



THE UNIVERSITY *of* EDINBURGH

Edinburgh Research Explorer

Integrating complexity thinking with teacher education practices

Citation for published version:

Jess, M, Atencio, M & Carse, N 2018, 'Integrating complexity thinking with teacher education practices: A collective yet unpredictable endeavour in Physical Education?', *Sport, Education and Society*, vol. 23, no. 5, pp. 435-448. <https://doi.org/10.1080/13573322.2016.1225195>

Digital Object Identifier (DOI):

[10.1080/13573322.2016.1225195](https://doi.org/10.1080/13573322.2016.1225195)

Link:

[Link to publication record in Edinburgh Research Explorer](#)

Document Version:

Peer reviewed version

Published In:

Sport, Education and Society

General rights

Copyright for the publications made accessible via the Edinburgh Research Explorer is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy

The University of Edinburgh has made every reasonable effort to ensure that Edinburgh Research Explorer content complies with UK legislation. If you believe that the public display of this file breaches copyright please contact openaccess@ed.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.



Integrating Complexity Thinking with Teacher Education Practices: A Collective Yet Unpredictable Endeavour in Physical Education?

RESEARCH ARTICLE: 8298 words

Mike Jess, University of Edinburgh

Matthew Atencio, California State University East Bay

Nicola Carse, University of Edinburgh

California State University East Bay

Carlos Bee Boulevard,

Hayward, CA 94542

1 510-885-3000

matthew.atencio@csueastbay.edu

University of Edinburgh

Charteris Land

Edinburgh

44(0)131 651 6614

nicola.carse@ed.ac.uk

Corresponding email: Mike.Jess@ed.ac.uk

Abstract

While complexity thinking features increasingly in the education and physical education literature, there remains a paucity of research presenting evidence of the influence that complexity principles have on learning. We further advocate that more work with complexity thinking is required to investigate how teacher educators engage with key complexity principles in their work with students and teachers. Accordingly, in this paper we investigate how one group of teacher educators, the Developmental Physical Education Group (DPEG), have grappled to develop their own knowledge of complexity thinking while concurrently attempting to support students and teachers in their efforts to apply these principles within local schools. Employing methodology from self-study, the paper provides data from two focus group interviews carried out in 2012 and 2014 in which six members of the DPEG discuss how they wrestled to understand, share and support the application of complexity thinking in practical contexts. In particular, the paper explores how the group members worked with complexity principles such as self-organisation, emergence, and ‘the edge of chaos’ to develop innovative pedagogical strategies with children, students and teachers. Findings from the study reveal how all members of the DPEG, in their initial engagement with complexity principles, raised questions about their personal approaches to the teaching and learning process but also struggled to use the principles to inform their practice. Two years later, however, as the group’s confidence with complexity thinking grew, the members had created a shared understanding and language around complexity thinking, were more comfortable debating issues around complexity and also describing how key principles had impacted upon their pedagogical strategies in practical settings.

Key Words: Complexity Thinking, Teacher Education, Primary Physical Education, Self-Organisation.

Introduction

Since the turn of the century, ideas from complexity thinking have increasingly featured in the education literature (e.g. Mason, 2008) and, more recently, in physical education (e.g. Ovens, Hopper & Butler, 2013). With this increased attention, there is undoubted interest in complexity thinking as a way of describing the emergent and nonlinear nature of the learning process (Morrison, 2010). Yet, despite this shift calling for the place of complexity thinking across education, few academic conversations have centred upon the practical implications of complexity thinking for teacher educators. While the implications *for* complex thinking in physical education have been raised in terms of teacher education programmes (Hopper, 2013), little research has focussed on *how* teacher educators themselves have deliberated upon principles from complexity thinking. We suggest therefore that more insight is needed to understand how teacher educators negotiate and employ complexity thinking in their work. In particular, as these practitioners are often affiliated with *both* schools and universities we suggest their position offers them the space to explore both the conceptual and applied possibilities of complexity thinking.

Accordingly, in this paper, we investigate how a group of teacher educators from the Developmental Physical Education Group (DPEG) at the University of Edinburgh have made efforts to understand and apply complexity thinking in their primary physical education work. To set the study in context, we first introduce the DPEG and discuss how its members have progressed through a “messy” and non-linear journey over many years as they have designed and shared new curriculum structures, pedagogical approaches and professional learning experiences in primary physical education. Then, following an overview of key complexity thinking principles that have increasingly influenced the group’s work, the paper provides focus group commentary from the period between 2012 and 2014. This illustrates how the group attempted to consolidate and extend its theoretical base as it grappled to understand and apply ideas from ecological and complexity thinking, namely self-organisation, emergence, non-linearity, ambiguous boundaries and “edge of chaos”. In a critically reflective manner, the paper discusses how DPEG members have sought to develop their personal understanding of complexity thinking whilst concurrently providing support to students and teachers who have attempted to understand and apply these principles in school contexts.

The DPEG

The DPEG is a group of physical education and primary teachers who have transitioned into the role of teacher educators. The group's goal is to design an innovative and integrated theory/practice approach to curriculum, pedagogy and professional learning within primary physical education and beyond (Jess, Keay & Carse, 2014). The group initially came together in 2001 following a successful grant application by the lead author to the main Scottish sport agency, sportscotland. The remit for this professionally-oriented project was to develop a movement approach for children aged between 5-7 years: "Basic Moves" (Jess, 2004). Focussing on these early childhood years was considered an important starting point because this age phase represented the key foundation period for children's physical education. Originally consisting of one lecturer (Mike¹), a seconded primary physical education teacher and a part time research assistant, the group expanded from 2006 onwards when a substantial grant was secured from the Scottish Executive² to develop a postgraduate physical education programme for primary teachers. By 2011, the group consisted of two lecturers (one of which was Mike), a postdoctoral researcher (Matthew), three full-time PhD students (one of which was Nicola), three teaching associates and an administrator. Since then, while most of the group remain at the University of Edinburgh, others have moved to different lecturing, teaching and management posts across Scotland, England and the USA. Consequently, the group's development efforts are now more varied as members continue to work together whilst also collaborating with colleagues across the world. As we discuss later, six DPEG members, with between seven and fifteen years' affiliation to the group, are involved in the collaborative self-study reported in this paper.

Moves towards complexity thinking

The DPEG's initial development efforts had a specific professional focus and were primarily informed by developmentally appropriate principles from the North America literature (Bredenkamp & Coppel, 1997). The project, "Basic Moves", was a holistic movement approach for five to seven year olds designed to integrate fundamental movements with the cognitive, social and emotional development that supports learning within physical education and across the curriculum. As such, "Basic Moves" set out to extend children's learning in physical education beyond technical movement acquisition to include the adaptability and

¹ Throughout the paper the authors will be referred to as Mike, Matthew and Nicola. All other DPEG members' names will be pseudonyms.

² The Scottish Executive was renamed the Scottish Government in 2007.

creativity that supports participation in lifelong physical activity. In addition to these curriculum efforts, the group's associated professional learning activities initially concentrated on collaborative activities within the group itself but, in its efforts to disseminate the approach widely, these activities soon evolved into large scale professional development courses delivered in a short, top-down and off-site manner (Atencio, Jess & Dewar, 2012).

By 2005, with the group's development activities expanding quickly, members of the DPEG were conscious of the theoretical and practical limitations of this work. From a "Basic Moves" perspective, the group struggled to theoretically explain the concurrent focus of this approach on technical features of fundamental movement patterns and the development of children's adaptability and creativity in their movement repertoire. This theoretical conundrum was exacerbated when the group attempted to extend its curricular efforts to both the pre-school and upper primary years and, accordingly, present its views on physical education to university students and teachers. In addition to these curricular issues, while the group's professional development courses attracted high numbers and reached many parts of the country, the method of delivery that treated teachers as passive recipients who were expected to return to their schools as change agents with little or no ongoing support, was proving problematic. In its excitement to disseminate "Basic Moves", the group had taken on the role of 'experts' and was making decisions *for* teachers, not *with* them, thus reflecting the top-down teacher development perspective that has been shown to have limited impact on practice (Armour, 2004). Unable to theoretically explain key elements of "Basic Moves" and recognising the shortfall of its adopted professional development approach, the DPEG acknowledged that a change in its theoretical and delivery approaches was needed.

In addition to these initial instances of 'dissonance' (Chow & Atencio, 2012), the need for change was highlighted when, in late 2005, the DPEG made a successful grant application to the Scottish Executive with the University of Glasgow to develop a postgraduate PE-CPD programme for primary teachers. While this project led to additional DPEG staffing it also necessitated the design and delivery of a programme for primary teachers focussed on the pre-school, primary and early secondary years. With the group's early childhood focus extending across a wider age range, the limitations of its initial development efforts were more apparent. However, while acknowledging a need for change was relatively easy, as we later exemplify, locating, negotiating and enacting a new theory/practice approach to our work proved to be a drawn-out and "messy" process.

Discussions with internal and external colleagues, alongside engagement with contemporary literature, led to useful, but largely disconnected, ideas from ecological theory, dynamical systems, social constructivism and situated learning being adopted by the group. As the group grappled to apply these different theoretical principles across its various curriculum, pedagogy and professional learning activities, it was ideas from the ecological perspective that began to integrate the group's thinking. While all group members were aware of the ecological ideas informing contemporary motor control developments (e.g. Newell, 1986), it was only when similar ideas were identified in the sociological literature (e.g. Rogoff, 1990) that the group's thinking became more integrated; specifically, recognising that behaviour emerges from the interaction between the individual, the task and the different layers of the environment. This theoretical vision not only helped describe factors influencing children's movement development but was also used to explore factors impacting on interactions within classrooms, schools and the wider policy community. For the first time, a collective theoretical perspective was helping the group view and reflect upon its work in teacher education. However, although this ecological frame informed the DPEG's work, it proved to only be the beginning of a process that would lead towards an engagement with complexity thinking. While ecological perspectives helped DPEG members understand the complex nature of their curriculum, pedagogy and professional learning efforts, it was soon apparent that the frame could only be used as a descriptive tool and offered few suggestions on how best to move things forward.

Given this moment of stasis, then, complexity thinking subsequently came to ground the work of the DPEG. Sharing his theoretical predicament with his PhD supervisory team, it was suggested to the Mike, who was also the lead of the DPEG, that complexity thinking may be a useful lens through which to view his research and development efforts. Although there was no evidence of physical education literature on complexity thinking at the time, and only a limited number of education texts (e.g. Morrison, 2003), numerous disciplines were now viewing complexity thinking as an umbrella term that could incorporate concepts from chaos theory, dissipative structures theory, complex adaptive systems, dynamical systems, situated perspectives and ecological theory. With the DPEG seeking a mechanism to integrate principles from different theoretical perspectives, complexity thinking appeared to be an attractive proposition to help the group underpin its work in a more coherent manner.

Between 2007 and 2011 Mike and Mathew negotiated the expanding complexity literature in education and concomitantly integrated complexity principles with the ecological frame.

Subsequently, Mike completed a PhD that used self-study to explore the possibilities of a ‘complex ecological approach’ in relation to his primary physical education work over twenty-five years (Jess, 2011). In addition, a number of academic papers and conference presentations describing the group’s existing curriculum and professional learning efforts from a complexity thinking perspective were generated (e.g. Jess, Atencio & Thorburn, 2011). However, while this academically-focussed work helped explain how complexity thinking could be used to present a detailed description of the DPEG’s development efforts, the attention being placed on the application of complexity thinking in the design and delivery of the group’s work was less evident. This was a particularly pertinent point as various authors had suggested that, while complexity may help describe events over time, it may be less effective in offering guidance for future practice (e.g. Morrison, 2010).

Subsequently, in late 2011, following Mike’s completion of his PhD, the group decided to more overtly use complexity and ecological principles in its development work. While this seemed a logical step, with a distinct lack of applied examples in the literature, initial efforts to present complexity principles to teachers enrolled on the postgraduate programme caused unease. Although the teachers acknowledged the logic of the complexity narrative, they were less clear about how the complexity principles would inform their physical education practice. In June 2012, recognising there was much work still to be done to apply complexity principles, six members of the DPEG took part in a focus group interview to discuss how each member of the group was personally engaging with this “complex ecological approach” in terms of their thinking and their practice. The focus group stemmed from the complex ecological research project that was approved by the Moray House School of Education Research Committee. However, before presenting the study, the paper focuses on the key ecological and complexity principles that informed the DPEG’s work at this time.

Complexity Thinking

As a relatively new theoretical perspective, a feature of the complexity thinking literature has been the range of different approaches and language presented. However, most views on complexity have their basis in a number of key tenets. From our perspective, complexity

thinking is best described by explaining the difference between two different types of system: complicated and complex (Osberg, Doll & Trueit, 2009). While both types of system consist of multiple interacting parts, they function in different ways. The parts within complicated systems are pre-programmed and work in a linear manner that leads to outcomes that have a high degree of certainty, while the parts within complex systems self-organise as they interact internally and externally with the environment. Complex systems, therefore, offer a different view of order and structure because they accommodate the co-existence of predictable and unpredictable outcomes (Biesta, 2010). Complicated systems are therefore stable entities, while complex systems have the potential to be adaptable and creative. From a learning perspective, complicated systems therefore mirror more traditional ideas associated with positivism as they present a centrally-driven, cause and effect approach, while complex systems connect more readily with postmodern thinking and recognise the need to better understand and support a learning process that is self-organising and emergent (Morrison, 2010). At its root, complexity thinking represents a paradigm shift for education because it views the learning process as unpredictable and non-linear and, as such, cannot be explained by more traditional rational models (Storey & Butler, 2013).

Building on this key tenet, the DPEG's engagement with complexity, as noted earlier, came from ecological thinking but then developed to include the complexity principles of self-organisation, emergence, non-linearity, ambiguous boundaries and "edge of chaos" (Jess et al, 2011). As we noted earlier, the ecological perspective links to complexity in that it represents a relational view of behaviour: a view that sees behaviour emerging from the interaction between the individual, the task and the environment in which the task is attempted. From this ecological starting point, complexity thinking highlights how, as learners engage in multiple interactions, they self-organise to create different behaviours and a non-linear learning trajectory. When interactions are repeated often the emergent behaviours may become predictable, while less frequent interactions may lead to behaviours that are more unpredictable. Concurrent with Davis & Sumara (2010), we recognise the co-existence of predictability and unpredictability as important features of complex systems and the accompanying learning process.

Further, as learners engage in these multiple self-organising efforts, they constantly interact with the ever-changing boundaries generated by the ecological components i.e. boundaries within the individuals themselves, the tasks attempted and the immediate and wider environment. For example, young children entering a gymnasium for the first time and being

asked to perform forward rolls will respond by self-organising on the basis of their previous experiences of this task, their interpretation of their physical attributes, their motivation, the response of classmates, the teacher's pedagogy, the equipment and numerous other boundaries. Critically, as they respond to the task in relation to the boundaries individual children will not react in a pre-programmed way but in their own self-organising manner: hence the concept of ambiguous boundaries.

This ambiguity can be observed as different children's self-organising behaviours result in a range of different outcomes. Responses far beyond the boundaries often result in errors, those around the boundaries can represent challenge and those well inside the boundaries may be safe, successful and consolidate behaviour. However, while this consolidating approach is an important part of the learning process, simply repeating one response consistently will likely lead to stagnation, sameness and the inability to be adaptable. Consequently, working around, or close to, the boundaries is termed the 'edge of chaos' (Morrison, 2003) and often leads to the learner being "constantly poised between order and disorder (and) exhibiting the most prolific, complex and continuous change" (Brown & Eisenhard, 1997, p. 29). In many instances, the more a child moves around the 'edge of chaos', the more likely they are to be "creative, open-ended, imaginative, diverse and demonstrate rich behaviours, ideas and practices" (Morrison, 2003, p. 286). As such, children's self-organising responses to these boundaries over time are a mix of errors and creative successes, consolidation and stagnation and challenge and pressure: all of which represent key features of the learning process. As complex systems, they function within boundaries that regularly change and are "continuously transformed through the interaction of the elements" (Olsen, 2008, p. 107), and are "neither entirely fixed nor chaotic" (Davis & Sumara, 2006, p. 149).

As we now discuss, as the academically-oriented work of the DPEG was increasingly informed by complex ecological thinking, the group members set out to explore the extent to which these principles were influencing their thinking and practice as teachers and teacher educators.

Methodology

Throughout the DPEG's initial period of working with complexity thinking described earlier in this paper, the group was constantly engaged in informal conversations about complexity thinking in relation to research and teaching. These informal conversations subsequently led

to the group wanting to have a more collective, in-depth discussion regarding negotiating, sharing and implementing complexity thinking principles. In response to this reflection we initiated qualitative research intended to capture the perspectives and practices of the group over an extended period of time. In essence, we wanted to discern how the nature of this theoretical lens had shaped the group's professional knowledge and practice. In line with complexity thinking, the purpose of initiating this conversation was not to linearly ascertain “certainty” through “final” conclusions about how this theoretical lens could be used in the “best” manner. Moving away from this instrumentalist approach, we followed Cuenca (2010) and wanted to utilise the “self-study” methodology in order to openly reflect upon and capture the emergent and shifting nature of complexity “knowledge” that had been collaboratively developed through the work of the DPEG.

Self-study focuses on the process of transformation emerging at a personal and professional level (Garbett, 2011). Accordingly, the research reported in this paper has been built around an understanding of the DPEG members' teacher and teacher education practices, challenging them to describe, articulate and share in meaningful ways how their knowledge of teaching and learning has developed over time (Loughran, 2006). In line with features of self-study methodology we enacted a form of collaborative inquiry to critically reflect and deliberate upon the group's fundamental views about the means and ends of their work as teachers and teacher educators as they endeavour to understand and enact theory (LaBoskey, 2004). Drawing on self-study supported a more thoughtful research investigation guided by the following research question: What are the views, experiences and practices of a Scottish physical education teacher education collective that has been involved with using complexity thinking principles? Through this paper we focus particularly on sharing the views and experiences of the collective as they grappled with theory.

This paper draws upon qualitative data derived from two focus group interviews conducted with DPEG members. Both focus groups were conducted with six DPEG members—Mike and Nicola and Louisa, Juliette, Zoe and Luke (pseudonyms). Prior to their involvement in teacher education the focus group participants had all worked in schools – Louisa, Juliette, Zoe and Mike as primary physical education teachers, Nicola as a primary teacher and Luke as a secondary physical education teacher. At the time of the focus group interviews the participants were involved in a range of roles within university contexts in relation to teacher education (see Table 1). The two focus group interviews were conducted in June 2012 and June 2014 and were recorded using a Dictaphone. The interviews lasted for around one and a

half hours respectively producing around thirty pages of data each once they were transcribed. Similar to unstructured interviews, the aim of the focus groups was to allow conversation to flow freely (Cohen, Mannion & Morrison, 2007). However, it was also noted that to tie in with the research question the conversation would require some focus. Therefore, while no interview schedule was used, to retain focus, Mike facilitated the focus group interviews with prompts in relation to how key tenets from complexity thinking were conceptualised and implemented through practice. This approach follows the views of Cohen, Mannion and Morrison (2007) who advocate that a balance must be struck between open-endedness and directionality; in this regard, skilful moderation is required to promote conversation, reflection and thinking.

INSERT TABLE 1 HERE

The first focus group was designed to capture the teacher educators' initial understanding regarding complexity thinking related to their pedagogical thinking and practice in various educational contexts such as schools and universities. The conversation was open in the beginning stage to allow for open reflection from the participants:

Mike: So it's just a general question – how do you feel that this approach (complexity thinking) has influenced your thinking about PE?"

As the focus group progressed the facilitator used more specific prompts in relation to key complexity tenets to guide the conversation more specifically down a complexity thinking route. As the facilitator of the focus group, Mike was very conscious of not dominating the conversation and within the transcript it is evident that he only interjected into the conversation to summarise or further prompt the discussion, for example: "What were you as the teacher doing in complexity terms?"

The second focus group was implemented two years later in order to provide time for participants to immerse themselves further in their respective teacher education endeavours, which included school and university teaching, workshop and seminar facilitation, programme development, and further research efforts such as academic conference presentations and research publications. It was assumed that the teacher education efforts enacted over two years since the first focus group would provide the participants with additional "deep" and "rich" experiences that could be subsequently unpacked in the second focus group. Following up on the initial themes discussed in the 2012 interview, the 2014

interview used a conceptual paper Mike and Nicola had written as a stimulus for continued discussion of complexity principles. Within the interview each group member discussed how their understanding and application of complexity thinking had progressed over the past two years.

Considering the validity of the research the data from the interviews were analysed by the three authors of this paper; this contributed to validity of the research process as it brought multiple perspectives to the data from the facilitator of the focus group, a participant and a member of the DPEG who had not contributed to the focus group (Cresswell & Miller, 2000). Drawing on self-study, the focus of the analysis was to make sense of the information as teacher educators ourselves who were simultaneously immersed in using and researching theory (Garbett, 2011). The three of us first approached the data transcripts individually in both Summer 2012 and Summer 2014, over the preceding months we then shared our individual analysis with each other to begin to establish commonalities and differences from our analysis. We drew on a grounded approach to code the data identifying emergent themes (Boeije, 2010) in relation to the groups understanding and use of complexity principles. As we searched for connections and patterns across the themes found within the transcripts; these interactions allowed validation of experiences and ideas (Denscombe, 2007). Analysing the data both as individuals and then as a collective enabled the identification of reflections and practical examples from the interviews that illustrated how the DPEG had developed their understanding and use of complexity thinking over the two years between focus group interviews. The discussion below focuses on one of the main themes that emerged from our analysis of the data which was the shift in confidence of the DPEG over the two year period which captures how we have grappled with our understanding, application and sharing of theory within our teacher education work.

Group Members Retrospective on their Initial Engagement with Complexity Thinking

While enthusiastic about using this theoretical frame as the starting point for their applied work, the discussion revealed that group members were still seeking clarity about the complexity principles themselves. It was apparent that the sharing of complexity thinking had been gradual over these initial years; as Juliette said, this was done in a '*drip, drip, drip*' fashion. While the academic conceptualisation of complexity thinking had gained momentum during these years, collaborative efforts to support the application of these ideas in practice had trailed behind. Quennerstedt et al. (2014) contend that despite the emergence of new

curricular perspectives under complexity and ecological thinking, there is a lack of empirical research examining how and what occurs in practice. Consequently, the focus group revealed how the language and the concepts of complexity had initially been difficult to understand. This point was stressed by Zoe when she noted that: *“I found it quite hard to get my head into it in the beginning. I remember conversations we had around what is emergence? And what is self-organisation? And I think we grappled and it took a wee while to try and understand”*. Therefore, while the academic writing projects had articulated a link between complexity and curriculum, applying complexity in practice seemed some way off because the DPEG members were working through their understanding of the key concepts.

It was apparent from the first focus group that complexity ideas had disrupted all of the group’s thinking leading them to question their views on teaching and learning. For example, Nicola reflected on how, as she engaged with complexity, she realised that *‘learning is long term’* and noted that *“when you reflect back, you realise that learning in the past was so short-term – “Here’s your learning outcome for your lesson. I’m going to tell you the success criteria and this is what it’s going to be like”*. Through analysis of examples of practice provided by the group it was possible to identify complexity in situ, as the following example from Luke demonstrates. He describes the adaptable way he had approached much of his teaching, where he *“used to plan the start (of the lesson) and whatever, however [as] the kids responded to each other or to me, the lesson progressed from that point onwards in whatever direction that was most relevant. So, again, I’m not saying I didn’t plan any lessons, but I was just quite amenable to change or adapting to what was happening in front of you, rather than having a clear, set structure that you must follow no matter what”*. In another example, complexity also seemed to help Zoe recognise how she had almost unwittingly adapted her teaching to fit the children’s needs and abilities. She highlighted that *“although I gave the spaces to self-organise, to practise – we’re now saying self-organising – I didn’t probably appreciate the importance of how I would sort of tailor that practice, sort of modify that practice, i.e. the types of spaces I was going to give them.”*. Although the group may have lacked confidence in deploying complexity in practice, it appeared that they had started to draw upon these ideas to reflect on their teaching.

As the focus group discussion progressed, it became apparent that two complexity principles, self-organisation and emergence, were impacting most significantly on the group’s thinking. For Nicola, coming to understand the concept of self-organisation was like *“a light bulb went on because it helped me understand why I could do the same thing with the same number of*

children and they would all come up with different answers. So the self-organisation and emergence just made sense and it was like, “Yes, that’s why”. She also reflected how these principles could provide for a more facilitative teaching approach: ‘the self-organisation and emergence says it all, because they self-organise and they... they do things their own way and you can kind of...it’s more...you...you can’t control it, but you can kind of facilitate’. Similarly, discussing self-emergence, Zoe revealed how she began to view teaching from a different perspective:

By understanding that children are self-organisers and that their learning is emergent, I’m actually going to start here and I’m going to say, “Right, let’s have a look and see what you can do first”, which allows you to approach it in a different route and that all the children will do things differently. Now, I didn’t do that before”.

Contrastingly, Luke grappled with how self-organising and emergent learning might impact upon the place and role of the teacher. Luke’s concern was that the teacher may ‘disappear from view’ or ‘go underground’:

I know that the learner as a self-organising being, that’s fine, and I know to some extent that’s what happens a lot of the time in classes... but I just also think that, at times, if we talk about education in that sense, it’s almost presenting the teacher as if they’ve not really got an awful lot to give and sometimes I still think that, at times, the teacher’s still got a place. ... I sometimes think that there’s been too much discussion – not here, but outside, in literature and things – too much discussion about learning and not that much discussion about teaching or pedagogy or whatever else. So just not to marginalise the teacher.

Following Luke’s cautionary view, discussion ensued around how incorporating complexity principles would require skilful teaching. Juliette noted how this new vision would require teachers to have “*a whole set of different skills*”. Mike also added that it was actually ‘*the professional skill of the teacher to be able to open and close the boundaries, or to change the nature of the tasks*’.

Taken together, these comments reveal that although complexity thinking had initially been difficult to ascertain, the group was able to debate key concepts such as self-organisation and emergence, and demonstrate how this had contributed to their continued development as

reflective practitioners. The implications of this type of complexity thinking-practice integration have been described by Hopper (2013) in terms of challenging ‘traditional and linear assumptions about learning that perennially seem to create theory and practice gaps’ as well as disrupting prevailing ‘expert-to-novice’ teaching modes (p. 165). Indeed, as the group started to view learning as complex, there was a gradual change in the way they approached learning situations. They were more regularly ‘stepping back’, observing and analysing, and beginning to offer children more control over their own learning. As Juliette’s thinking evolved, for instance, she began to amend her practice and “... *had to relinquish some of the power to the kids, so that there were quite a few wobbly times there*”, while Louisa felt compelled in: “*trying different things and different approaches*”. In fact, as Juliette began to amend her practice she commented that ‘*if I had this knowledge 30 years ago, 30-odd years ago, when I started teaching, the knowledge that I have now, my vision would have been quite different to what it was then*’.

The first focus group revealed a learning trajectory for the DPEG's engagement with complexity thinking and provided a foundation for future applied efforts, building on the connections between complexity principles and applied examples from their teaching experiences. While progress in applying these principles in current practice was relatively limited, the group members had cognitively and emotionally invested in the key tenets of complexity thinking. The challenge was now to refine their understanding of complexity thinking and more overtly apply the key principles.

“You’ve got to be quite brave”: Applying complexity

By the end of 2012, the make-up and focus of the DPEG had evolved. While most members remained in Edinburgh, the group had gradually taken on features of the rhizome plant (Guerin, 2013), a metaphor often used in complexity (e.g. Davis, Sumara & Luce-Kempler, 2008). Some group members moved away to take up new posts as university lecturers in Scotland and Singapore and, while they remained in contact with Edinburgh, semi-independent nodes evolved as complexity thinking was shared in new contexts. This dispersing process was increasingly non-linear as complexity ideas continued to evolve in Edinburgh, but were shared with group members who were negotiating and sharing their thinking in international contexts (e.g. Atencio et al, 2014).

Following on from the first focus group between 2012 and 2014 in Edinburgh, the group began to concentrate on the application of complexity thinking in its teacher education work,

particularly with teachers enrolled on the PgCert. Concurrently, Mike and Nicola collaborated with a new associate member to consolidate the group's thinking by designing a complexity-informed framework as a catalyst for future primary physical education projects (Jess et al, 2014). With the group now involved in proliferating application efforts, this framework acted as the basis for a second DPEG focus group in June 2014. As with the previous interview, this discussion set out to track how the group's complexity thinking and practice had evolved in the intervening two years.

While the initial focus group revealed a tentative relationship with complexity thinking, the group members were now more confident, more specific in their understanding, and more focussed on sharing their thinking. As the group more readily discussed a wider range of complexity concepts, they used words like *'brave'* (Juliette) and *'relishing'* (Louisa) to describe recent experiences of applying complexity in practical contexts. In addition, the group was also aware they had previously talked less about sharing complexity and had concentrated on their own individual experiences. This point was captured by Zoe when commenting that she had been initially *"more focussed on starting to understand how the principles could be used in relation to me and how my career had evolved and where my thinking was."*

From the subsequent discussion, the group talked with increased confidence about their use of complexity principles in their work. For example, Nicola, now a teacher educator at another University in Scotland, noted that complexity, *"...guides what I do within PE, it guides what I do working with primary education students. I'm always thinking about the task individually...I'm always thinking about the complexity principles and thinking about how that can be applied"*. Luke, now a University teaching fellow, suggested he had overcome his initial hesitancy about displacing the teacher's role through complexity thinking and stated that the principles may have given him *"... a bit of confidence just to let things go from time-to-time. So I think useful concepts, useful ideas and a useful lens to see things, help us to understand things."* Further, reflecting on her work in schools with children, Louisa now confidently embraced key complexity principles: *"the self-organisation and the emergence, it's been a real eye-opener for me to be able to watch my children almost from a different lens and just widen the lens ... and widen the opportunities of the tasks that you give the children, and just to see what actually does emerge...what learning does emerge from just giving a variety of different tasks"*. Two years later and the DPEG members were now more confident and demonstrative about complexity as it impacted upon their practice.

It was in their applied work with teachers and students that progress seemed to have been made by Edinburgh-based DPEG members. For example, reflecting on her professional development work with teachers, Juliette was delivering courses differently based on complexity thinking because it *“.... gives me enough confidence to actually delegate a lot of the stuff to the people who come along so that they can find their way through the complexity of it, the maze that is all of these things”*. With specific reference to her outdoors work with teachers, she enthused that *“without doubt what emerges there is unpredictable, it's very open-ended and you've got to be quite brave in the early stages and that's what I usually say to teachers who come on training, that you really have to be brave and step back and let the learning emerge, let the children self-organise and do all of these things.....the outcome is much richer for the bravery”*. Zoe, now lead officer in a local authority, also reported how she was working differently with her primary teachers: *“In relation to the teachers I'm working with at my school and with the teachers throughout the authority the principles, particularly self-organisation, emergence, “edge of chaos”, recursive elaboration and feedback, feedback loops, are really helping me to look at the learning process for them.”* She was now able to *“step back and think about the sort of things that are going to help them to learn, not giving them ‘tips for teachers’ but helping them to learn as part of a journey.”* We suggest these observations diverge significantly from those offered in 2012 as they highlight the group’s growing knowledge, confidence and ability to articulate the change process in practice. This gain in confidence was also highlighted in Nicola’s efforts to collaborate with new colleagues by *“talking to them about complexity theory and sharing papers with colleagues there who are beginning to express an interest.”*

This change in practice was also evident in the group’s work with university students, particularly teachers enrolled on the PgCert. While there was agreement that the first attempt to overtly share complexity with these students was overwhelming, recent efforts were much more successful. Louisa enthused about this progress when she noted how the most recent students *“were engaged with complexity theory much more”* and continued by explaining how *“we tried very hard with all the practical that we did to look at the application of theory across the range of games, gymnastics, dance and outdoor learning”*. She then suggested that although this, *“was a difficult journey”* it was still something that she *“would relish entering into again just to develop more of the application of the theory with these teachers and how they're using it with their children.”*

Yet, while all group members noted the appropriateness of sharing complexity principles with the postgraduate students, there was more reticence when considering undergraduates. For example, Luke was “...*just worried ...if we start with too much too soon that we might lose some of the students and they might not be able to catch that back up again if they can't get it*” . Nevertheless, although moving too quickly was a concern, it was apparent that the group members had made strategic amendments to their practice to engage these students. It was revealing how the longest serving members, Louisa, Juliette and Zoe, all highlighted how their early teaching at university had been specific and controlling. Zoe, for example, noted how “*in the beginning we were very much cramming and we were force feeding them and they have to do this and they've got to learn this, they've got to learn that*” while Louisa acknowledged that they had “*wanted to be in control and to be very behaviourist*”. However, this had started to change because, as Zoe said:

we've really stepped back and we understand that it's a small part and it's a process in their learning journey and we understand that they will only be able to take on so much and they will self-organise and they will make decisions about what they're going to do. It's about them and I feel that we're able to still deliver but step back and understand it's them and their learning and they have to go and do it themselves.

In a similar vein, Juliette recognised how the group had “*stepped away a wee bit (and) we're seeing them as individuals more and for some you'll give them that additional nudge and for others you'll pull back because you just know that'll put them onto the “edge of chaos”, so you don't do it.*” These statements signal how complexity thinking was influencing the group’s practices with different cohorts of students.

As the focus group discussion continued, “edge of chaos” became a topic of pedagogical interest in relation to the learning and engagement of students. Louisa, for instance, revealed how she had developed the confidence to set up boundaries that were flexible enough to even allow students to experience failure, as part of sustaining their learning:

[I] put kids into situations or allow situations to arise and happen where there will be kids who'll be unsuccessful. letting somebody experience that whole, “I can't do this” and then getting them as the learner to say, “So what do you need to be able to do to be successful at this?” “Well, I need to do this, this and this better than I do it already.” And I think that is a difficult situation to have confidence as a teacher”.

This significant shift in the group's thinking and practice was further accentuated by Zoe when she said that *“although we all understand the importance of “edge of chaos” in terms of learning, I think again it’s important for the children to understand actually what that feels like and what it means and why it’s important in their practise”*. From being controlling and narrow, the group had gradually approached their teaching from a different complexity perspective: a perspective in which the learners' ability to self-organise, explore possibilities and understand the value of errors in the learning process had become a key focus. While complexity did not present specific guidance in terms of ‘what’ to teach and ‘how’ to teach, it offered a new lens to better understand and support the learning journey of children, students and teachers.

Discussion: Implications for complexity-informed practice in physical education

As discussed earlier, there is a perception that while complexity thinking may be useful in describing educational experiences, it may lack the capacity to influence what future practice may look like (e.g. Morrison, 2010). Physical education scholars such as Tinning and Rossi (2013) have been “drawn to ask whether complexity thinking... has an impact of any significance on the way teachers either think or go about their teaching within the contexts of physical education lessons and programmes of study” (p. 194-195). Therefore, we have taken the view in this paper that there is need to explore the influence of complexity thinking on the sustained work of teacher educators. In relation to this call for applied clarity, we suggest three interconnected findings highlight the impact that complexity thinking has had on both the thinking and the practice of one group of teacher educators.

First, as the DPEG engaged with complexity thinking, each member shifted from a view of learning as a short term and reasonably straightforward process to one that is both long-term and non-linear. This change was both cognitive and emotional as the group began to see children, students, teachers and themselves, as teacher educators, in a different light. As teacher educators, complexity helped them become more aware of the untidy nature of their students' learning experiences and also the lifelong learning and career long professional learning (CLPL) agendas that have become a key feature of education and teacher education in Scotland (Scottish Government, 2011).

Second, complexity thinking acted as an umbrella to integrate the numerous post-modern views of learning that had initially seemed disconnected. From a teacher education perspective, it seemed vital to understand the relationship between the self-organising and

emergent principles and the ever-changing ecological factors. This view helped the DPEG make sense of the complex interaction between teacher agency and the layered contexts in which they worked. As the group continued its engagement with complexity, they gradually began to reflect how their work with students and teachers was informed by the ecological frame and complexity principles, namely self-organisation, emergence and “edge of chaos”. Through this reflective process, it was apparent that the group was now more confident to regularly stand back, observe and analyse learners in context before using their professional judgement to ‘orchestrate’ the best way forward. However, they were conscious that this approach required a different ‘pedagogical repertoire’ to help them create the most appropriate learning experiences for students and teachers.

While complexity may not directly inform teacher educators about *what and how they should teach* in any precise or pre-determined manner, it has helped the DPEG build a more detailed understanding of their learners, more confidently structure next steps and subsequently, we suggest, become more adaptable professionals. Hopper (2013) suggests that this complexity-infused approach provides for more open-ended learning conditions to emerge that go beyond what is initially planned and ‘imagined’ (p. 165).

Therefore, while developing an understanding of complexity has been, and continues to be long-term and messy, the DPEG members are now more confident and invested in articulating their understandings of complexity, and crucially, applying these principles in practice. However, although the group is now more capable and reflective in its engagement with complexity thinking, one final comment from a DPEG member signals the need to continually wrestle with and clarify key concepts in order to integrate complexity thinking with practice. Luke provided a cautionary statement regarding this process, alluding to the continual difficulty of working in an “*emerging self-organising ‘edge of chaos’ sort of way if we haven’t got the knowledge and skills to do that, or the experience to be able to?*”. While the DPEG seems to be moving forward in its thinking and practice, there is a need to provide coherent, meaningful and sustainable support to these teacher educators and others who embark upon a similar complex learning journey. Luke’s final comment illustrates how teachers require significant capacity, experience, time and intellectual space to make sense of complexity principles that will be deployed in practice.

References

Armour, K. M. & Duncombe, R., (2004), Teachers' continuing professional development in primary PE: Lessons from present and past to inform the future. *Physical Education and Sport Pedagogy*, 9 (1), 3-22. doi: 10.1080/1740898042000208098

Atencio, M., Jess, M., & 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 & Sport Pedagogy*, 17(2), 127–144. doi:10.1080/17408989.2011.565469

Atencio M., Chow, J., Tan, W., & Miriam, L., (2014), Using a complex and nonlinear pedagogical approach to design practical primary physical education lessons." *European Physical Education Review* 20 (2): 244–263. doi: 10.1177/1356336X14524853.

Biesta, G. (2010) Five theses on complexity reduction and its politics. In Osberg, D. and Biesta, G. (Eds.) *Complexity Theory and the Politics of Education* (pp. 5-15). Rotterdam: Sense.

Boeije, H. (2010). *Analysis in qualitative research*. London: Sage Publications Ltd.

Bredenkamp, S. & Copple, C. (Eds.). (1997). *Developmentally appropriate practice in early childhood Programs*. Washington DC: NAEYC.

Brown, S., & Eisenhard, K. (1997). The art of continuous change: Linking complexity theory and time-paced evolution in relentlessly shifting organizations. *Administrative Science Quarterly*, 42, 1–34. doi:10.2307/2393807

Chow, J., & Atencio, M., (2012), Complex and nonlinear pedagogy and the implications for physical education. *Sport, Education and Society* 19 (8): 1034-1054. doi: 1080/13573322.2012.728528

Cohen, L., Manion, L. & Morrison, K. (2007). *Research Methods in Education Sixth Edition*. Oxon: Routledge.

Creswell, J. W. & Miller, D. L. (2000). Determining validity in qualitative inquiry. *Theory into Practice*, 39(3), 124-131. doi: 10.1207/s15430421tip3903_2

- Cuenca, A. (2010). Self-Study Research: Surfacing the Art of Pedagogy in Teacher Education. *Journal of Inquiry & Action in Education*, 3(2), 15-29.
<http://eric.ed.gov/?id=ED509048>
- Davis, B. & Sumara, D. (2006). *Complexity and education: Inquiries into learning, teaching, and research*. London: Lawrence Erlbaum.
- Davis, B. & Sumara, D. (2010). Enabling constraints: Using Complexity Research to Structure Collective Learning. In: Butler J & Griffin L (Eds.) *More teaching Games for Understanding: Moving Globally*. (pp. 105-120). Champaign, Ill: Human Kinetics.
- Davis, B., Sumara, D., & Luce-Kapler, R. (2008). *Engaging minds: Changing teaching in complex times* (2nd ed.). New York: Routledge.
- Denscombe, M. (2007). *The Good Research Guide: for small-scale social research projects third edition*. Maidenhead: Open University Press.
- Garbett, D. (2011). Constructivism Deconstructed in Science Teacher Education. *Australian Journal of Teacher Education*, 36(6). <http://dx.doi.org/10.14221/ajte.2011v36n6.5>
- Guerin, C. (2013). Rhizomatic research cultures, writing groups and academic researcher identities. *International Journal of Doctoral Studies*, 8, 137-150.
<http://ijds.org/Volume8/IJDSv8p137-150Guerin0400.pdf>
- Hopper, T. (2013). Emergence in school integrated teacher education for elementary PE teachers: Mapping a complex learning system. In A. Ovens, T. Hopper & J. Butler (Eds.) *Complexity Thinking in PE: Reframing curriculum, pedagogy and research* (pp. 151-163). Routledge: London.
- Jess, M., (2004), *The Basic Moves Manual*, University of Edinburgh, Edinburgh
- Jess, M., (2011), *Curriculum Innovation from a Complex Ecological Perspective: A Developmental Physical Education Case Study*, Unpublished PhD Dissertation, University of Edinburgh

Jess, M., Atencio, M., & Thorburn, M. (2011). Complexity theory: Supporting curriculum and pedagogy developments in Scottish physical education. *Sport, Education and Society*, 16, 179–199. doi:10.1080/13573322.2011.540424

Jess, M., Keay, J., & Carse, N. (2014), Primary Physical Education: A Complex Learning Journey for Children and Teachers. *Sport, Education and Society*. doi:10.1080/13573322.2014.979142.

LaBoskey, V. K. (2004). The methodology of self-study and its theoretical underpinnings. In J. J. Loughran, M. L. Hamilton, V. K. LaBoskey & T. Russell (Eds.), *International handbook of self-study of teaching and teacher education practices* (Vol. 2, pp. 817-869). Dordrecht: Kluwer Academic Publishers.

Loughran, J. J. (2006). *Developing a pedagogy of teacher education: Understanding teaching and learning about teaching*. Oxon: Routledge.

Mason, M. (2008). What is complexity theory and what are its implications for educational change? *Education Philosophy and Theory*, 40, 135-49. doi: 10.1111/j.1469-5812.2007.00413.x

Morrison K. (2003). Complexity theory and curriculum reforms in Hong Kong. *Pedagogy, Culture and Society* 11(2): 279-302. doi: 10.1080/14681360300200174

Morrison, K. (2010). Complexity Theory, School Leadership and Management: Questions for Theory and Practice. *Educational Management Administration & Leadership* 38(3), 374-393. doi: 10.1177/1741143209359711

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*. (pp. 295-317) Amsterdam: Elsevier Science.

Osberg, D., Doll, W. & Trueit, D. (2009). Editorial: Limiting complexity. *Complicity: An International Journal of Complexity & Education*, 6(2), iii–x.

Ovens, A., Hopper, T., & Butler, J. (Eds.). (2012). *Complexity thinking in PE: Reframing curriculum, pedagogy and research*. London: Routledge.

Quennerstedt, M., Annerstedt, C., Barker, D., Karlefors, I., Larsson, H., Redelius, K., & Öhman, M. (2014). What did they learn in school today? A method for exploring aspects of learning in physical education. *European Physical Education Review*, 20, 282–302. doi: 10.1177/1356336X14524864

Rogoff, B. (1990). *Apprenticeship in thinking: Cognitive development in social context*. New York: Oxford University Press.

Scottish Government. (2011). *Teaching Scotland's Future: Report of a Review of Teacher Education in Scotland*. Edinburgh: Scottish Government.

Storey, B. & Butler, J. (2013). Complexity thinking in physical education: game-centred approaches, games as complex adaptive systems, and ecological values. *Physical Education and Sport Pedagogy*, 18 (2), 133-149. doi: 10.1080/17408989.2011.649721