UNIVERSITY OF
GLOUCESTERSHIRE

This is a peer-reviewed, post-print (final draft post-refereeing) version of the following published document, This is an Accepted Manuscript of an article published by Taylor & Francis in Physical Education and Sport Pedagogy on 4 Mar 2019, available online: https://www.tandfonline.com/doi/full/10.1080/17408989.2018.1552675 and is licensed under All Rights Reserved license:

Roberts, William M ORCID logoORCID: https://orcid.org/0000-0001-5736-5244, Newcombe, Daniel J. and Davids, Keith (2019) Application of a Constraints-Led approach to Pedagogy in Schools: Embarking on a journey to nurture Physical Literacy in Primary Physical Education. Physical Education and Sport Pedagogy, 24 (2). pp. 162-175. doi:10.1080/17408989.2018.1552675

Official URL: https://www.tandfonline.com/doi/full/10.1080/17408989.2018.1552675
DOI: http://dx.doi.org/10.1080/17408989.2018.1552675
EPrint URI: https://eprints.glos.ac.uk/id/eprint/6244

Disclaimer

The University of Gloucestershire has obtained warranties from all depositors as to their title in the material deposited and as to their right to deposit such material.

The University of Gloucestershire makes no representation or warranties of commercial utility, title, or fitness for a particular purpose or any other warranty, express or implied in respect of any material deposited.

The University of Gloucestershire makes no representation that the use of the materials will not infringe any patent, copyright, trademark or other property or proprietary rights.

The University of Gloucestershire accepts no liability for any infringement of intellectual property rights in any material deposited but will remove such material from public view pending investigation in the event of an allegation of any such infringement.

PLEASE SCROLL DOWN FOR TEXT.

Application of a Constraints-Led approach to Pedagogy in Schools: Embarking on a journey to nurture Physical Literacy in Primary Physical Education

Roberts, William M., Newcombe, Daniel J. and Davids, Keith (2018) *Application of a Constraints-Led approach to Pedagogy in Schools: Embarking on a journey to nurture Physical Literacy in Primary Physical Education.* Physical Education and Sport Pedagogy. ISSN 1740-8989 (In Press)

Abstract

Background: Oversimplified, reductionist approaches to operationalising Physical Literacy (PL) have been a barrier to the development of a complex, dynamic and embodied understanding of the individual Physical Literacy journey. Further, there has been no appropriate approach that might allow practitioners to integrate Physical Literacy in Physical Education (PE). Whilst popular approaches, such as Teaching Games for Understanding (TGfU) and Game Sense (GS), for operationalising learner-centred and problem based learning, have gained professional traction in the last three decades, the development of a comprehensive theoretical basis to underpin pedagogical principles has been neglected – particularly in Physical Education. Pedagogical approaches grounded in *play* have gained popularity as a vehicle for Physical Literacy development in Physical Education. Despite the prominence of a Constraint-Led Approach (CLA) in sport pedagogy to assist in developing 'the intelligent, autonomous individual' in sport, application to Physical Education is limited.

Purpose: In this article, we propose key pedagogical principles of a Constraints-Led Approach (CLA) in primary physical education, underpinned by the theoretical framework of Ecological Dynamics (ED). Driven by the challenge of designing affordance landscapes for learning, we present our reflections on a recently designed PE curriculum for primary schools, Boing, which could facilitate the development of movement capacities in play based curricula designed to nurture the Physical Literacy journey for individuals. An articulation of support for the key theoretical ideas is provided in this paper.

Design: This is achieved through reflections on the play-based curriculum (BOING) founded on the principles of Ecological Dynamics (ED) underpinning a Constraints-Led approach (CLA) to better serve the implementation of a Physical Literacy focussed Physical Education in a Primary school setting based on key principles for delivery.

Findings: Summarising the findings, the authors were able to highlight the importance of developing key principles for delivering a theoretically informed curriculum that elicits key principles of Physical Literacy. Whilst movement skills are key, these approaches are able to elicit the intended outcomes in learners of confidence, motivation and competence (Whitehead, 2010; 2016).

Conclusions: A CLA affords the theoretical design of a play-based curricula beyond just *play* or *sport* towards purposeful, inclusive learning environments. Practitioners should look to underpin their practice with key theoretical ideas. This paper is of particular interest to those coaches and teachers tasked with designing practical environments for learning beyond the rhetoric of skill development in sport.

Keywords: Constraints-Led Approach; Physical Literacy; Physical Education

Introduction: The importance of a pedagogically informed Physical Education

Developing a pedagogically sound approach to Physical Education (PE) is an emerging concern given that recent reports (All Party Commission on Physical Activity 2014; DfH 2014; UK Active 2014) highlight the extent of physical inactivity in the UK. With regards to children specifically, the Health Survey for England published by the Health and Social Care Information Centre (2013) presents research that shows only 20.3% of children aged 5 to 15 years old are meeting the Chief Medical Officer's recommendation on physical activity levels. Whilst we acknowledge the complex and nuanced factors that impact on health and physical inactivity globally, it is important to consider how a theoretically informed pedagogical approach to PE might contribute to nurturing each individual's Physical Literacy (PL) journey (Green et al. 2018) and contribute to addressing some concerning trends in physical inactivity.

In this paper we articulate the role that a Constraints-Led Approach (CLA) has played in the development of the *Boing* project, a play-based curriculum for primary school PE. Our aim in developing the Boing project (found here at www.boingplaytank.co.uk) was to contribute to the ongoing debate about the importance of physical literacy, by developing a pedagogical approach founded on the theoretical constructs of Ecological Dynamics (ED). Within this paper, we briefly define Physical Literacy, and outline why operationalising PL has been problematic for practitioners. We also provide an overview of the Constraints-Led Approach (CLA) for practitioners new to this domain and finally we articulate our reflections on the implementation of this in the Boing project.

Physical Literacy: Definitions and Operationalising a Pedagogy for Change

Physical Literacy has emerged as an important construct in the debate pertaining to physical activity, health and well-being in recent times. Previous attempts to define physical literacy have resulted in an oversimplification of the concept (Whitehead 2010) and reductionist definitions have manifested themselves in an unsatisfactory application of physical literacy in practical settings. A complex, dynamic and embodied definition of physical literacy is required if appropriate learning environments are to be designed by sport pedagogues, something that appropriately fits the concerns of those involved with CLA. A recent systematic review (Edwards et al. 2017) highlighted the value of Whitehead's (2010) definition, seen below:

> *"The motivation, confidence, physical competence, understanding and knowledge that individuals develop in order to maintain physical activity at an appropriate level throughout their life." (Whitehead 2010, 5).*

Hardman (2011) asserts that a physically educated person is a physically literate person. However, as physical literacy increasingly becomes the end goal for physical educators,

Almond (2013a) suggests that physical education content is increasingly focussed on the development of fundamental movement skills and very little else. Almond (2013a, 81) further called for a "thorough debate and the development of a more informed understanding of what is implied by an association of fundamental movement skills with physical education [toward generating] more informed guidance and more clarity in the vision of what constitutes quality physical education". Whilst research into physical literacy development has begun to answer the calls of Castelli et al. (2014) and Giblin et al. (2014) to bolster the empirical foundations of the concept, convincing work is significantly lacking. Moreover, when considering primary school settings, it is important to focus on the relationship between play-based physical education and physical activity levels, engagement and physical literacy development (Coe et al. 2006; Linduer 2002; Taras 2005; Trudeau and Shephard 2008; Yu et al. 2006). This specific focus may help us understand how practitioners can operationalise and deliver a physical education that better serves the development of physical literacy in young people.

Jurbala (2015) has criticised current models of pedagogy in sport and physical education by challenging professionals to adopt physical literacy as an avenue to reject traditional, directive approaches to skill development. Practitioners should embrace the concepts of intrinsic challenge, personal experimentation and discovery, and self-selected risk taking in physically challenging environments. This challenge is important if instead of viewing physical literacy as a brief window of opportunity to become physically literate by the end of formal schooling, physical literacy is in fact seen as a journey (Green et al. 2018) throughout the lifespan extending beyond organised physical education. The importance of physical literacy across the lifespan (Whitehead and Murdoch 2006), establishes a definitional focus on multi-domain development e.g. confidence, competence, knowledge and understanding (Whitehead 2016). More developed multi-stage, multi-domain articulations of physical literacy require a powerful, multi-layered pedagogic framework. There is currently no theoretical framework powerful enough to facilitate implementation of physical literacy within physical education contexts. Such a theoretical framework should provide a multidisciplinary perspective, that supports the individual journey of physical literacy (Green at al. 2018), addressing the relationship between psychological, emotional and physical dimensions of physical activity. One such framework is the theory of ecological dynamics (see Moy et al. 2014; 2015; Renshaw et al. 2010). Current pedagogic approaches for promoting the development of physical literacy tend to be more reductionist through over-reliance on Fundamental Movement Skills (FMS), failing to consider a multifaceted and deeper definition of physical literacy.

Invoking the work of Chow et al. (2007) and Moy et al. (2015) we argue that the "evolution of physical education teaching practice away from the dominant traditional approach" (Moy et al. 2015, 387) requires further attention. Due to a dissatisfaction with a de-contextualised approach to learning in physical education settings it is essential to consider alternative approaches. Such approaches should aspire to ensure all pupils "develop competence to excel in a broad range of physical activities, are physically active for sustained periods of time, engage in competitive sports and activities [and] lead healthy, active lives" (DfE 2013, 1).

Physical Literacy: Physical Education and 'evidence-based' Pedagogy

There are currently very few widely established pedagogical practices or principles that are philosophically consistent with the concept of physical literacy. Dudley (2015) offers a useful discussion relating to observed practices in PL and whilst still worthy of ongoing debate, here we propose how researchers could progress beyond the iteration of philosophical and definitional nuances and provide a framework for application of physical literacy in practice. It is therefore imperative that we establish an approach to designing learning environments that attend to the depth and complexity associated with enhancing physical education. Almond's (2013a) suggestions, discussed earlier, have received support from Vinson et al. (2016, 54) who highlighted that it is "commonly reported that the majority of practitioners remain committed to technically led linear pedagogies". Physical literacy is increasingly becoming the end goal of the means of physical education. Therefore, the importance of developing independent, self-sufficient and innovative learners is an essential component of primary school physical education programmes becomes paramount. Given the importance of school-based experiences in future physical activity, physical education must help learners to build competence and confidence for movement and as a result physical activity beyond the school age (Lee et al. 2017). Renshaw et al. (2010) highlighted the need for those responsible for the pedagogic practice of helping learners develop knowledge and skill, to symbiotically work with research scientists to better understand how to develop "adequate models of skill acquisition in physical education" (Renshaw et al. 2010, 118). This proposal was based on the separate critiques of Hoffman (1990) and Locke (1990) in a special issue of *Quest*, who argued that motor learning research had led to very few empirically verified recommendations for physical educators. Renshaw et al. (2010) highlighted that little had been done since Hoffman and Locke's comment with most assumptions being based on laboratory based, non-representative approaches to skill acquisition in physical education. In particular, one issue highlighted is the lack of work done by pedagogues in collaboration with movement scientists, something we address in this paper. Our direct response to this limitation in extant literature was to develop a curriculum based on a Constraints-Led Approach (CLA).

Academics and practitioners have adopted Games Centred Approaches (GCAs) such as Games Sense (GS) (Light, 2013), Sport Education (Siedentop, 2002) or Teaching Games for Understanding (TGfU) (Bunker & Thorpe, 1986) for the delivery of physical education, arguably without a theoretical basis for their development (but see recent articles in this journal for a contentious debate on this topic). It is arguable that the over emphasis on sport as a vehicle for delivering movement and skill acquisition can be a limiting factor in nurturing the journey of physical literacy, a journey more concerned with the holistic development of participants. In attempting to address the issues of inclusion and physical activity that appear at the forefront of practitioner, policy makers and researcher's decision making, it is important to return to the theoretical basis for practice design.

Ecological Dynamics (ED) and a Constraints Led-Approach – Implications for Practice in Physical Education

Ecological dynamics is a theoretical framework that has evolved by interlacing the theories of dynamical systems and ecological psychology. Which in turn provide the principles of a nonlinear pedagogy (Handford et al. 1997; Renshaw et al. 2010). The ecological dynamics framework emphasises the essential relationship between the learner and the environment as a key foundation of practice design and a theoretical tenet on which to consider skill acquisition processes. Adopting an ecological dynamics approach drives practitioners to conceptualise learners as complex, adaptive dynamical systems, co-adapting with events, objects and significant others in an ever-changing performance environment. Whilst philosophical and theoretical clarity has been provided by the extensive literature in the area of nonlinear pedagogy, there is a significant body of work required to establish the methodological clarity to facilitate its effective application in practice (cf. Chow et al. 2016; Davids et al. 2008; Handford et al. 1997; Renshaw et al. 2009)

A CLA is the practical articulation of key theoretical ideas of ecological dynamics, providing guiding principles for the design of learning environments. A CLA is a well-promoted framework for understanding how humans acquire and organise the necessary actions to successfully engage with sport and exercise contexts (Araújo et al. 2004; Davids et al. 2008; Handford 2006; Renshaw et al. 2010). The CLA articulates that, through the interaction of different constraints - task, environment, and organism -, individuals will self-organise actions, perception and cognitions in an attempt to generate functional movement solutions (Renshaw et al. 2010).

At one level of analysis, it could be argued that a CLA is present in the design of all the practice environments, as the interacting constraints (Task, Environment and Organism) by which the dynamical system organises against are ever present (Newell 1986). However, we would also emphasise that the CLA can be employed both successfully and unsuccessfully, and here lies the crucial issue. As highlighted by academics when referring to other alternate pedagogies, just because we call it CLA does not necessarily mean it is CLA (Reid and Harvey 2014). We discuss some of the practical implications of employing a CLA in a physical education context below.

A Constraints-Led Approach to Physical Literacy and its Pedagogic Implementation

A greater understanding though enhanced self-realisation and how we interact with the world as a physical being has been identified as a key factor in the development of physical motivation and autonomy. As yet there is a paucity of research pertaining to a pedagogical model for physical literacy development. As previously stated current foci tend to surround fundamental skill development (Thompsett, Burkett, and McKean 2014). A move away from approaches with an explicit primary focus on technical development are advocated (Tan et al. 2012). The adoption of a play-based curriculum could be an answer for the holistic

development of physical literacy. However, akin to the nature and philosophy of play, a play-based curriculum has the potential to lack purpose and focus. We propose that the application of the philosophical and theoretical underpinnings of a CLA has the potential to add more purpose to the design of play-based environments. If practitioners are better supported and informed in the successful design of learning environments consistent with the philosophical and theoretical underpinning of CLA they are more likely to facilitate and nurture the development of PL.

In order to design purposeful, playful, rich environments for the children to engage with there is a need for an appreciation of the interactions between living systems, their environments and the reciprocity that has evolved between the two (Kugler and Turvey 1987). An ecological lens is helpful to comprehend why interactions occur and more importantly how these interactions are encouraged (Handford et al. 1997). Most pertinent to this was recognition of the importance of affordances, which are defined by Gibson (1967) as opportunities for action provided by the environment or ecology we exist in. Understanding that affordances are environmental properties (Gibson quoted in Weiss and Haber 1999, 129) available as resources for the individual that can be utilised to regulate behaviour (Silva et al. 2014) was a central concern for us when considering the design of learning environments with functionality in mind (genuine purpose). The analogy that we as human beings would never realise our ability to swim if the opportunity to interact with water was not forthcoming is an important reflection. Essentially, the learner must be offered/afforded the opportunity for interaction when engaging with their environment.

We developed a realisation of the need to ensure that all the environments presented in a curriculum should be meaningful. Each environment must have a specific development focus - that speaks directly to an element of physical literacy - as opposed to unstructured play. As a result, a constraints-led approach (Davids 1999; Newell 1986; Renshaw 2010) was employed within the pedagogical practice of delivering the curriculum, this was to encourage children to engage with their own development when commencing or being on their journey of physical literacy. An approach that is ‘affordance driven’ is a nuance that we feel is a promising facet in ensuring that the opportunities for action are offered in an implicit manner and that decisions to act emerge from continuous interactions with the environment.

We utilised a CLA to design each learning environment in the *Boing* curriculum. Every environment was considered and constrained to offer relevant affordances to each learner. The rules of a game or challenge, the size of the area, the number of children on each team and the amount and size of the equipment were available were manipulated to create environments that implicitly offer the opportunities for action aligned to the chosen development focus.

The *Boing* project: A Constraints Led-Approach – Principles for Learning Design

It was crucial to understand how a play-based curriculum would manifest itself in practice.

The curriculum sought to provide rich learning environments that were playful, accessible and engaging and that could be replicated from school to school with minimal equipment. Moreover, these learning environments were designed so that they provided effective problems for the children and allowed scope for multiple answers to the same problem. The curriculum was developed and defined in context over a period of three years and full access to the curriculum can be found at the following link: www.boingplaytank.co.uk

The following are presented as guiding principles for the application of a CLA in a physical education context:

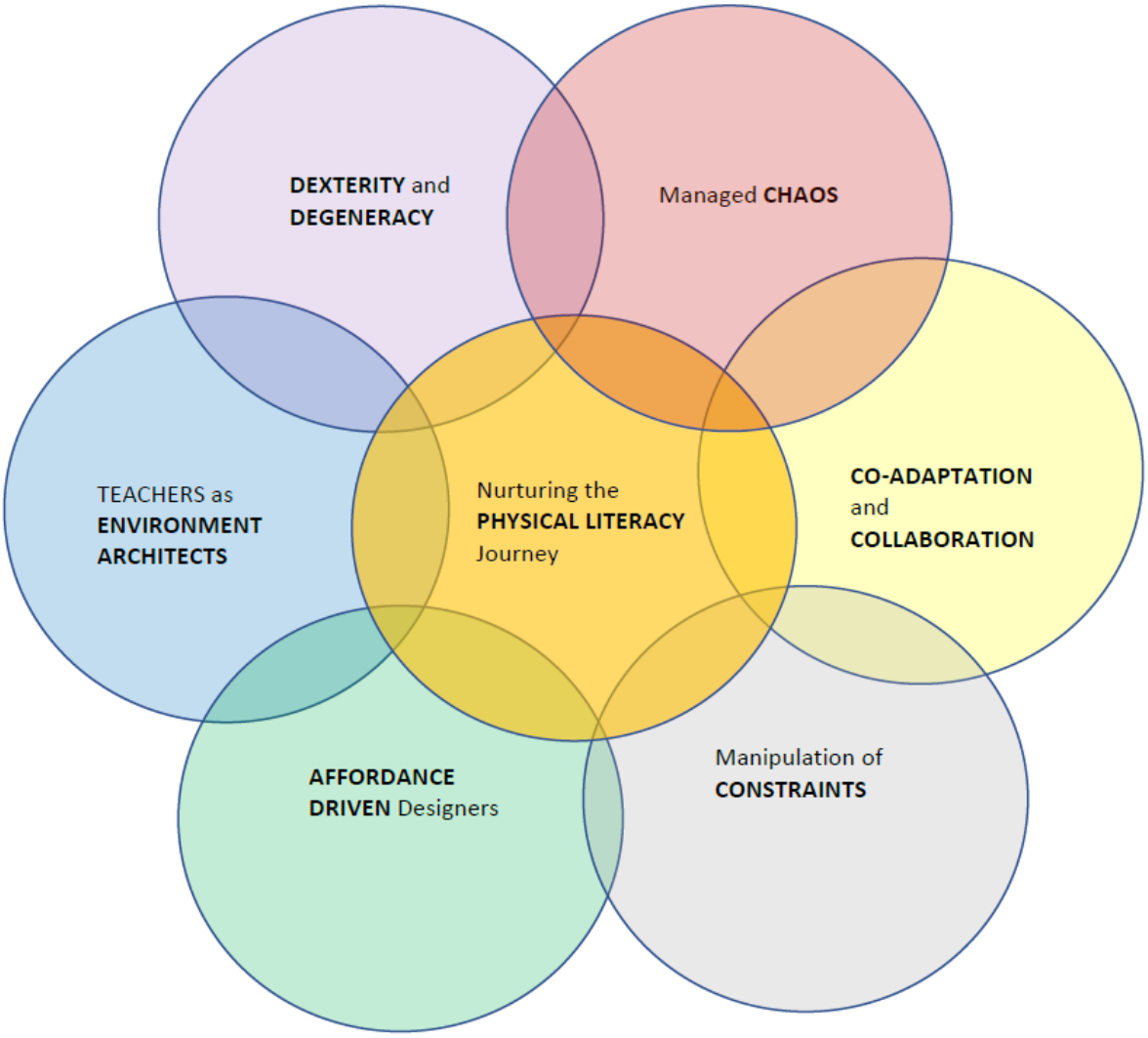

Figure 1. Some Principles for Teachers Implementing a CLA approach to Primary PE

1. Teachers as Environment Architects
2. Affordance Driven Designers
3. Manipulation of Constraints
4. Co-adaptation and Collaboration
5. Managed Chaos
6. Dexterity and Degeneracy

Teachers as Environment Architects

We argue that the role of the teacher as the *environment architect* must be given greater emphasis. This is in contrast and proposed as a challenge to the cliché of considering *the game as the teacher*. Whilst we would agree with the philosophical notions of this mantra it has been associated with developing practitioners with an overly passive pedagogical approach. We suggest that this misinterpretation has led to practitioners being too hands-off. An under appreciation of how nuanced the successful application of a CLA is has led to the provision of vague environments that lack purpose and any form of targeted development. If practitioners are to attend to the development of a learner's physical literacy they need to provide carefully designed environments which offer the desired affordances that adhere to the underpinning theories of ED. In order to ensure the holistic development of children it is important to embrace the embodied nature of physical literacy. It is essential that the learning environment facilitates problem solving during movement regulation. Observing the children engaged in decision making is a sign they are constructing knowledge across many different domains. It is important to ensure that the decisions of when and how to act are stimulated by information for affordances within the environment. If we are seeking children to develop and realise their ability to hop and balance using a single leg landing, we need to provide an environment that facilities the development of this understanding. For example, in the *Bear Hunt* play-game, the task constraints are manipulated to encourage jumping from one disk to another, by carefully placing the disks we can challenge an understanding of which distances they can and cannot move between as a function of the variable distances between spots. Further, the restriction of movement from spot to spot in time with the beat of a drum is another example of developing self-realisation through task constraints manipulation. Success within the environment is characterised by increased self-realisation which is characterised by more efficient and strategic routes being planned and executed by the children.

Affordance Driven Designers

The essential question practitioners must ask is '*does the environment offer, invite and/or encourage learners to explore the opportunities for action related to the current development focus?'* Designing learning tasks through the manipulation of constraints to provide affordances for action requires practitioners to be 'problem setters' who are able to

implicitly invite desired perception-action couplings. The *Affordance Driven* principle postulates that the decisions to act need to come through the learner *choosing* to attune to the information for affordances in the environment. It is vital to consider that the decision about when to act is as important as the action itself and the two must remain coupled to the performance environment. Just because an affordance is available does not mean an individual should use it and knowing when a learner "ought" to use an available affordance is perhaps just as important as knowing how to use it (Heft 2003). In simple terms, well-structured environment design must offer learners the opportunity to move beyond 'what' they must do, and towards an understanding that allows them to construct for themselves the 'how, why, where and when' of movement. This is implicitly linked to the definition espoused earlier with regards to PL (Whitehead 2010) when we consider the knowledge and understanding of movement beyond FMS. The ability to select an appropriate affordance at any one moment is a key part of learning to play. In essence, we need to ask if the answer that the problem elicits regarding the decisions and movements of an individual are the intention of that specific environment. An affordance refers to an environmental property which can be detected as information to support an action. In simple terms an affordance is an *opportunity for action* (Gibson 1967). An affordance driven approach is based on the deliberate designing 'in' (a field within a landscape) of key affordances with which learners can interact during practice (Chow et al. 2016). For example, if a practitioner is designing an environment for the development of a learner's catching and throwing ability the relevant opportunities to act (i.e. throw and catch) must be provided. Practitioners must then move past this common-sense notion and identify for manipulation the important control parameters (key variables that can move the system to a different state of organisation) in the environment (Handford et al. 1997) to create the *need* for the learner to perform that action. In order to facilitate this performance need, the problem must be designed in such a way that successful engagement with the environment is defined by the development of a learner's throwing and catching skills. An effective environment in this context will provide the learner with the opportunity to develop functional perception-action couplings or emergent synergies (coordinated states) needed to achieve the task goal. Put simply, the opportunity and the need to throw and catch objects in a dynamic and decision-rich environment must be provided.

Manipulation of Constraints

If we understand which affordances are important we will be able to manipulate key constraints in a learning environment to support learners in searching for, and discovering, elicit effective solutions to a movement problem. Practitioners can manipulate constraints to shift the learner's intentionality, the development of new bodily attributes (e.g., increased muscle strength, flexibility, postural stability), improved motor skills or through on-going perceptual learning that increases differentiation. It is imperative that practitioners understand that *how* constraints are manipulated is just as important as *whether* or not constraints are being manipulated during practice. The ability to learn to choose the most appropriate affordance at any one moment is a key part of learning to play games; however, in their desire to focus practice there is often a temptation by coaches and teachers to over-constrain practice by introducing rules or restrictions to explicitly *force* 'desired' actions (see

Partington and Cushion 2013). Examples include practices such as the ‘must make 5 passes before scoring’ rule often seen in invasion games. This type of constraint over-emphasises the mere reproduction of an action and misses the key point in invasion games: that learners need to understand the function of a pass to a teammate. Passes are made when needed by a team games performer. The removal of decisions and the opportunity to search for action here can be detrimental to learner development. The simple manipulation of task constraints allowed us to encourage multiple editions of the same problem to occur within the one environment. For example, in the *Kings and Queens* environment, a game based on ‘capture the flag’ we can increase width of the access point by ensuring there are multiple *Kings and Queens* to defend and capture. An interesting observation of this in practice is that the learners will migrate to the iteration of the game they feel most comfortable engaging with, evidence of self-realisation in action.

Co-adaptation and Collaboration

The presence of collaboration in the environment is crucial if we are to attend to a more holistic physical literacy journey for our learners. A learner’s interactions with teammates and opponents within an environment will have the biggest impact on exploring inherent self-organisation tendencies. As learners attempt to achieve their task goal they must collaborate with their team mates by self-organising to satisfy interacting constraints. This continuous process has been characterised as co-adaptation. With each learner’s behaviours constrained by the information from the actions of the other learners in the environment (Passos et al. 2016). Practitioners should avoid setting problems for learners to solve in environments devoid of other learners. Task constraints must be manipulated to provide learners with the opportunity to collaborate and co-adapt. Principle number four was based on the notion of collaboration. The observation of the children working together within the environment was important for the holistic nurturing of the development of PL. It is important for the learners to develop an understanding of how their interaction with others within the environment can impact on both their own development, and upon others. Through the manipulation of task constraints, we shifted the emphasis from individual competition onto collaboration. The environment created by the *Hungry Snakes* play-game is an example of how a game based on the principle of *tag* can be adapted and manipulated to focus on collaboration. Furthermore, joining learners up as pairs in any of the games provided an increased emphasis on collaboration as well as being a useful method for differentiation.

Managed Chaos

Rosser (2008) discussed the notion that complex systems are open to fluctuations and consist of complex chaotic behaviours, and in self-organising to adapt to these fluctuations, the process of pattern-formation is functional. Put simply, the learners in the practice environment will endeavour to make sense of the chaos they are presented with by forming performance solutions via goal directed behaviour. This leads us to the deliberate manipulation of control parameters (via task constraints) to move individuals into less stable

areas and create these phase transitions (Handford et al. 1997). It is proposed that if a system is poised at the edge of chaos (at a point where there are many solutions available for performance) it has the ability to create emergent problem-resolving behaviours (Langton 1990). This tipping point on the edge of chaos is a location of instability for learners, which is useful for them to explore different options. If a system is located in a performance region which is too stable, then the resultant behaviours may be accordingly static, with little demand made on the inherent pattern forming system tendencies. In contrast, any system that is located in a performance region which is always too unstable, it will become inherently chaotic and unmanageable (Davids et al. 2003). If the designed practice task is not capable of providing opportunities for learners to resolve consistent questions, then the system may be too chaotic. For example, if a novice learner is placed into an environment with a large number of opponents and teammates with a multitude of performance outcomes, the information at a localised level could become too difficult to perceive and act upon. The manipulation of task constraints to place the novice learner into a learning situation which is regulated according to skill levels and needs, will result in less information and the potential for better engagement and development within the environment. The manipulation of task constraints such as the number of learners, boundaries and shape, number of objects, and equipment scaling will all have significant impact on the amount of information learners are required to attend to. When designing practices, it is essential that practitioners manipulate the system to be poised at the critical point, *on the edge of chaos* (Bowes and Jones 2006). Increasing the amount of time children spend engaging in the environments will maximise the potential for PL development. Observing the children engaged in constant and active play was therefore one of the driving principles in our environment design process. In order to facilitate constant and active play we aimed to design environments that are more continuous in nature. Environments that require the teacher to initiate the start and the finish of active period were avoided. This was achieved through the manipulation of task constraints to create environments that regenerate on an infinite, continuous loop. If we take the *Foxes and Rabbits* environment as an example, the foxes earn an advantage which sees the game become significantly harder for them, facilitating a shift in momentum back towards the rabbits and vice versa. The design of environments where the instability in the system is constantly shifting is based on the notion that complex systems exhibit tendencies towards stability and instability (Renshaw et al. 2010).

Dexterity and Degeneracy

Bernstein (1967, 228) defined dexterity as the ability to find a motor solution to solve any emerging motor problem correctly, quickly, rationally and resourcefully. He identified the need for flexibility in skill development to encourage learners to seek different solutions to the same or similar problems, thus advocating the need for practice task design to incorporate variability into learning contexts. In neurobiology, this is known as exploring system *degeneracy* (Edelman and Gally 2001). In movement behaviour, degeneracy supports the greater flexibility, adaptability and robustness needed for a learner's functionality during task completion. *Repetition without repetition* is Bernstein's response to the perceived over simplification within the traditional model for skill acquisition and the inclusion of variability. Providing environments which allow lots of problem-solving opportunities is essential in allowing learners to repeatedly search and explore effective adaptable movement

solutions. The presence of functional variability is a hallmark of more skilled performers (Davids et al. 2006) and the generation of functionally variable movement patterns is an important characteristic of skilled learners operating within a dynamic environment. As a result, manipulation of task constraints in practice environments must offer both repetition and variation to facilitate this process (Travassos et al. 2012). Practitioners can purposely manipulate task constraints to increase the variability. For example; i) increasing the number, type (size, weight, surface, colour) of the objects in the environment ii) Providing multiple and varying ball feed and player start positions iii) move past square boxes and varying the size and shape of environments iv) provide multiple iterations of the play-game within the same environment. In summary learners need to be provided with practice task constraints that allow them to explore dexterity in their interactions with the performance environment. Exploration and Exploitation of inherent *degeneracy* is a major goal for learners during continuous effective interactions with key features of an environment, or dexterity.

Reflections on the development of a Play-Based Curriculum with ED and CLA as the Foundational Premise:

As part of a collaborative project with Oxford Brookes University, the authors designed and implemented a Play Based Curriculum based on a constraints-led methodology, underpinned by ecological dynamics in order to facilitate and nurture the journey of physical literacy. The authors used this as *a model of* physical literacy as opposed to *the model for* physical literacy. Remaining consistent with the research to-date in physical literacy we set out to move beyond the reductionist narrative explored by Jurbala (2015) and focussed on the holistic notions of physical literacy in developing a practitioner-friendly curriculum for physical literacy development that removes movement competency from a hallmark of physical education and physical literacy to a by-product.

Our play-based curriculum was an experimental primary school physical education curriculum focused on placing physical literacy development at the heart of physical education. Based on Whitehead's (2010) definition of physical literacy aligned with a CLA we introduced a fully resourced and scheduled curriculum which includes teacher delivery resources, learning outcomes and learning environments to implement in primary school settings. The sole aim of the project was to better understand what a curriculum that revolves around developing physically literate children would look like and to explore the delivery mechanisms through which, such a curriculum might operate.

The aim of our play-based curriculum is clear; to develop fluent movers, confident and creative young people who have a deep understanding and awareness of how they interact with the environment around them. The curriculum works toward this outcome by creating a modular based curriculum that is aligned with key components of the UK national curriculum for physical education but removes sport and skill-based instruction from its curriculum; and replaces this with what we termed *play-games*, games that are focussed on problem solving, child-centred play and learning. A *free-to-teacher's* curriculum was developed and can be found via www.boingplaytank.co.uk for further detail.

To ensure playful encounters with the environment were deliberate and learning oriented within the curriculum, key tenants of problem-based learning were positioned as the parameters of these environments. Problems were set for the children to solve in their own unique way and for the children to explore the multitude of solutions afforded to them. Thus, we started out with the aim of creating a curriculum which provided playful and rich learning environments which provided effective problems for children to solve.

The premise that our embodied sense of self is intimately related to the environment around us (Whitehead 2007) and that a child does not develop independently from their surroundings highlights the importance of focusing on the environments provided for children to develop their physical literacy. The authors fully agree with Whitehead's (2007) notion that the richer this interaction with the world the more fully we will realise our human potential. Therefore, the authors assert that any curriculum that sets out to develop physical literacy ought to provide children with the richest possible environments to engage with. In turn, this will offer the greatest opportunity for the deepening of their awareness and understanding of what it feels like to creatively, confidently and fluently engage with the environment around them (Lloyd 2011).

Conclusion:

It is important to note that it was not the purpose of this paper to provide a model framework for a Constraints Based Methodology for Primary School Physical Education. Rather, our aim is to respond to the growing call for Physical Literacy to be embedded in curricula across the globe by providing some principles by which practitioners might be able to implement appropriate practices and lessons. Nevertheless, it is clear in our message that theoretically informed approaches utilising a Constraints Based methodology could provide a platform upon which to build an individual's Physical Literacy journey.

If indeed physical literacy is concerned with a process of self-realisation (Whitehead 2007) and the perpetual enrichment of one's understanding by the individual from their unique person-environment interactions (Gréhaigne and Godbout 1995) it is important to operationalise curricula and pedagogic approaches that allow young people to develop these skills. Savery and Duffy (1995, 1) note that when "understanding is in our interactions with the environment… [and that] …. we cannot talk about what is learned separately from how it is learned, as if a variety of experiences all lead to the same understanding". The Constraints-Led Approach has afforded us the opportunity to develop a curriculum that encourages problem-based learning (Barrows 1986) and playful pedagogies (Broadhead and Burt 2012). Thus, we started with the aim of creating playful and rich learning environments which provided effective problems for children to solve. These pedagogies proved successful in affording the opportunity to develop their physical literacy and develop a sense of self-realisation. As defined by Whitehead (2007), physical literacy focuses on the embodied dimension of human existence through enriching experience. Moreover, Kentel and Dobson (2007, 159) suggested that "children need time to play freely, to wonder and wander in the environment, to engage the world in their own imaginative ways" in order to develop their understanding and awareness of how they interact with and within that

environment. Thus, the exploratory, flexible and ever shifting experiences within playful environments are well suited to providing the exploration of experience and environmental interaction needed to develop physical literacy. Playful environments, according to Broadhead and Burt (2012), are where children develop their understanding of how the world works and make sense of how they fit within it.

Whilst Physical Literacy as a growing research concern has some interesting facets, it has been argued that the body of literature currently offers little for practitioners in the way of 'how to' achieve the intended outcome. Physical literacy as a concept - and a desired outcome - has become a central aspect of discourse pertaining to physical education (Capel and Whitehead 2012; Castelli et al. 2014; Jurbala 2015; Kirk 2013; Whitehead 2013). Whitehead (2013) articulates this movement by suggesting that whilst physical education is becoming the means, physical literacy is becoming 'the goal to be reached' (Whitehead, 2013 p. 42). Whilst it is increasingly apparent that Physical Literacy is beginning to embed itself into national physical education programs (New South Wales Department of Education and Communities 2015; Sport Wales 2017; United Nations Educational, Scientific and Cultural Organisation 2015) what is not so clear is how practitioners might be advised to deliver these lofty and admirable aims. However, as we have articulated in this paper, the desired next steps must be to mobilise a profession by shifting physical education policy and curricula towards the constraints-led approach to delivering physical education in a way that serves to promote the physical literacy journey. It may be that what is needed by practitioners is not simpler definitions, but more information on what PL-supportive programs look like in practice, principles for which we have outlined in this paper.

References:

All Party Commission on Physical Activity. 2014. *Tackling physical inactivity: A coordinated approach*. Retrieved December 10, 2017, from https://parliamentarycommissiononphysicalactivity.files.wordpress.com/2014/04/apcopa-final.pdf

Almond, L. 2013a. Physical Literacy and Fundamental Movement Skills: An introductory 1critique. *Journal of Sports Science and Physical Education*. Bulletin No. 65.

Almond, L. 2013b. What is the value of Physical Literacy and why is Physical Literacy valuable? *Journal of Sports Science and Physical Education*. Bulletin No. 65.

Araújo, D., Davids, K., Bennett, S., Button, C. and Chapman, G. 2004. Emergence of sport skills under constraint. In *Skill Acquisition in Sport: Research theory and practice, eds.*

A.M Williams and N.J. Hodges, 409 – 433. London: Routledge.

Barrows, H. S. 1986. A taxonomy of problem-based learning methods. *Medical Education* 20: 481–486.

Bernstein, N. A. 1967. The control and regulation of movements. London: Pergamon Press.

Bowes, I., and Jones, R.L. 2006. Working at the edge of chaos: Understanding coaching as a complex, interpersonal system. *The Sport Psychologist* 20: 235-245.

Broadhead, P., and Burt, A. 2012. Understanding learning through Play: Building playful pedagogies. London: Routledge.

Bunker, B., and Thorpe, R. 1986. The curriculum model. In *Rethinking games teaching, eds.* R. Thorpe, Bunker, D., and Almond, L, 7 – 10. Loughborough: University of Technology, Loughborough.

Capel, S., and M. Whitehead. 2012. *Debates in Physical Education*. London: Routledge.

Castelli, D. M., E. E. Centeio, A. E. Beighle, R. L. Carson, and H. M. Nicksic. 2014. Physical Literacy and comprehensive school physical activity programs. *Preventive Medicine* 66: 95-100.

Chow, J.Y., Davids, K., Button, C., Shuttleworth, R., Renshaw, I., and Araújo, D. 2007. The role of nonlinear pedagogy in Physical Education. *Review of Educational Research* 77(3): 251–278.

Chow, J.Y., Davids, K., Button, C., and Renshaw, I. 2016. *Nonlinear pedagogy in skill acquisition: An introduction*. London: Routledge.

Coe, D. P., Pivarnik, J. M., C. J. Womack, M. J. Reeves, and R. M. Malina. 2006. Effect of physical education and activity Levels on academic achievement in children. *Medicine, Science and Sports Exercise* 38(15): 15-19.

Davids, K., Glazier, P., Araujo, D. and Bartlett, R. 2003. Movement systems as dynamical systems. *Sports Medicine* 33(4): 245-260.

Davids, K., Bennett, S., and Newell, K. 2006. *Movement system variability*. Champaign, IL: Human Kinetics.

Davids, K., Button, C., and Bennett, S.J., 2008. *Dynamics of skill acquisition: A constraints-led approach*, Champaign, IL, Human Kinetics.

Department for Education. 2013. The National Curriculum in England: Key Stages 1 and 2 Framework Document. Retrieved December 10, 2017 from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/425601/PRIMARY_national_curriculum.pdf

Department of Health. 2014. Moving More, Living More: The Physical Activity Olympic and Paralympic Legacy for the Nation. https://www.gov.uk/government/publications/moving-more-living-more-olympic-and-paralympic-games-legacy

Dudley, D. A. 2015. "A conceptual model of observed Physical Literacy". *The Physical Educator* 72: 236-260.

Edelman, G.M. and Gally, J. A. 2001. Degeneracy and complexity in biological systems. *Biological Sciences – Evolution.* 98(24): 13763-13768

Edwards, L. C., Bryant, A. S., Keegan, R. J., Morgan, K., and Jones, A. M. 2017. Definitions, foundations and associations of Physical Literacy: A systematic review. *Sports Medicine* 47(1): 113-26

Giblin, S., Collins, D., and Button, C. 2014. Physical literacy: Importance, assessment and future directions. *Sports Medicine* 44: 1177-1184.

Gibson, J. J., *James J. Gibson*. 1967. In *History of Psychology in Autobiography, eds.* E. G. Boring and G. Lindzey, 127–143, New York, Appleton-Century-Crofts.

Green, N. R., Roberts, W. M., Sheehan, D., and Keegan, R. J. 2018. Charting physical literacy journeys within physical education settings. *Journal of Teaching in Physical Education* 37(3): 232–240

Gréhaigne, J-F., and Godout, P/ 1995. Tactical knowledge in team sports from a constructivist and cognitivist perspective. *Quest* 47(4): 490-505

Handford, C.H., Davids, K., Bennett, S. and Button, C. 1997. Skill acquisition in sport: Some applications of an evolving practice ecology. *Journal of Sport Science* 19(4): 321-349.

Handford, C. H. 2006. Serving up variability and stability. In *Movement system variability, eds.* K. Davids, C. Button & K. Newell, 73-83. Champaign, IL: Human Kinetics.

Hardman, K. 2011. Physical Education, movement and physical literacy in the 21st Century: Pupils' competencies, attitudes and behaviours". In 6th FIEP European Congress.

Physical Education in the 21st Century–Pupils' competencies, edited by I. Prskalo, and D. Novak, 15-25 Zagreb: Hrvatski kineziološki Savez.

Health and Social Care Information Centre. 2013. Health Survey for England – 2012. http://www.hscic.gov.uk/catalogue/PUB13218

Heft, H. 2003. Affordances, dynamic experience, and the challenge of reification. *Ecological*

Psychology 15(2): 149-180

Hoffman, S.J. 1990. Relevance, application, and the development of an unlikely theory. Quest 42: 143–160.

Jurbala, P. 2015. What is Physical Literacy, really? *Quest* 77(4): 367–383.

Kentel, J.A., and Dobson, T.M. 2007. Beyond myopic visions of education: revisiting movement literacy. *Physical Education and Sport Pedagogy* 12(2): 145-162

Kirk, D. 2013. Educational value and models-based practice in Physical Education. *Educational Philosophy and Theory* 45(9): 973-986.

Kugler, P.N. and Turvey M.T. 1987. *Information, natural law, and self-assembly of rhythmic movement: Theoretical,* Hillsdale, NJ, Lawrence Erlbaum Associates.

Langton, C.R. 1990. Computation at the edge of chaos: Phase transitions and emergent computation. *Physica D.* 42: 12-37.

Lee, M. C. Y., Chow, J. Y., Button, C., & Tan, C. W. K. 2017. Nonlinear Pedagogy and its role in encouraging twenty-first century competencies through physical education: a Singapore experience. *Asia Pacific Journal of Education, 37*(4): 483-499.

Light, R. 2013. *Game Sense*. Routledge: London.

Linduer, K. J., 2002. The physical activity participation-academic performance relationship revisited: Perceived and actual performance and the effect of banding (Academic Tracking). *Paediatric Exercise Science* 14(1): 155-169.

Lloyd, R. J. 2011. Awakening movement consciousness in the physical landscapes of literacy: Leaving, reading and being moved by one's trace. *Phenomenology and Practice* 5(2): 73-92.

Locke, L.F. 1990. Why motor learning is ignored: A case of ducks, naughty theories, and

unrequited love. *Quest* 42: 134–142.

Moy, B., Renshaw, I., & Davids, K. 2014. Variations in acculturation and PETE students' receptiveness to an alternative pedagogical approach to games teaching. *Physical Education and Sport Pedagogy* 19: 349-369.

Moy, B., Renshaw, I., Davids, K., and Brymer, E. 2015. Overcoming acculturation: Physical Education recruits' experiences of an alternative pedagogical approach to games teaching. *Physical Education and Sport Pedagogy* 21(4): 386 – 406.

Newell, K.M. 1986. Constraints on the development of coordination. *Motor development in children: Aspects of coordination and control* 34: 341-360.

New South Wales Department of Education and Communities. 2015. *The Physical Literacy Continuum.* Accessed 3 November 2015. http://www.curriculumsupport.education.nsw.gov.au/secondary/pdhpe/pdhpe7_10/physical_activity/pa_001.htm

Partington, M. and Cushion, C. 2013. An investigation of the practice activities and coaching behaviors of professional top-level youth soccer coaches. *Medicine and Science in Sports* 23(3): 374-382.

Passos, P., Araujo, D. and Davids, K. 2016. *Competitiveness and the process of co-adaptation in team sport performance. Frontiers in Psychology* 10(7): 1562, 1-5

Reid, P. And Harvey, S. 2014. We're delivering Game Sense … aren't we? *Sports Coaching Review* 3(1): 80-92

Renshaw, I., Davids, K., Shuttleworth, R. and Chow, J. Y. 2009. Insights from ecological psychology and dynamical systems theory can underpin a philosophy of coaching, *International Journal of Sport Psychology* 40(4): 540–602.

Renshaw, I., Chow, J.Y., Davids, K., and Hammond, J. 2010. A Constraints-led perspective to understanding skill acquisition and game play: A basis for integration of motor learning theory and physical education praxis? *Physical Education and Sport Pedagogy* 15(2): 117-137.

Rosser, B. 2008. Econophysics and economic complexity. *Advances in Complex Systems* 11(5): 745-760.

Savery, J.R., and Duffy, T.M. 1995. Problem based learning: An instructional model and its constructivist framework. *Educational Technology* 35(5): 31–38

Sidentop, D. 2002. Content knowledge for physical education. *Journal of Teaching in Physical Education.* 21(4): 368-377.

Silva, P., Travassos, B., Vilar, L., Aguiar, P., Davids, K., Araújo, D. and Garganta, J. 2014. Numerical relations and skill level constrain co-adaptive behaviors of agents in sports teams. *PloS one* 9(9): 107-112.

Sport Wales. 2017. *Physical Literacy – A Journey Through Life*. Available at: http://physicalliteracy.sportwales.org.uk/en/ retrieved at 10:08 10/7/2017.

Tan, C. W. K., Chow, J. Y., and Davids, K. 2012. 'How does TGfU work?': examining the

relationship between learning design in TGfU and a nonlinear pedagogy. *Physical Education and Sport Pedagogy 17*(4): 331-348.

Taras, H., 2005. Physical activity and student performance at school. *Journal of School Health* 75(2): 14 - 218.

Thompsett, C., Burkett, B., and McKean, M. 2014. Development of physical literacy and movement competency: A literature review. *Journal of Fitness Research* 3(2): 53-74.

Travassos, B., Duarte, R., Vilar, L., Davids, K., and Araújo. D. 2012. Practice task design in team sports: Representativeness enhanced by increasing opportunities for action, *Journal of Sports Sciences* 30(13): 1447-1454

Trudeau, F., and R. J. Shephard. 2008. Physical Education, school physical activity, school sports and academic performance. *International Journal of Behavioural Nutrition and Physical Activity* 5(10) https://doi.org/10.1186/1479-5868-5-10

UK Active. 2014. *Turning the Tide of Inactivity* http://ukactive.com/downloads/managed/Turning_the_tide_of_inactivity.pdf

United Nations Educational, Scientific and Cultural Organisation. 2015. Quality physical education: Guidelines for policy-makers. UNESCO Publishing

Vinson, D., Brady, A., Moreland., B., and Judge, N. 2016. Exploring coach behaviours, session contexts and key stakeholder perceptions of non-linear coaching approaches in youth sport. *International Journal of Sport Science & Coaching* 11: 54-68.

Weiss, G., and Haber, H.F. 1999. *Perspectives on embodiment: The intersections of nature and culture*. London: Routledge.

Whitehead, M. 2007. Physical Literacy: Philosophical considerations in relation to developing a sense of self, universality and propositional knowledge. *Sport, Ethics and Philosophy* 1(3): 281-298

Whitehead, M. (ed). 2010. *Physical Literacy throughout the Lifecourse*. London: Routledge.

Whitehead, M. 2013. What is Physical Literacy and how does it impact on Physical

Education? In *Debates in Physical Education*, ed. S. Capel, and M. Whitehead, 37-52. London: Routledge.

Whitehead, M. 2016. International Physical Literacy Association. Available at: https://www.physical-literacy.org.uk/ retrieved at 11:39 10/7/2017.

Whitehead, M., and Murdoch, E. 2006. *Physical Literacy and Physical Education:*

Conceptual mapping. Available at: http://www.physical-literacy.org.uk/conceptualmapping2006-abstract.php Retrieved at 21:37 11/7/2017.

Yu, C. C. W., S. Chan., F. Cheng., R. Y. T. Sung., and K-T. Hau. 2006. Are Physical activity and academic performance compatible? Academic achievement conduct, physical activity and self-Esteem of Hong Kong Chinese primary school children. *Educational Studies*. 32(1): 331 - 341.