Understanding teachers as complex professional learners

Understanding teachers as complex professional learners

Jeanne K Keay

Leeds Beckett University

Nicola Carse

University of Edinburgh

Mike Jess

University of Edinburgh

Corresponding Author: Dr Nicola Carse

Professor Jeanne Keay, Leeds Beckett University, Room 201, Carnegie Hall, Headingley Campus, Leeds LS6 3QQ j.k.keay@leedsbeckett.ac.uk

Dr Nicola Carse, University of Edinburgh, Moray House School of Education, Charteris Land, Room 3.10, Holyrood Road, Edinburgh, EH8 8AQ, Nicola.Carse@ed.ac.uk, T: 0131 651 6614, ORCID identifier 0000-0003-0395-809X

Dr Mike Jess, University of Edinburgh, Moray House School of Education, St Leonards Land, Room 4.19, Holyrood Road, Edinburgh, EH8 8AQ, Mike.Jess@ed.ac.uk, T: 0131 651 6646

Professor Jeanne Keay is Pro Vice Chancellor (Global Engagement) at Leeds Beckett University.

Dr Nicola Carse is a lecturer in primary education in the Moray House School of Education at the University of Edinburgh.

Dr Mike Jess is a senior lecturer in the Moray House School of Education at the University of Edinburgh where he is also Director of the Developmental Physical Education Group (DPEG).

Understanding teachers as complex professional learners

Abstract

This article explores how ideas from complexity and ecological thinking have the potential to act as a conceptual lens to help us better understand, design and support teachers' long term professional learning. Using primary physical education (PPE) as a curriculum context, the challenges of contemporary professional learning, particularly within this PPE context are explored. From an ecological starting point, key ideas from complexity thinking are then introduced that have the potential to inform our view of professional learning. Teacher professional learning is considered as a process which is recursive and non-linear and two themes as the key to the future are proposed and discussed: the need to recognise and appreciate the 'initial conditions' of each teacher and the need to have a long-term focus on five professional learning drivers i.e. self-organise and interact; reflect and inquire; identify and negotiate boundaries; consolidate, challenge and create, and make connections. As this recursive process unfolds, we stress how teachers should be supported to elaborate and deepen their knowledge, skills and relationships through a mixture of experiences that consolidate, challenge and support creativity.

Keywords: professional learning; complexity thinking; ecological perspectives; primary physical education;

Introduction

Professional learning opportunities for teachers have traditionally been offered through time-limited, short term professional development courses (Pedder *et al*. 2010). While these 'events' are frequently reported to lack relevance and value, be disconnected from teachers' previous learning, offer little follow-up and fail to promote opportunities for implementation of the new learning gained, they continue to persist as the dominant approach to teacher professional learning (Desimone 2009; Keay and Lloyd 2011). This 'traditional' approach seems to 'contradict(s) everything we know about the ways in which people are most likely to learn' (Armour 2006, p. 204). Therefore, we align ourselves with Kennedy's (2014) view that professional learning should increase capacity for teacher professional autonomy and that there is a need to 'develop sophisticated but accessible means of understanding continuing professional learning more deeply' (p. 690). Accordingly, we suggest that the problematic situation described above is unlikely to change until those who offer and participate in teachers'

professional learning develop a more robust and in-depth understanding of how this complex process evolves over time. More specifically, and in common with an increasing number of authors, (e.g. Opfer and Pedder 2011, Cochran-Smith *et al*. 2014, Sanford, *et al*. 2015), we seek to contribute to this professional learning debate by exploring how ideas from complexity thinking and ecological perspectives have the potential to act as a conceptual lens to help us better understand, design and support teachers' long term professional learning.

The views presented in this article draw on our recent attempts to construct a conceptual framework informed by complexity and ecological thinking as the catalyst for future developments in primary physical education (PPE) (Jess *et al*. 2016a). We use our own professional experiences as teachers and teacher educators, our previous research (e.g. Elliot, Atencio, Campbell and Jess 2013; Keay, 2005) and the work of others in this area (e.g. Petrie and McGee 2012) to present a theoretical proposal and illustrate how we might apply the developing concepts in practice. From a complex ecological perspective, our framework proposes that progress in PPE should be seen as an integrated process involving developments in curriculum, pedagogy and teacher professional learning alongside a greater clarity about the conception of physical education across the different layers of the education and political systems. As a marginal subject area largely delivered by generalist class teachers within a congested primary school curriculum, PPE is a valuable example of how complexity and ecological thinking can help inform our understanding of teachers' professional learning because 'quick fix' professional development programmes have traditionally been unsuccessfully used to eradicate the perceived failings of the subject in primary schools (e.g. Petrie 2010, Jess and McEvilly 2015).

In our most recent writing, focused on the complex nature of the PPE curriculum development process (Jess *et al*. 2016b), we have stressed the importance of generalist class teachers developing the capacity to deliver PPE experiences that support children's learning as self-organising, emergent and iterative. Building on this proposal, we now seek to discuss a complex ecological informed approach to professional learning that can help teachers, both individually and collectively, to consistently design, deliver and assess experiences that support children's learning. To present this discussion, the paper is split into three main sections: exploring the challenges of contemporary professional learning, particularly within the context of PPE; introducing key ideas from complexity and ecological thinking that inform our view of professional learning, and finally, presenting key implications for the future of teachers' professional learning.

Contemporary Professional Learning Challenges

Professional learning has increasingly been recognised, nationally and internationally, to enhance teachers' feelings of motivation and confidence and their capacity to improve the quality of their teaching and children's learning (Day and Gu 2007, Guskey 2002). Correspondingly, and notably at the policy level, the last two decades have witnessed a significant increase in interest in teacher professional learning (e.g. Pedder *et al*. 2010, Donaldson 2011, AITSL 2012). While some of this policy interest stems from a concern about teacher professionalism, there has been a tendency for government agencies to take a more simplistic cause and effect approach to their professional learning projects. This dominant view is predicated on the perception that improving teacher quality, in a linear and top-down sense, will lead to an improvement in pupil outcomes, which ultimately contributes to nation-states' economic competitiveness (Loomis *et al*. 2008). Concurrently, and synonymous with much of the managerialism that now underpins education systems globally, an increasing emphasis is being placed on measuring the impact of teachers' professional learning (Keay and Lloyd 2011). We suggest, however, that while it is important to justify investment in professional learning programmes, deterministic and linear conceptions of professional learning are not constructive in ensuring that teachers' professional learning activities have an impact on pupil learning. Professional learning is a much more complex process which focuses on the individual needs of teachers and their pupils alongside a commitment to organisational agendas (Day and Gu 2007, Fullan 1993, Kennedy 2005).

Despite this apparent move towards enhancing teachers' professionalism through professional learning, questions remain about the nature and quality of the learning experiences available to teachers (Desimone 2009). In particular, much contemporary literature highlights the prevalence and inadequacy of a one-off, off-site mode of delivery (Armour and Yelling 2007, Darling-Hammond *et al*. 2009). Often presenting teachers as passive recipients of new ideas to be implemented in their schools, this approach has been shown to rarely lead to any long-term change in practice (Kennedy 2005, O'Sullivan and Deglau 2006). As a result of this pervading climate, teachers have become accustomed to 'set' forms of professional learning that act as a prerequisite to the delivery of national curriculum outcomes and require little consideration of the appropriateness for their pupils or context. They are now more likely to value specific answers to their perceived professional deficiencies that come in the form of curriculum packages, many of which encourage acceptance of 'set' answers, rather than analysis of the resource for use in their own context. As Stenhouse (1975) proposed several

decades ago, a view we suggest is even more pertinent today, teachers should not be led to see the curriculum process 'as a package of materials or a syllabus of ground to be covered', but more as a 'way of translating any educational idea into a hypothesis testable in practice' (p. 142). Consequently, there is growing recognition within the literature of a need to challenge 'traditional' transmission modes of professional learning in order to create a context for professional learning that is more transformative, participative, situated, recursive and long term. Notably, there is an awareness emerging from within the educational research community of the need for professional learning approaches that are more explicitly underpinned by theoretical perspectives that can support our understanding of the relationship between professional learning, policy and practice (Ball, Maguire and Braun 2012, Kennedy 2014). As we discuss later, it is through our work with complexity and ecological thinking that we seek to contribute to the discourse around this theory–practice gap.

Primary Physical Education Professional Learning

The increased interest in professional learning is mirrored in PPE with an increasing number of studies in the UK (e.g. Harris *et al*. 2011, Jess and McEvilly 2015) and across the world (e.g. Ha *et al*. 2004, Morgan and Bourke 2008, Petrie 2010) reporting on the practices of generalist primary teachers. Much of this interest stems from the growing public, political and commercial interest in young people's health (Petrie and lisahunter 2010), concerns about the preparedness of generalist primary teachers to teach physical education (Caldecott *et al*. 2006) and also the quality of children's learning experiences in PPE (Griggs and Ward 2012). From this ever-growing research base, it is evident that many primary teachers lack confidence in their teaching of physical education (Morgan and Bourke 2008) while the quality of the physical education experiences in both initial teacher education (ITE) and professional development are often considered inadequate and inappropriate. Indeed, Harris *et al*. (2012) go so far as to suggest that the current predicament faced by PPE is largely due to a combination of insufficient provision of physical education within ITE programmes and ineffective professional development. However, this problem may not only be the result of ineffective professional development but also a lack of engagement by primary teachers. For example, Spence (2012) found that 52.5% of 761 teachers surveyed across England reported engagement in 'very little' or 'no' professional development in physical education across their teaching careers. In addition, investigating the impact of a national PPE professional development programme in England, Harris *et al*. (2011, 2012) concluded that while the professional development experiences on offer had some positive impact on teachers' attitudes and subject

knowledge, the short-term nature of the courses, the focus on resources rather than pedagogy and the lack of follow-up support limited the effectiveness of the programme.

This criticism is not isolated to the UK. In New Zealand, Petrie and McGee (2012) found that while the provision of resources, such as games and lesson plans, may have extended primary teachers' repertoire of activities, they tended to stifle the teachers' creativity as the plans were followed like scripts instead of being adapted to create appropriate learning experiences that reflected the children's needs and the learning context. Similar to O'Sullivan and Deglau (2006), Petrie and McGee (2012) highlight that professional development should provide time for teachers to engage with resources, discuss the underpinning rationale and pedagogical implications of any resources and also consider how resources could be modified to reflect the needs of learners in context. In addition, Petrie and McGee (2012) noted that time should be given to explore how resources are designed as part of the professional development experience so that teachers are encouraged to innovate and develop learning experiences rather than just implementing a resource. Reflecting on over a decade of devising PPE professional development for specialist and generalist teachers within a Scottish context, Atencio, *et al*. (2012) reach a similar conclusion. Recalling early attempts at professional development through short-term, off-site courses supported by a manual, they outline how teachers' learning floundered when they returned to their school contexts as they had no support mechanisms in place. In contrast, Jess and McEvilly (2015) note how a later longer term, theoretically-informed and accredited professional learning programme proved to be 'more participative, situated, collaborative and supportive' (p. 9) with a specific view to build teacher capacity in PPE.

We suggest that these examples reflect the argument made earlier that positive professional learning experiences do not have their basis in a simple causal relationship where teachers engage in short courses, copy pre-prepared plans, learn and then change their practice. Concurrent with Hoban (2002), Kennedy (2005) and Jess and McEvilly (2015), we recognise the complex, non-linear and messy nature of the professional learning process and, in common with Atencio *et al*. (2014), we propose that complex ecological thinking offers a useful lens through which to investigate and explain the processes involved and the associated impact on teacher learning and, as a consequence, pupil learning. As we now discuss, we believe that ideas from complexity and ecological thinking have the potential to support a move beyond the traditional 'quick-fix', 'one-size-fits-all' approach to professional development towards the recognition that professional learning is a long-term and dynamic process in which the teacher

plays a central role.

Complexity and Ecological Thinking and Professional Learning

In recent years, ideas from complexity and ecological thinking have become more evident within the education literature (e.g. Rogoff & Lave 1984, Morrison 2003, Davis et al. 2008, Rhoades and Woods 2014) and we believe that these overarching perspectives can help inform our understanding of teacher professional development and learning. Therefore, in the remainder of this paper we explore how ideas from these related perspectives have informed our own thinking about teachers' professional learning. First we will define our understanding of complexity and ecological thinking before considering how key concepts from these perspectives have helped us view teachers' professional learning as a non-linear, emergent and long term capacity building process.

Defining Complexity and Ecological Thinking

In this section, we define both complexity and ecological thinking and explain why we use these interrelated perspectives to inform our approach to teachers' professional learning. We believe that complexity thinking is an overarching perspective that is best understood by considering how systems function. Systems are entities that are made up of interacting elements and are observed almost everywhere. They include larger systems like the earth, forests and cities and smaller systems like human beings, cars and watches. Central to our thinking about complexity, and in agreement with Osberg, Doll & Trueit (2009), we believe that the difference between complicated and complex systems is key to our understanding of this paradigm shift. In complicated systems, the interactions between the different elements of the system are pre-programmed and have little, or even no, relationship with the environment in which they are functioning. As such, complicated systems tend to operate in a linear and closed-loop fashion, are usually quite stable and produce outcomes that have a high degree of predictability or even certainty. Traffic lights, fridges and televisions are examples of the many complicated systems we regularly meet in our daily lives. Conversely, while complex systems also have the capacity to be structured, ordered and predictable, they possess one key difference. Elements within complex systems are self-organising and have the capacity to interact within their own structure and with the environment (Prigogine, 1976). Critically, and unlike complicated systems, this self-organising capacity offers complex systems the opportunity to generate 'rich interactions' (Cilliers, 1998) that may lead to behaviours or outcomes that are unpredictable, adaptable and even creative. Complex systems are therefore

"inherently dynamic and transformational" (Byrne, 1998, p. 51) because they have the capacity to be ordered and structured whilst concurrently also having the potential to be unstable and open-ended.

With this in mind, we would argue that teachers, like all humans, are complex systems because they function in a self-organising and emergent manner. Not only do the different physical, cognitive, social and emotional elements within the human system interact holistically to create emergent behaviours, they also interact with their immediate and more distant environmental factors, for example, directly with children, facilities and equipment in the classroom and with the more removed school community setting and national policy context. As complex systems, therefore, teachers can be predictable and stable whilst also having the potential to be unpredictable and creative in their behaviours. As we discuss later, viewing teachers in this non-linear complex way has significant implications for the way we now look to design and support teachers' professional learning.

Resonating with these self-organising and emergent features of complex systems, we have found ideas from ecological thinking to be a useful starting point in helping us explain our complexity-informed approach to teachers' professional learning. Specifically, we are attracted to the ecological view that human behaviour emerges from the ongoing interaction between the individual, the environment and the task being attempted (e.g. Gibson 1979, Newell 1986). Further, while ecological thinking recognises that human behaviour emerges from the interaction with the immediate environment, it also acknowledges the influence of both the meso and macro layers of the environment so that a 'ripple' effect is created as each layer influences the other (Bronfenbrenner 1979, Stokols 1992, Rovengo 2006)

If we are to acknowledge the complex nature of teachers' professional learning, it is important to reiterate that teachers' engagement in a series of disconnected 'quick fix' courses selected in an ad hoc or 'top-down' manner, often decided by school management, is unlikely to be the best way to support their professional learning. On the basis of what we have written above, the final section of this paper presents a number of complexity and ecologically-informed drivers that we suggest can be used to guide a re-orientation of the professional learning process. It is not our intention to present these ideas as a new model or approach to professional learning, but to highlight how complexity and ecological thinking can help raise important questions to help re-shape or re-frame the professional learning process over time. In this sense, two overarching themes for teachers and those tasked with leading or managing the professional learning process will be presented. The first theme focuses on the way that the ecological features can help frame our understanding of the many professional learning

'starting points' that teachers meet across their career. The second theme then highlights complexity-informed concepts, most notably self-organisation emergence, connectedness, nestedness, ambiguous bounding, 'edge of chaos' and recursive elaboration, that can be used to design, support and guide the non-linear and emergent professional learning process as it unfolds over time. Further, while these themes influence the professional learning process over time, we highlight that both have a particularly significant impact on the early phase of the learning process when teachers engage with new professional learning tasks or topics.

Teachers' Professional Learning: An Ecological Starting Point

As teachers progress through their professional lives, they encounter many new professional development opportunities. We suggest that each of these new starting points can be viewed as the ecological interaction between themselves as a self-organising individual/practitioner and the many boundaries, or constraints, created by the new task they are engaging with, the children they teach and the environment in which they work. As an example, we can consider the starting point for a group of teachers following their individual attendance at a 'traditional' short, off-site course focussed on PPE. On returning to their schools to begin the process of including this newly acquired movement-related knowledge in their practice, the different teachers engage in a self-organising process as they interact with many personal and local boundaries. These boundaries include the content of the new topic (the task), the starting points and initial responses of the children they teach (individuals), the facilities, equipment, response of colleagues, school ethos and national policy influences (environment) and their personal strengths and limitations in terms of, for example, their knowledge, pedagogy, motivation. As each teacher interacts with these personal and 'situated' boundaries, they react or adapt in their own self-organising way; hence the 'ambiguous' nature of the boundaries.

From a complex ecological perspective, it is counterintuitive to ignore these different starting points of teachers and the schools in which they teach. While a detailed understanding of these 'initial conditions' (Senge 1990) will not lead to an accurate prediction of what will happen in the future, it will help all those involved in the professional learning process realise that teachers and schools have 'a specific and particular history of interactions' (Haggis 2008, p. 168) that come together to create unique and usually 'messy' contexts. At the beginning of any new professional learning experience, teachers and schools are at different starting points. Some will be ready to engage wholeheartedly with the new task or topic, using new skills or understandings, some may have no interest or capacity to engage while others will be

somewhere between these extreme starting points. We would suggest therefore that if teachers can be effectively supported to gather and make use of this 'starting point' information about themselves and their context, the nature of their professional learning experiences will quickly move towards a more informed and situated process: one that has the potential to more readily make connections between teachers', schools' and policy aspirations.

However, while this approach may make sense from a complex ecological perspective, we recognise that it will require a significant shift in thinking for many professional development deliverers, leaders and managers, particularly as teachers have long had a limited input into their professional learning and may not have the desire, expectation and/or capacity to actively engage with this more participative process. Enacting and supporting this shift, therefore, is likely to be as much an emotional endeavour as a knowledge building process as providers, teachers, schools and managers will need to 'buy-in' and acknowledge the value and importance of understanding 'initial conditions'. To develop this understanding of teachers' 'initial conditions' we propose it is important to focus on two key aspects: teachers' evolving visions for education and the boundaries that influence their initial engagement with the new learning.

On the first point, if professional learning is to become a more participative and long-term process, it is not only the vision of leaders and managers that should drive engagement. Teachers must be given some degree of freedom and support to 'take a stand for a preferred future' (Block 1987, p. 102) and work to articulate, share, negotiate and adapt their personal vision for education: a vision that will give their work meaning and will be a key feature of their long term professional learning (Senge, 1990). However, as we have alluded to earlier, with many education systems traditionally based upon a top-down and linear leadership/management approach, teachers are unlikely to be offered 'carte blanche' to create unrealistic personal visions for education. They will need to be realistic and acknowledge the influence of the boundaries within their local contexts and the inevitability of some external accountability. Nevertheless, in agreement with Fullan (1993), we believe that this 'personal purpose is the route to organizational change' (p. 14), but only if teachers are supported in the development, articulation and sharing of their vision. Primary generalist teachers will inevitably have widely differing visions of physical education based on their own personal experiences and their initial teacher education. They may align themselves with a view of PPE as fun, health related, sport focused or may simply see it as a break from 'real' teaching and therefore absolve themselves from any responsibility to develop themselves in this area of learning. If we are to view professional learning as a complex phenomenon it cannot continue

to be the 'pot luck' experience it has traditionally been, but it must be one that starts with a shared acknowledgement that teachers' personal visions are critical to professional learning futures.

Aligned with teachers' personal vision, it is also important to recognise the key boundaries influencing their initial engagement with the new professional learning task. Earlier in the paper we used a traditional PPE example where little, if any, acknowledgment of teachers' 'initial conditions' had been considered. Turning this problem around, we suggest that before engaging in any professional learning activity, and during the activity, teachers should seek, and be supported, to explore a number of 'starting point' considerations. For example, from a personal perspective they may wish to consider how the task relates to their vision, any previous experiences related to the task, their understanding of the task, their existing knowledge base and their motivation in terms of the importance of the task and the relevance to their pupils' learning needs. In addition, they could also consider the contextual relevance and importance of the task in relation to their class, colleagues, the school and the national agendas.

We argue that with this background information, teachers, groups of teachers and professional learning leaders will be in a more informed position to engage in the early and ongoing phases of the professional learning experience as it unfolds.

Teachers' Professional Learning: Complexity-Informed Drivers

Building on the detailed understanding of 'initial conditions', complexity thinking offers important clues as to how the professional learning process may progress as a long term, emergent and collaborative process that is both unpredictable and non-linear in nature. As such, the complex professional learning process, informed by an interweaving mix of complexity drivers, begins to evolve in a recursive manner that involves teachers revisiting and elaborating on their learning. We now discuss briefly how these complexity drivers inform this recursive professional learning process (see Figure 1).

Insert Figure 1 here

1) Self-organise and interact

While teachers' professional practice always involves self-organisation by the teacher, this self-organising process is constrained by a range of different boundaries. However,

teaching is fundamentally an interactive activity because it involves regularly negotiating with children, colleagues and management in a collective endeavour. However, as was previously highlighted, the boundaries imposed by the more traditional approach to professional learning often means that teachers view professional learning as something that is done to them by external sources and not something that they have the agency to influence (Priestley *et al*. 2014). Therefore, while external influences will always be in evidence, a more participative view of professional learning highlights the need for all those involved to recognise and support teachers' self-organising capacities. Fortunately, we would suggest that contemporary, more collaborative approaches to professional learning like self-study (LaBoskey 2006) and practitioner inquiry (Cochran-Smith and Lytle 2009) are all more aligned with complexity ideas and offer opportunities for teachers to regularly engage in professional learning experiences that are self-organising, interactive and emergent in nature.

We are however conscious that this important driver may be particularly challenging for those leading and supporting teachers' PPE professional learning. As we noted earlier, many generalist primary teachers have negative and ill-informed views of physical education, have little confidence in their teaching of this practical subject and have no interest, and see little relevance in, PPE professional learning. As a starting point, if professional development leaders are to help teachers self-organise and interact with PPE professional learning in a positive manner, it is critical they design development activities that the teachers perceive to be relevant to their own learning needs and to those of their pupils (Keay and Lloyd 2011). From our experiences over many years, this key challenge will not be overcome by short, one-off sessions but by working with teachers over time and ensuring that the professional learning activities are not only relevant but can also be seen as achievable by non-specialist teachers.

2) Reflect and inquire

We suggest that reflection and inquiry are key self-organising processes, both individually and collectively, that teachers need to help sustain the coherence, adaptability and on-going development of their professional learning. Together these processes have the potential to help teachers keep their professional learning loosely 'on track' by supporting and sustaining the development of their educational vision, knowledge base and connections, while also helping them respond to feedback and make the 'bifurcation' decisions (Biesta 2008) that will lead to changes in the direction of their professional learning. Without this reflection and inquiry process, there is the possibility that teachers' practices will remain static and they may

begin to lack the confidence or commitment to engage with the on-going development process (Borko *et al*. 2002).

The role of reflection in teachers' professional learning cannot be overemphasised as it helps them support, consolidate and evaluate their practice and can feed back into the inquiry process. Critically, it can help teachers develop an in-depth understanding of their practice and create opportunities for continuous learning and ongoing inquiry (Stenhouse 1975, Ertsas and Irgens 2017). To gain this insight, however, it is important teachers receive the appropriate support and guidance to assume the actor/critic role that helps them analyse their own and others practice honestly and recognise how this practice is informed by the ideas, or theories, framing the actions (Osterman and Kottkamp 1993). As such, reflection and inquiry are an on-going and integrated process focussed on the cognitive, social, emotional and applied aspects of practice, while also the continuous learning that helps teachers cope with externally-driven agendas. As teachers develop a focus on continuous professional learning, inquiry and reflection are critical aspects of the capacity building process.

As we highlighted in the previous section, primary teachers may encounter many challenges in relation to developing a reflective approach to professional learning in physical education. This is where actively engaging with the process of recursive elaboration within their own professional learning is both helpful and necessary. Through this process teachers can be encouraged and supported to revisit topics in different ways to not only help them build confidence in their practice but also adopt a reflective approach that will help them consolidate and extend their current learning.

3) Identify and negotiate boundaries

While teachers self-organise constantly in their professional life their interactions are not only with humans but also with different task-related and environmental boundaries. While many of their actions with these different boundaries may be subconscious (Korthagen 2016), teachers are also able to negotiate many of the boundaries. It is important, therefore, that teachers spend time identifying the different boundaries that they have the capacity to negotiate and potentially influence whilst also being aware of those boundaries that they have little or no chance of influencing. In a similar way to the starting points discussed above, teachers do not have the same backgrounds or capacities to negotiate these different boundaries and, in context,

will need to develop different knowledge sets, skills and relationships to successfully engage in this negotiating process.

This driver not only needs to be recognised as an important starting point but also in the process of selecting relevant learning experiences and when putting new learning into practice. In relation to PPE, as mentioned in the previous section, teachers are likely to encounter more actual and perceived boundaries than may be evident in other subjects. For example, the context in which pupils learn physical education presents challenges for those teachers who lack confidence in teaching children in an open space where they are physically active. This then links to the task related boundaries that teachers may set to keep control of the class. If teachers are able to recognise and admit such boundaries they will then be able to select appropriate professional learning activities to support them in overcoming these challenges.

4) Consolidate, Challenge and Create: Complexity-in-action

As teachers' careers evolve over time, as we have just noted, they are constantly negotiating different boundaries, most notably when they attempt to include new or different learning into their practice. Consequently, at different times they will respond to events in ways that are inside, around and outside the different boundaries. This idea of teachers' practice as 'complexity-in-action' resonates with the 'edge of chaos' (Morrison 2003) experiences that unfold as a result of the recursive elaboration process. Critically, as deeper learning develops, teachers' behaviours will likely oscillate around the 'edge of chaos' as some of their teaching efforts remain inside, others move around and others extend beyond the different task, individual and environmental boundaries within their professional context. Table 1 highlights how these different responses lead to outcomes that will consolidate, challenge and extend teachers' learning: both from a positive and negative perspective.

Insert Table 1 here

While we have seen many primary teachers 'playing safe' as they regurgitate and consolidate the tried and tested (and often pointless) games e.g. dodgeball, other teachers explore the different 'edge of chaos' possibilities as they push the boundaries and make errors, consolidate behaviours and challenge themselves as part of an iterative, integrated and interactive process (e.g. Carse 2015). Deep professional learning, as with children's deep learning, is therefore not the result of a straightforward transmission process but a non-linear,

messy and recursive process that involves periods of consolidation, challenge and error. While it is likely that teachers will meet all these six different outcomes during their professional careers we would suggest they should not only be aware of the different possibilities but also work to develop a balance between the positive outcomes whilst developing the resilience to cope with the negative outcomes when they occur.

5) Make connections: within, across and beyond

Connections bring integrity to teachers' professional learning because they help maintain the coherence of learning over time. Without connections, both in knowledge and relationships, teachers' professional learning journey is likely to become disconnected and de-contextualised from the complex world in which they live. From a knowledge perspective, teachers should seek to build and develop a coherent knowledge base that informs their understanding of curriculum learning within subject areas, across the whole school curriculum and beyond the school to the 'real' world of learning, including the ever-changing policy arena. If teachers only focus on the compartmentalised knowledge locked into specific subject areas or disciplines, they are more likely to cut themselves off from the broader community and exacerbate disconnection across the education system. Furthermore, it is unlikely teachers will be able to engage in this knowledge base effectively without working collaboratively with a range of learners and colleagues within, across and beyond their immediate setting. We would suggest that teachers not only need to consider the nature of these relationships but also how to develop and sustain these as their professional learning progresses.

To support this recursive elaboration process, the complexity concepts of connectedness and nestedness have important implications for the way in which deep learning will develop. Given the relational nature of teachers as complex learning systems, iteratively making appropriate connections between key elements is central to the deep learning process because 'new properties and behaviours emerge not only from the elements that constitute a system, but from the myriad connections among them' (Mason 2008, p. 48). However, while many connections 'naturally' exist they do not necessarily support the deep and coherent learning that can be applied and transferred across contexts. For example, within the context of PPE, with many staff in primary schools having been reported to lack the knowledge and confidence to teach PPE effectively (Harris *et al*. 2011), there is a need to explore different ways to put appropriate support mechanisms in place to ensure that the recursive elaboration process is both positive and ongoing. As such, while some connections may help support links

between teachers' thinking and practice, weaker connections can lead to the isolation associated with more shallow learning (Bransford *et al*.2000). We suggest it is this weak connectivity that is the main problem of the traditional PPE professional development approach because it is often difficult for teachers to integrate new knowledge with existing knowledge and practice and develop shared understandings with colleagues. Subsequently, we recognise the need to engage in a more connected professional learning approach that creates coherent, connected and situated experiences that integrate professional learning across teachers' individual and collective thinking and practice.

Alongside these local connections, teachers and school leaders also need to be aware of the nested school, community and policy influences on their practice. As complex systems are embedded within nested systems that are 'simultaneously a unity, a collection of unities and a component of a greater unity' (Davis and Sumara 2001, p. 85), teachers' professional learning will be influenced, to different degrees, by ever-changing school-wide, local authority and national policy trajectories. The relationship between these different nested layers, however, is not straightforward and linear, but creates a 'ripple effect' as the smaller systems feed into the larger system which in turn exerts influence back into the smaller parts of the system (Morrison 2003). Accordingly, while policy makers may view the implementation of education policy as a relatively straightforward and simple process, the reality is much more complex as policies are viewed differently in different contexts and subsequently enacted in different ways and also to different degrees (Ball *et al*. 2012). It is therefore, important that teachers are supported to make connections not only to understand the impact of policy changes on their practice but also to know where to go to improve their practice. They need the support of subject leaders to enable their development in their school context and they need to know how a subject community or network can support their development and how they can link with the external sport and physical education community.

Conclusion

With the growing acknowledgement that teachers' professional development will be a key feature of future developments in education around the world, it has been widely reported that traditional professional learning approaches continue to have limited impact on practice. Kennedy (2005 and 2014) highlights this, suggesting that the more transformative in nature professional development models are, the more they can contribute to increasing capacity for

professional autonomy and teacher agency. This is important as teachers attempt to assert their professionalism within a neo-liberal educational agenda that has challenged teacher autonomy and has been perceived to reduce teachers to technician status. Building on Kennedy (2005 and 2014), in this paper we theorised and considered what a transformative approach to teachers' professional learning may look like in the future. Using primary physical education as our curriculum example, we employed a complex ecological lens to present teachers as adaptive practitioners who develop as self-organising, interactive and emergent professional learners through a long term recursive elaboration process. At the heart of this recursive and non-linear process we have highlighted how teachers are actively engaged in regular efforts to interpret and negotiate the many task, environment and individual boundaries they consistently encounter in their professional lives. Critically, as this recursive process unfolds, we stress how teachers should be supported to elaborate and deepen their knowledge, skills and relationships through a mixture of experiences that consolidate, challenge and support creativity. In our efforts to support this complexity-informed professional learning process, we presented two key themes as the key to the future: the need to recognise and appreciate the 'initial conditions' of each teacher and the need to have a long-term focus on five professional learning drivers i.e. self-organise and interact; reflect and inquire; identify and negotiate boundaries; consolidate, challenge and create, and make connections. Taken together, we suggest that these complex ecological drivers have the potential to contribute to building capacity for teachers to exercise their professional autonomy, leading teachers into a long-term process of professional learning that is transformative in nature. Furthermore, we take the view that these key themes will not only have important implications for teachers but also for the professional learning leaders and managers who seek to support teachers' long term professional learning.

References

Armour, K., 2006 Physical education teachers as career-long learners. *Physical Education and Sport Pedagogy,* 11/3, 203-207.

Armour, K. and Yelling, M., 2007. Effective professional development for physical education teachers: the role of informal, collaborative learning. *Journal of Teaching in Physical Education*, 26 (2), 177-200.

Atencio, M., Jess, M. and Dewar, K., 2012. 'It is a case of changing your thought processes, the way you actually teach': Implementing a Complex Professional Learning Agenda in Scottish Physical Education. *Physical Education and Sport Pedagogy,* 17 (2), 127-144.

Atencio, M., Yi, C.J., Clara, T.W.K. and Miriam, L.C.Y., 2014. Using a complex and nonlinear pedagogical approach to design practical primary physical education lessons. *European Physical Education Review*, 20 (2), 244-263.

Australian Institute for Teaching and School Leadership (AITSL), 2012. *Australian Teacher Performance Framework,* Australia: AITSL.

Ball, S., Maguire, M. and Braun, A., 2012. *How schools do policy: policy enactments in secondary* schools. London: Routledge.

Biesta, G., 2008. Five theses on complexity reduction and its politics. Paper presented at the *Annual Meeting of the American Educational Research Association*, New York, USA, 24-28 March.

Block, P., 1987. *The Empowered Manager*. Jossey-Bass: San Francisco.

Borko, H., Elliott, R., & Uchiyama, K., 2002 Professional development: A key to Kentucky's educational reform effort. *Teaching and Teacher Education*, 18, 969–987.

Bransford, J., Brown, A., & Cocking R., 2000. *How people learn: Brain, mind, and experience & school*. Washington, DC: National Academy Press.

Bronfenbrenner, U., 1979. *The ecology of human development.* Cambridge. Harvard University Press*:* MA, United States.

Byrne, D., 1998. *Complexity Theory and the Social Sciences.* London: Routledge.

Caldecott, S, Warburton, P. and Waring, M., 2006. A survey of the time devoted to the preparation of primary and junior school trainee teachers to teach physical education in England. *British Journal of Teaching Physical EducationI,* 37 (1), 44–48.

Carse, N., 2015. Primary teachers as physical education curriculum change agents. *European Physical Education Review*, 21 (3), 309-324.

Cilliers, P., 1998. *Complexity and postmodernism*. London: Routledge.

Cochran-Smith, M., Ell, F., Ludlow, L., Grudnoff, L. and Aitken, G., 2014. The challenge and promise of complexity theory for teacher education research. Teachers College Record. 116 (5), 1-38.

Cochran-Smith, M., & Lytle, S. L. 2009. *Inquiry as stance: Practitioner research in the next generation.* New York: Teachers College Press.

Darling-Hammond, L., Chung Wei, R., Andree, A., Richardson, N. and Orphanos, S., 2009. *Professional Learning in the Learning Profession: A Status Report on Teacher Development in the United States and Abroad.* The National Staff Development Council and The School Redesign Network, Stanford University.

Davis, B. and Sumara, D., 2001. Learning communities: Understanding the workplace as a complex system. *New Directions for Adult and Continuing Education* 92, 85–95.

Davis, B., Sumara, D. and Luce-Kapler, R., 2008. *Engaging Minds: Changing Teaching in Complex Times*, second edition. New York: Routledge.

Day, C. and Gu, Q., 2007. Variations in the conditions for teachers' professional learning and development: sustaining commitment and effectiveness over a career. *Oxford Review of Education*, 33 (4), 423-443.

Desimone, L. M., 2009. Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational researcher*, *38*(3), 181-199

Donaldson, G., 2011. *Teaching Scotland's Future: Report of a review of teacher education in Scotland*. Scottish Government (Scotland).

Elliot, D., Atencio, M, Campbell, T. and Jess, M., 2013. "From PE experiences to PE teaching practices? Insights from Scottish primary teachers' experiences of PE, teacher education, school entry and professional development." *Sport, Education and Society* 18 (6): 749-766. doi: 10.1080/13573322.2011.609165

Ertsas, T. and Irgens, E., 2017. Professional theorizing, *Teachers and Teaching*, 23 (3), 332-351, DOI: 10.1080/13540602.2016.1205013.

Fullan, M., 1993. *Change Forces,* London: The Falmer Press.

Gibson, J. J., 1979. The ecological approach to visual perception. Houghton Mifflin: Boston.

Griggs, G. and Ward, G., 2012. Physical Education in the UK: disconnections and reconnections. *Curriculum Journal*, 23 (2), 207-229.

Guskey, T., 2002. Professional Development and Teacher Change. *Teachers and Teaching: theory and practice*, 8 (3/4), 381-391.

Ha, A., Lee, J., Chan, D. and Sum, R., 2004. Teachers' perceptions of in-service teacher training to support curriculum change in physical education: The Hong Kong experience. *Sport Education and Society*, 9 (3), 421-438.

Haggis, T., 2008. Knowledge Must Be Contextual: Some Possible Implications of Complexity and Dynamic Systems Theories for Educational Research. *Educational Philosophy and Theory* 40(1): 158-176. doi:10.1080/135406002100000512

Harris, J., Cale, L., Musson, H., 2011. The effects of a professional development programme on primary school teachers' perceptions of physical education. *Professional Development in Education*, 37 (2), 291-305.

Harris, J., Cale, L. and Musson, H., 2012. The predicament of primary physical education: a consequence of 'insufficient' ITT and 'ineffective'CPD?. *Physical Education and Sport Pedagogy*, 17 (4), 367-381.

Hoban, G., 2002. *Teacher Learning for Educational change: a systems thinking approach* Buckingham: Open University Press.

Jess, M. and McEvilly, N., 2015. Traditional and contemporary approaches to career-long professional learning: a primary physical education journey in Scotland. *Education 3-13*, 43 (3), 225-237.

Jess, M., Keay, J. and Carse, N., 2016a. Primary physical education: A complex learning journey for children and teachers. *Sport, education and society*, 21 (7), 1018-1035.

Jess, M., Carse, N. and Keay, J., 2016b. The primary physical education curriculum process: more complex that you might think! *Education 3-13*, 44 (5), 502-512.

Keay, J., 2005. Developing the physical education profession: new teachers learning within a subject-based community. *Physical Education and Sport Pedagogy*, *10*(2), 139-157.

Keay, J.K. and Lloyd, C.M., 2011. *Linking children's learning with professional learning*. Rotterdam: Sense Publishers.

Kennedy, A., 2005. Models of Continuing Professional Development: a framework for analysis. *Journal of In-service Education*, 31 (2), 235-250.

Kennedy, A., 2014. Understanding continuing professional development: the need for theory to impact on policy and practice. *Professional development in education*, *40*(5), 688-697.

Korthagen, F., 2016. Inconvenient truths about teacher learning: towards professional development 3.0, *Teachers and Teaching,* DOI: 10.1080/13540602.2016.1211523

LaBoskey, V. 2004. The methodology of self-study and its theoretical underpinnings (pp. 817-869). In Loughran, J,..Hamilton, M., LaBoskey, V., & Russell, T. (Eds.) *International handbook of self-study of teacher education practices*. Dordrecht: Kluwer Academic Publishers

Loomis, S., Rodriguez, J. and Tillman, R., 2008. Developing into similarity: Global teacher education in the twenty- first century. *European Journal of Teacher Education*, 31 (3), 233-245.

Mason, M., 2008. What is complexity theory and what are its implications for educational change? *Education Philosophy and Theory*, 40, 135–149.

Morgan, P. and Bourke, S., 2008. Non-specialist teachers' confidence to teach PE: the nature and influence of personal school experience in PE. *Physical Education and Sport Pedagogy*, 13 (1), 1-29.

Morrison, K., 2003. Complexity theory and curriculum reforms in Hong Kong. *Pedagogy, Culture and Society* 11 (2), 279-302.

Newell, K., 1986. Constraints on the development of coordination. In Wade, M. & Whiting, H.T.A., (Eds.), Motor development in children: aspects of coordination and control, 295-317. Elsevier Science: Amsterdam.

Opfer, V.D. and Pedder, D., 2011. Conceptualizing teacher professional learning. *Review of educational research*, 81 (3), 376-407.

Osberg, D., Doll, W. & Trueit, D., 2009. Editorial: Limiting Complexity. Complicity: An International Journal of Complexity & Education, 6/2, iii-x.

Osterman, K. F. & Kottkamp, R. B., 1993. *Reflective Practice for educators: Improving Schooling Through Professional Development*. Corwin Press: Newbury Park, Ca.

O'Sullivan, M. and Deglau, D., 2006. Principles of Professional Development. *Journal of Teaching in Physical Education*, 25, 441-449Ovens, A., Hopper, T. and Butler, J., 2013. *Complexity Thinking in Physical Education: Reframing Curriculum, Pedagogy and Research*. London: Routledge.

Petrie, K., 2010. Creating confident, motivated teachers of physical education in primary schools. *European Physical Education Review*, 16 (1), 47-64.

Petrie, K. and lisahunter, 2011. Primary teachers, policy, and physical education. *European Physical Education Review*, 17 (3), 325-329.

Petrie, K.C. and McGee, C., 2012. Teacher Professional Development: Who is the learner? *Australian Journal of Teacher Education*, 37 (2). 59 – 72.

Priestley, M., Minty, S. and Eager, M., 2014. School-based curriculum development in Scotland: Curriculum policy and enactment. *Pedagogy, Culture & Society*, *22*(2), pp.189-211.

Prigogine, I., 1976. Order through fluctuations: Self organization and social system. In E. Jantsch and C. Waddington, eds. *Evolution and consciousness: Human systems in transition*,. Reading, MA: Addison-Wesley, 93–130.

Rhoades, J.L. and Woods, A., 2015. Repertoire networks among national board-certified physical education teachers. *Professional Development in Education*, 41 (3), 436-451.

Rogoff, B., & Lave, J. 1984. (Eds.). Everyday cognition: Its development in social context. Cambridge, MA: Harvard University Press

Rovengo, I. 2006. Situated perspectives on learning. In: D. Kirk, D. Macdonald and M. O'Sullivan, eds. *The handbook of physical education*, London: SAGE, 262–274.

Sanford, K., Hopper, T., and Starr, L., 2015. Transforming teacher education thinking: Complexity and relational ways of knowing. *Complicity: An International Journal of Complexity and Education.* 13(2), 26‑48

Senge, P. M., 1990. *The art and practice of the learning organization*. Doubleday: New York.

Spence, J., 2012. Bupa Start to Move Final Report for Youth Sport Trust and Bupa, July 2012.

Stenhouse, L., 1975. *An Introduction to Curriculum Research and Development.* London: Heinemann Educational.

Stokols, D. (1992). Establishing and maintaining healthy environments: toward a social ecology of health promotion. American Psychologist 47:6–22.