynamic and ambiguous. Boundary spaces are dynamic because the flexible

boundaries, and some fixed boundaries, can change, often dramatically, in the short term and transform the nature of the boundary spaces. In addition, boundary spaces are ambiguous because individuals view boundaries differently because of their different 'starting points' in present time and their ability to self-organise and adapt to situations. Consequently, in this contemporary context, boundaries are not only fixed barriers but are transformative mechanisms that can create 'spaces with potential for learning' (Akkerman & Bakker, 2011, p. 3).

Boundary spaces are a particularly valuable feature of the shift to complexity because they enable individuals and objects to come together to share and integrate ideas for generative, expansive and creative purposes (Akkerman & Bakker, 2011). In this way, boundary spaces offer individuals 'a chance to explore the edge of your (their) competence, learn something entirely new, revisit your (their) little truths, and perhaps expand your (their) horizon.' (Wenger, 2000, p. 233). These spaces are the catalyst for individual and collective self-organising efforts to develop more integrated, inclusive and emergent practises that help address complex issues. However, with many PE teachers still holding fixed views about the content to be 'covered' during activity 'blocks', creating boundary spaces represents a significant challenge for the PE profession. While it is outside the remit of this paper, we recognise that a long-term challenge for PE will be to develop practitioners with the adaptability, openness and confidence to not only create boundary spaces but also develop the self-organising skills to make the most effective use of the 'rich interactions' that these boundary spaces offer.

Two contemporary perspectives offer useful insights into the ways that boundary spaces can be created and utilised in the shift towards complexity-informed PE: transdisciplinary inquiry (TDI) and ecologically informed practice (EIP). Focussed on more conceptual issues, TDI recognises the need to step outside fixed disciplinary frames and also to address the disconnect of the postmodern 'camps' (McGregor, 2018). The goal of TDI is therefore to create new, integrated knowledge (Nicolescu, 2002) to tackle the 'wicked' problems that cannot be dealt with by mono-disciplinary specialists (Robinson, 2008). TDI seeks to integrate disciplinary and professional knowledge to co-create new knowledge in a process that is both iterative and transformative (McGregor, 2018). As such, TDI takes place in boundary spaces because it simultaneously seeks to enable a discourse between, among and beyond disciplines (Nicolescu, 2002) and see something different unfold in a non-linear, zig-zag manner (McGregor, 2018). TDI is therefore different from interdisciplinary work which is focussed on solving well-defined problems and requires a more superficial relationship between stakeholders, e.g. tradespeople building a house (see Augsburg, 2014). TD knowledge creation needs people to talk to each other and overcome resistance to each other's ideas (McGregor, 2018). From a boundary space perspective,

> knowledge creation occurs in the fecund middle ground where contradictory perspectives are set aside (people temporarily give up sovereignty) to create a space for the intellectual fusion and integration of ideas and perspectives leading to the emergence of new, in vivo TD knowledge; knowledge is emergent, complex, embodied and cross fertilized. (McGregor, 2018, p. 187)

This knowledge creation, therefore, not only takes place in boundary spaces but also requires some boundary crossing by participants as they move between and beyond disciplines (Akkerman & Bakker, 2011).

For PE, TDI can help create the boundary spaces in which a self-organising shift towards a lifelong and life-wide agenda can be facilitated. While PE has traditionally been informed by physical sciences, contemporary developments lean towards a TDI perspective. Cognitive, social and emotional domains from developmental psychology have increasingly been employed to inform holistic developments (e.g. Gallahue & Cleland-Donnelly, 2007; Kirk, 2013), while postmodern and critical perspectives have influenced the non-linear trajectory of the subject, e.g. socio-critical theory, post-structuralism etc. (O'Connor & Jess, 2019). From a complexity perspective, TDI offers PE an opportunity to use boundary spaces as a way of generating the 'rich interactions' that can create new forms of thinking to break down divisions and accelerate the shift towards lifelong and life-wide PE.

While TDI may be useful from a conceptual perspective, EIP is particularly valuable for practitioners because it helps them develop a detailed understanding of the different boundary spaces in which 'rich interactions' can take place to initiate and foster complexity-informed practice. To support this development, EIP focusses on the co-existence of three boundary categories that help practitioners identify the interrelated fixed and flexible boundaries that make up the boundary spaces across their practice, e.g. in classes, with colleagues and with stakeholders within and beyond the school. These three boundary categories are found within the TIE boundary framework made up of the *task(s)* being attempted, the *individual(s)* attempting the task(s) and the *environment* in which the task(s) are being attempted (see Figure 2).

Task boundaries are important because they define the limitations of the different activities that individuals attempt. Task boundaries are holistic in nature and can be physical, cognitive, social and/or emotional. Individual boundaries are personal and set the limits of an individual's capacity to engage in particular tasks. These individual boundaries align with individual's self-organising capacities and are also physical, cognitive, social and/or emotional. In a relational sense, individual boundaries closely align with the boundaries of the task being attempted. Environmental boundaries are equally influential because they frame the parameters of the contexts in which individuals attempt tasks. Environmental boundaries are human and non-human and are evident across the interconnected micro, meso and macro environmental layers (Morrison, 2003). Micro boundaries are evident in the immediate environment (Davis et al., 2008) and directly influence an individual's efforts to carry out a task, e.g. PE equipment, facilities and students. While more removed, meso and macro boundaries are also influential. Meso boundaries, e.g. a school's history, management structures and ethos, and the nature of the local community, e.g. urban/rural, population, socio-economic demography, are all be influential in shaping expectations. Further, macro boundaries include the national policies that guide, or compel, the way that education is approached in a school. These boundaries across the nested environment create a 'ripple effect' with the immediate layer feeding into the more removed layers which in turn exert influence back onto the micro boundaries (Morrison, 2003).

As the different fixed and flexible boundaries from the three categories come together, practitioners can identify the nature of the boundary spaces in which they are working, the specific boundaries they are able to modify and those boundaries that will likely remain rigid and inflexible, particularly in the short term. Critically, if most of the TIE boundaries in a boundary space are fixed
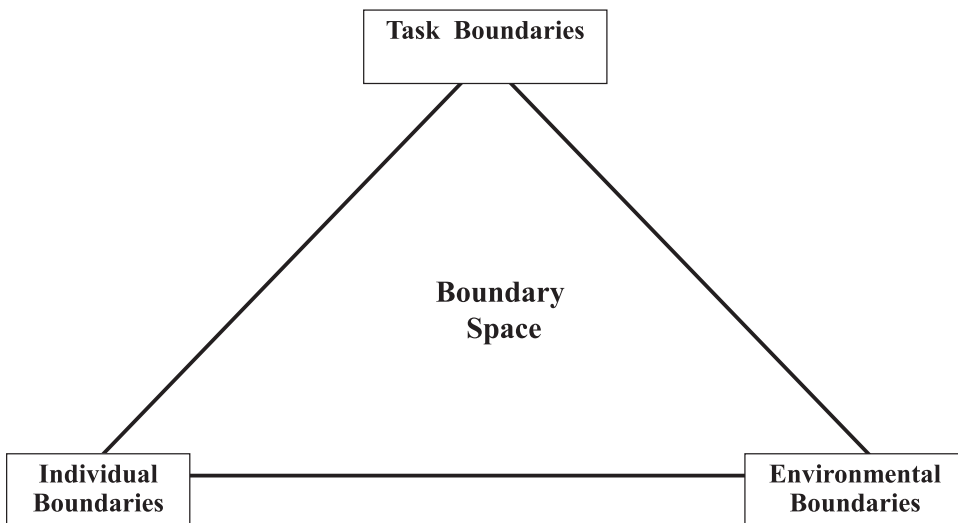

Figure 2. The TIE ecological framework.

Table 1. Creating boundary spaces to initiate lifelong and life-wide PE developments.

	Environmental Boundaries
Macro	• What national policy support is in place for a lifelong and life-wide agenda, e.g. education, health, sport?
	• What global literature is available to support a lifelong and life-wide agenda?
Meso	• What physical activity opportunities are currently available in the local community and after school setting for students?
	• Who are potential stakeholders within the school and community? What is their view of the purpose of PE?
	• What expectations are placed on PE in the context of the school?
Micro	• From a holistic perspective, how well prepared are students to engage in lifelong and life-long PE?
	• What is the PE department's history in relation to curriculum and other key topics, e.g. inclusion, gender, behaviour, school teams etc?
	• How appropriate are the facilities and equipment for a lifelong and life-wide programme?
	Individual Boundaries
Holistic	• Emotionally, how prepared are department members to engage in a lifelong and life-wide agenda?
	• Cognitively, how prepared are department members to engage in a lifelong and life-wide agenda?
	• What is the relationship between the PE department and other stakeholders within and beyond the school?
	Task Boundaries
	• What structures are in place to enable the 'rich' discussions needed to prepare a lifelong and life-wide approach?
	• What does a lifelong and life-wide programme look like at the different phases of schooling and in community settings?
	• What are the holistic topics to be addressed in a lifelong and life-wide programme?

few opportunities for 'rich interactions' will be available. Conversely, if the boundaries are mostly flexible or porous, the boundary space will be particularly loose and maybe too open for 'rich interactions' to be effective. As such, from a complexity perspective, the most effective boundary spaces have some structure and some openness. However, as we note above, boundary spaces are unlikely to be static and are always in some state of flux as different boundaries change to influence the nature of the boundary space.

While there are endless practical examples, EIP has significant potential for PE departments as they seek to introduce a lifelong and life-wide PE programme. Focussing on the initial planning phase of such a project, the TIE framework can help departments identify the fixed and flexible boundaries that come together to create the boundary space in which 'rich interactions' between colleagues can initiate, or stall, the shift towards a lifelong and life-wide programme. These discussions will help departments identify the TIE boundaries that are likely to constrain and/or enable the introduction of a new programme. However, because there is difference, often significant difference, within and between schools, the following questions may help departments create the boundary spaces to facilitate the discussions that will lead to the introduction of a lifelong and life-wide programme (Table 1).

Without an understanding of the different boundary spaces, the department will be ill-informed and, in most cases, any outcomes will be 'pot luck'. As such, as the shift to complexity thinking builds some momentum, EIP offers stakeholders, particularly teachers, the opportunity to build a detailed understanding of the boundary spaces in which the self-organising efforts to initiate a lifelong and life-wide PE agenda can take place.

The complexity commonalities: a final note

We finish this main section of the paper by re-iterating that these four complexity commonalities constantly function as an overarching but integrated umbrella framework that seeks to set conditions to initiate and sustain complexity-informed developments in PE. The main theme running through the paper therefore is that individuals and groups of individuals are constantly engaged in a self-organising lifelong process of becoming that takes place within lived time and within

boundaries. In this way, each of the four commonalities are indivisible from one another and are inextricably linked in the shift towards a complexity thinking approach to PE.

Conclusion

In this paper we propose that an ontological shift towards complexity thinking has a key role in the future of PE. Complexity not only moves PE beyond long dominant modernist approaches but also offers an opportunity to integrate the disconnected postmodern perspectives that currently seek to frame PE. Four interconnected complexity commonalities have been presented as an overarching frame to guide future lifelong and life-wide PE developments in ways that are coherent, connected and emergent. We argue that PE is not a stable entity but always in the process of becoming in ways that are non-linear, messy and never-ending. Likewise, students, teachers and other PE stakeholders are also complex phenomena whose past, present and future experiences constantly merge in a lived time unity to create lifelong and life-wide PE journeys that are personalised, holistic and non-linear. At the heart of these lifelong and life-wide journeys lies each stakeholder's ability to self-organise and, in some way, influence the trajectory of their pathways. This self-organisation process, however, is not 'anything goes' but constantly taking place within a multiplicity of boundaries: boundaries that are everywhere. However, while boundaries have traditionally been viewed as divisive barriers, complexity recognises that the co-existence of fixed and flexible boundaries help create the boundary spaces in which 'rich' self-organising interactions take place. We subsequently suggest that creating boundary spaces will be key to the 'rich' discussions needed to develop more coherent, connected and emergent ways of viewing PE. Consequently, we propose that TDI and EIP can have a significant role in helping physical educators create the 'boundary spaces' in which they instigate the 'rich discussions' that can lead to lifelong and life-wide PE. It is with this final point in mind, we re-iterate that a key challenge for PE in the future will be to develop practitioners with the adaptability, openness and confidence to not only create 'boundary spaces' but also, as we will discuss in future papers, the self-organising understanding and skills that will help them make the most effective use of the 'rich interactions' that these 'boundary spaces' offer.0.

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