Nonlinear Pedagogy and its implications for practice in the Singapore PE context

CHOW, Jia Yi, KOMAR, John, DAVIDS, Keith <http://orcid.org/0000-0003-1398-6123> and TAN, Clara Wee Keat

Nonlinear Pedagogy and its implications for practice in the Singapore PE context

Abstract

Background

Nonlinear Pedagogy, underpinned by concepts in ecological dynamics, is a pedagogical framework that advocates an exploratory approach to acquisition of movement skills with an emphasis on individualised movement solutions. Its key principles have been successfully implemented in sports teaching and coaching and are currently being applied to learning designs in PE programmes.

Purposes

The purposes of the paper are to provide an overview of the theoretical underpinnings and practical implications of Nonlinear Pedagogy (NLP) for Physical Education (PE). We also seek to discuss how NLP is being implemented as a methodological framework for learning design in PE programmes of Singapore schools. Our analysis aims to focus on the 'What', 'Why' and 'How' of NLP to illustrate its application in Singapore PE programmes.

Discussion

Understanding the 'What' and 'Why' of NLP can provide a sound foundation to examine how this pedagogical framework can be applied in the school PE setting. While it is important for teachers to know what NLP is, the 'Why' of NLP, referencing its effectiveness as a pedagogical approach, can provide a rationale for its adoption to enhance teaching and learning. This paper seeks to exemplify the 'How' of NLP's practical implementation in schools, which is of primary interest for teachers, managers and policy makers in education.

Conclusion

Key pedagogical principles from NLP can provide a platform for teachers to design effective lessons and practices to enhance learning in PE programmes. An important practical implication of the current paper is to provide educators with guidance for incorporating

pedagogical principles in NLP in lessons and learning programmes to enhance 'nonlinearization' of their current practices.

Keywords: Nonlinear Pedagogy; Physical Education; Learning designs; Professional Development; Singapore education programmes.

Introduction

Effective Physical Education (PE) programmes should encompass the development of an individual in the major domains of learning: psychomotor, cognitive and affective (Metzler, 2017). For example, in the Singapore PE context, one key goal pertains to how an individual should acquire a range of foundational movement skills that supports their functionality to participate in a variety of learning activities within the psychomotor domain (MOE, 2014). Unsurprisingly, skill acquisition has always been a topic of interest among

sports science support staff and practitioners like PE teachers and sports coaches as it provides the foundations on understanding how individuals move and engage with the surrounding environment on a daily basis. The benefits of developing effective approaches to enhancing skill acquisition and development of Physical Literacy goes beyond the realm of sports or physical activities in clubs and schools, playing an important role in helping individuals gain functionality in their movements. Importantly, there is a need for learners to use skills adaptively and transfer learning to different contexts across various activities, sports, games and outside of the school sports setting. For instance, Corlett and Mandigo (2013) described the principle of Physical Literacy as a construct that organizes our understanding of the experience of learning and performing of a wide range of activities and the whole person. The emphasis is more than just knowing how to perform basic movements but more importantly, to adapt and use these movement capabilities in authentic and more complex contexts. These ideas on Physical Literacy have been aligned with the ideas of Araújo and Davids (2011) on skilled negotiation of dynamic performance environments in sport and physical activity. In an ecological dynamics framework, these authors highlighted how the process of learning movement skills is not just about acquiring them as mental representations, but rather could be better described as skilled functional adaptations (Araújo and Davids 2011; Woods, McKeown, Rothwell, Araújo, Robertson and Davids 2020). More recently, these ideas have been implemented in PE contexts, addressing how Physical Literacy can be harnessed in developing skilled adaptation and movement functionality throughout the lifespan (see Rudd, Pesce, Stratfford and Davids 2020; O'Sullivan, Davids, Woods, Rothwell and Rudd 2020).

The emphasis on Physical Literacy in PE, has thus created an inherent challenge for applied scientists, educators and practitioners to consider approaches that would best engage students in PE lessons (Lundvall, 2015). Importantly, there is a critical need to understand

how learners can take on a more active role in developing their own Physical Literacy to underpin skilled adaptation to dynamic performance environments throughout the lifespan. These foundational skills and experiences are needed to support teachers and coaches to facilitate learning by designing relevant activities and methods to channel learners to search and explore functional movement solutions (Button, Seifert, Chow, Araújo and Davids 2020). The level of autonomy given to learners and students in such settings, which are student- and learner-centred, would undoubtedly be higher, compared to learning contexts where the teacher prescribes specific movement templates for students to reproduce and adhere to (Moy, Renshaw, Davids and Brymer 2016). Thus, over the last decade, there has been increased interest in understanding processes behind exploratory learning, regarding practitioners as designers of practice (Chow, Davids, Button and Renshaw 2016; Correia, Carvalho, Araújo, Pereira and Davids 2019, Orth, Van der Kamp and Button 2019; Pinder and Renshaw 2019; Roberts, Newcombe and Davids 2019).

Nonlinear Pedagogy (NLP) is a pedagogical methodology that accounts for nonlinearities in individual learners, providing principles that govern effectiveness and efficacy in the learning process (Chow et al. 2016; Chow, Davids, Renshaw and Rudd 2020). Underpinned by concepts from Ecological Dynamics, NLP takes into account the critical learner-environment mutuality and advocates key pedagogical design principles that can address the inherent nonlinearity that is ever present in interactions of a complex system formed by each learner and a performance environment. Implementing these pedagogical design principles can help learners to adapt their goal-directed behaviours as conditions in a learning environment change, typically encountered in PE contexts. A rich understanding of this conceptual framework can provide practitioners with innovative learning design principles that can enhance learning for students engaged in PE (Chow and Atencio 2014). In recent years, interest in NLP has grown tremendously and significant attempts to understand

application of pedagogical principles of NLP in PE contexts have been published (e.g., Chow et al. 2016; Lee, Chow, Komar, Tan and Button 2014; Komar, Potdevin, Chollet and Seifert 2019; Lee, Chow, Button and Tan 2017; Orth et al. 2019; Roberts et al. 2019).

The aim of this paper is to provide an overview of the theoretical underpinnings and practical implications of NLP for PE, exemplifying how it is being implemented as a methodological framework for physical educators to implement in learning designs in Singapore schools. Specifically, the paper focuses on the 'What', 'Why' and 'How' of NLP to present a coherent description of its application in the Singapore context. The 'What' section outlines the design principles of a NLP. The 'Why' elaborates on the evidence that supports the potential effectiveness of NLP. Last, but not least, the 'How' presents a discourse on the ongoing educational initiatives to promote NLP to the PE community in the Singapore PE context. An attempt is also made to examine important practical implications to support teachers in incorporating pedagogical principles in NLP in their existing lessons to enhance 'nonlinearization' of their current practices. In the rest of this paper, we seek to provide a platform for applied scientists, educators, academics and practitioners to consider the relevance of NLP in making teaching and learning in PE more meaningful for the students in schools.

What exactly is NLP?

NLP is a pedagogical approach underpinned by concepts of Ecological Dynamics, adopting a Constraints-led Approach (CLA) as the methodological framework to help learners develop, explore and exploit a functional relationship with a performance environment (see Renshaw and Chow 2019). Key pedagogical design principles have been proposed to support how NLP could be enacted in teaching and learning contexts (Chow et al., 2016). At the centre of the approach lies the individual learner/student (see Figure 1). The

learner should be an active participant in the learning process and is empowered with the autonomy to search, explore and exploit individualised movement solutions (Button et al. 2020; Chow 2013). It has been argued that enhancing Physical Literacy through PE is an important foundation of this empowerment process in learning, whether the learner is engaged in recreational or elite development programmes (Rudd et al. 2020; O'Sullivan et al. 2020).

Insert Figure 1 about here

Learners in PE and sport have been conceptualised as nonlinear dynamical systems (Chow et al., 2016), demonstrating a myriad of behaviours in different learning environments. Chow, Davids, Hristovski, Araújo and Passos (2011) described some of these features of nonlinearity, relating how practitioners in sport may: i) observe non-proportionate changes in behavioural outcomes (e.g., practising for a long time does not necessarily lead to a pre-defined quantum of improvement; sometimes rapid jumps in learning can emerge from small periods of practice and small improvements may emerge from long periods of play and practice), ii) help learners develop multiple ways to accomplish a task goal, predicated on an individualised foundation of movement competencies (Hulteen Morgan, Barnett, Stodden and Lubans 2018) (e.g., one can throw a ball in different ways as long as an intended outcome is achieved: e.g., the learner hits an assigned target); iii) scale task constraints leading to the emergence of preferred (intended) behaviours (e.g., scaling the size of the ball can lead to different ways of catching it in a throw and catch game to encourage better understanding and experience of success); and iv), vary learning task designs to encourage learners to explore innovative movement behaviours that could be more functional. These characteristics of NLP demonstrate how properties of nonlinearity in learners may support the emergence of learning

in a PE setting. These inherent learning behaviours may form the basis of pedagogical methods that practitioners could design in lessons, games and activities to exploit inherent nonlinearity (Chow and Atencio 2014; Ovens, Hopper and Butler 2013).

It has been proposed that a rich understanding of key concepts of ecological dynamics can provide a solid conceptual framework for practitioners to develop innovative learning design principles that can enhance skill in individuals (Chow et al. 2016). What are these key concepts and how can they be translated into design principles for physical educators?

One of the key features of NLP is the focus on designing representative learning contexts with a purpose in mind (framing learner intentionality) (Chow, Davids, Renshaw and Rudd 2020). The design of **Representative learning environments** for learners requires a deep understanding of the information that constrains actions so that affordances available in a performance environment (defined as invitations for actions by Withagen, De Poel, Araújo and Pepping 2012) may be utilised to help individual learners to achieve intended task goals (for a more detailed explanation see Chow et al. 2020). Representative learning design (Button et al., 2020) is based on long-standing specificity of learning principles (see Henry, 1958). The critical thinking behind creating representative learning environment is to replicate and include relevant information and invitations for actions in specific play and learning activities in PE classes (Chow et al., 2020). Taking the example of a territorial game in the Singapore PE context (MOE, 2014), if a lesson objective in football (or soccer) is to maintain ball possession where the learning outcome is to send the ball to a teammate in a supporting position (and for off-the ball attacker to move and be ready to receive), the ability to pass and receive would be key learning. A passing drill where students are stationary, conducted in the absence of any pressure from opponents, can merely allow for success in replication and reproduction of a passing technique. However, practice and performance in this more static learning environment would not be representative of whether students could

perform the task in an actual game context. The passing drill without an opponent could be representative if that was the intended outcome (i.e., if the performance goal was merely to reproduce and complete passing actions between isolated teammates without the presence of field markings and defenders). But the pass is a component within a game, which contains information in the form of the location of active defenders, restrictive field markings and intended outcomes, such as to advance upfield and score goals. At least some of these task constraints need to be present in practice designs rather quickly for learners. Perhaps a 3v1 or 5v2 possession game may be designed to encourage passing and receiving between learners in the team with the ball. This type of representative design would present relevant information and thus affordances for the learners to perceive and use while trying to keep ball possession under defensive pressure (maintaining a focus on transfer of passing and receiving actions to a competitive game). From a NLP approach, the emphasis is on supporting learners to become familiar (or attune) to the nature of the information supporting interactions between themselves and the practice environment (see Renshaw, Araújo, Button, Chow, Davids and Moy 2016). The more representative a learning task is, the more specific is the replication of information between the learning task and the performance environment. In PE classes, teachers need to explore different learning tasks, varying in representative design (e.g., manipulating key constraints such as playing area dimensions, numbers of learners involved and task goals), depending on the skills, capacities and experience levels of the learners. Establishing *representativeness* in the learning context is the ultimate learning objective that the teacher would like to achieve with the learners, to enhance their functionality.

A major challenge for PE teachers is to understand how to help learners explore available affordances (opportunities or invitations for actions) that can be used to achieve their intended learning goals, such as maintaining ball possession by completing accurate

passes between team members. This is a fundamental aspect of skill acquisition from a NLP perspective (Chow et al. 2016). How can PE teachers design relevant affordances into a learning activity to help learners perceive and use them to functionally adapt their actions? Chow, Davids, Shuttleworth and Araújo (2020) discussed how the micro-structure of practice (i.e., the critical features of learning tasks that are shaped in every lesson, each day and each week by PE teachers) theoretically contains a rich landscape of affordances, capturing available opportunities for action for a learner. The teacher has the knowledge, skills and experience in PE to design learning practices where affordances can range from narrow and limited in variability at one end (constrained by prescription and instructional constraints of a coach or teacher) to extensively (e.g., randomly) varied at the other end (as captured in unstructured practice environments or when tasks are designed to facilitate exploratory behaviours and discovery learning) (see Chow, Davids, Shuttleworth et al. 2020). The design choices of the teacher, in terms of where to situate the practice in this continuum, has an impact on the kind of behaviours that the learners may eventually explore, discover and exploit in learning. The teacher has to decide on what affordances could be adapted and acquired by the learner and, therefore, what representative learning contexts should be designed.

The second key pedagogical principle of NLP relates to **constraints manipulation** which basically underlies and supports many of the other design principles. Manipulating interacting constraints related to the learner, task and environment is the key methodological tool underpinning the CLA which can be used to support learning by PE teachers and sports coaches. For example, creating a representative learning environment requires the carefully-considered manipulation of task constraints such as equipment, space, rules and task goals. The manipulation of equipment could be used by PE teachers to reduce the spatial and temporal challenges faced by learners. Scaled manipulation of constraints also allows self-

adjusted behaviours to emerge (i.e., exploiting inherent self-organisation tendencies in the learner). In NLP, teachers and coaches are considered learning designers (Button et al. 2020; Woods et al. 2020; Rudd et al., 2020; O'Sullivan et al., 2020). Scaling the parameters of task constraints from one level to the next, helps to engage learners to search and exploit innovative, exploratory movement behaviours in the absence of prescriptive top-down instructions by the teacher. For example, when the playing dimension of a 3v1 possession game of football is progressively scaled from a larger to smaller area, the passing and receiving behaviours of learners could progress from one where the players just have to shift minimally to keep possession (i.e., maintaining channels of passes) to the challenge of making quick scanning movements to look for space and play fast/short/accurate passes to keep the ball away from an immediate defender. Scaling of ball sizes from small to big or vice versa could also encourage different throw and catch behaviours in learners using single and two limbs. Similarly, scaling the length of a bat can afford different swinging movement solutions in striking games. Critically, PE teachers could be made more cognizant through the understanding of the key principle of constraints manipulation to design practices that support exploratory learning.

Task simplification rather than task decomposition is another key design principle of NLP since the way that a teacher organises a learning task can influence skill acquisition in learners. Ecological dynamics advocates that learners need to develop and maintain strong functional couplings of information and actions, gradually strengthened during learning. In a representative learning context, information is directly perceivable to be picked-up by individual learners to constrain their actions (Chow et al. 2016; Button et al., 2020). It has been argued that perception is, therefore, a process of searching for 'specifying' information that can be used to regulate actions and guide the generation of functional movement solutions (Chow, Davids, Shuttleworth et al. 2020). Task simplification is a principle that

helps learners seek, explore and maintain information and action relationships in task designs. It has relevance to the principle of constraints manipulation as the scaling of constraints by a teacher can allow for greater simplification of a produced movement (exemplified by the scaling of playing area dimensions or tennis racket and ball compression properties in mini-tennis games for children: see Fitzpatrick, Davids and Stone 2018). Importantly, task simplification supports learners in moving flexibility to explore the environment and generate more information that can be subsequently used for regulating performance but without compromising on the relevance of the intended learning objective in PE (i.e., it cannot be so simplified to the point where it is not meaningful for the learner) (Tan, Chow and Davids 2012).

Another key pedagogical principle relates to **informational constraints** where attentional focus on augmented information such as feedback and instructions could either emphasise the movement form or movement effect (Chow 2013). When the augmented information provided by a teacher is focused on a certain expected movement form, there is greater likelihood of an overly conscious control of movement solutions to movement problems in a learning context (Chow, Davids, Shuttleworth et al. 2020). Providing specific verbal instructions on an optimal movement form can be counter-productive because it solves the movement problem for the learner and it typically fails to account for differences in individual constraints. In contrast, instructions that do not solve specific problems for learners but instead focus on movement outcomes (e.g., trajectory of ball flight, finding the biggest space in an area) can encourage learners to explore new and different solutions to solve a movement problem, achieving the same movement outcome in different ways. Critically, learners can become attuned to the impact that such key informational constraints can have on movement outcomes, supporting the exploration of movement problems in the specific learning context.

Given this emphasis on the nature of augmented information from teachers that help learners discover and explore different movement solutions, the inclusion of **variability in practice** provides a functional role in supporting the emergence of adaptive exploratory behaviours. From an Ecological Dynamics perspective, variability is not seen as something that is undesirable in motor learning and performance. Rather, variability is critical to allow a system to explore transitions to new behavioural patterns (Davids, Bennett and Newell 2006). With reference to human movement systems, variability is an important feature to support skill adaptation to occur (Button et al. 2020; Hacques, Komar, Dicks and Seifert 2020). Opportunities to explore movement variability in practice can be facilitated by effective task constraints manipulation to allow for students in PE classes to experience different conditions under which a skill can be learned. This aim could be achieved by requiring the learner to explore objects differing in material composition, mass, dimensions, and shapes, during play activities for moving them from one area to another. The use of small-sided games in PE (e.g., 2v2 or 5v5) will incorporate inherent levels of variability in the practice as game situations are dynamic in nature and possess higher levels of uncertainty due to the need to consider the actions of others (teammates and opponents). There is no need for high levels of variability in practice all the time, especially when a learner is seeking to stabilise the coupling of information and action. The amount of variability designed into a play activity or learning game by a teacher needs to be considered with regards to possible movement solutions that could be functional for learners to achieve an intended task goal. Search and exploratory behaviours should typically be guided by teachers in PE lessons and skilful design of task constraints manipulation will be essential to help learners engage in meaningful exploratory behaviours. Such behaviours are important and can support the learners to become better attuned to information that matches the environmental properties and the learner's own action capabilities (Hacques et al. 2020). This in turn could facilitate

transfer of skills to different performance situations and this is indeed aligned to one of the key objectives of PE: to be able to transfer the use of a range of movement skills to more diverse contexts. A key challenge for educators is to consider how to manipulate the amount of variability (in individual, task or environmental constraints) within and between learning sessions to challenge individual learners and enhance their self-regulatory capacities, rather than over-rely on the coach or teacher (Chow, Teo-Koh, Tan, Tan, Button, Kapur and Choo 2019).

These fundamental pedagogical principles of NLP provide a framework for practitioners to consider when designing effective PE lessons to account for nonlinearity in the trajectory of learners. In recent years, there has been some empirical work on NLP conducted in school settings, although it is important for more to be done in the future. Notably, Lee et al. (2014) conducted a study involving 24, Primary level 4 children (10 year olds) and presented learning activities that were either NLP or a pedagogical approach focused on drills to develop consistency to an expected movement form (termed as Linear Pedagogy in the study). The skill that was taught to the children was the tennis forehand groundstroke and the children were placed in either the Nonlinear or Linear pedagogy group with the intervention period lasting 4 weeks in the school context. It was found that the NLP group performed just as well as the Linear pedagogy group despite the absence of specific instructions on expected optimal technique for the tennis stroke. More interestingly, the NLP group displayed a greater number of movement behaviours to achieve the same performance outcome. That is, a greater variety of movement solutions emerged in the NLP group and they did not necessarily match those seen to be ‘optimal, accepted’ movement forms for a tennis forehand groundstroke. Findings from Lee et al. (2014) challenged the notion that there is only one ideal movement solution for a task, suggesting that the design principles of

NLP have value in engaging learners differently to harness their individual performer constraints in relation to the task and environment constraints.

Moving forward in terms of empirical work, there is an impetus to undertake more work situated within the school PE context to examine how teaching and learning occurs with NLP.

The 'Why' of NLP

In a recent study examining the impact of NLP on the adaptation of fundamental movement skills by children (n=187, 8 years old) in two Singapore schools, it was found that the learning of students who were presented with an NLP intervention (lasting 8 weeks during the PE lessons) was at least as good as that in the Linear Pedagogy condition or better (Chow et al., 2019) based on data from TGMD-2 results. Specifically, the students in the NLP condition achieved higher scores for running and stationary dribbling at a post-test session, as well as elevation of scores for the overhand throw between post to pre-test sessions. Referencing the Validated Developmental Sequences (Gallahue and Ozmun 2012), it was also determined that there was a greater transition in terms of percentage of students from Elementary Stage to Mature Stage for the skills of sliding and stationary dribble from pre to post test for the NLP group, compared to the Linear Pedagogy group. Further interview data of both students and teachers also found perceptions that the learning processes differed qualitatively between the Nonlinear and Linear Pedagogy conditions. Students presented with the NLP intervention demonstrated behaviours that showed greater exploration in their learning (i.e., trying different movement solutions in representative learning tasks that are not overly prescriptive). Nevertheless, some of the teachers involved in the study responded that, while NLP seemed to encourage more active learning on the part of the students, some form

of inclusion of Linear Pedagogy type instructions may still be relevant (i.e., consider a Nonlinear-Linear Pedagogy hybrid approach).

In another study that examined the impact of an intervention programme based on Nonlinear Pedagogical principles on enhancing movement creativity among 140 fourth-grade students, it was found that children in the creative programme demonstrated higher originality in thinking and improved fluency as well as flexibility in their movement (Richard, Lebeau, Becker, Boiangin and Tenenbaum 2018). Specifically, the students were involved in a 3-month intervention progamme where NLP design principles such as relating to enhancing variability in practice, providing problem-solving possibilities, using imagination and creating opportunities to challenge the students to try different movement solutions underpinned the creative intervention condition. This school-based empirical study provided valuable evidence on the relevance of meaningful manipulation of constraints and improvisation as key pillars to develop creativity among children. In brief, findings from Chow et al. (2019) and Richard et al. (2018) are recent examples of the promise that NLP holds and more of such empirical research needs to be conducted in schools.

The above findings create questions whether NLP has relevance for learning designs in movement skills that are not related to ball games such as tennis, basketball and football. Komar et al. (2014), in a pedagogical setting, showed that in early learning, merely practising breaststroke, through guided discovery learning, without any continuous pedagogical support, led to an improvement in performance after two months. Moreover, this improvement in swimming performance was not different to outcomes of other groups who received prescriptive instructions from a teacher about how to swim more efficiently or NLP intervention groups who received some augmented information through analogy and specific focus of attention during their practice, applying principles of NLP without any prescription of an ideal technique to imitate. On one hand, the performance improvement in the control

group was due to an optimization of the initial behaviour instead of the adoption of a more efficient one. For instance, the control group swimmers may have increased their force impulse during arm or leg propulsion in order to counteract the higher water resistances due to their inefficient movements. On the other hand, the effectiveness of NLP appeared through the adoption of an efficient movement behaviour by the students, which seems to be critical for acquiring deeper expertise and then reaching the highest stages of learning with later practice (Newell 1986). With reference to learning in a PE setting, these findings bode well for considering the need to guide the discovery of students to explore a diverse array of movement solutions. Rather than focusing too much on specific performance outcomes being reproduced, it could be more relevant to observe how students can be guided to use the movements that they have acquired for other physical activity contexts.

A recent study based in a school environment provided some insights on the value of the exploratory learning process. In a wall-climbing context, the amount of visible holds was modified during the ascent to help beginners rely on information that contributed to perception of affordances (Komar, Ding and Iodice 2020). With the use of an electronic climbing wall, the holds available in the route only appeared one step at a time during the climb. The number of holds that were visible by the climber for each ascent changed from one visible hold during the ascent to six visible holds. For instance in the first ascent, the climber was able to see only the next hold he can use, and once he touched this hold, the next one appeared, and so on until he reached the top of the wall. Preliminary results showed that compared to more experienced climbers, novices were impacted by the reduction in visible holds only when the visibility was reduced to one and two holds. For the more experienced climbers, performance was already impacted when the visibility was reduced to four holds or less (Komar et al 2020). This result highlighted that experienced climbers utilised more holds as useful information to perceive their action capabilities or affordances. Learning is not

about accumulating information across trials but rather generating and exploiting useful information for action. Interventions must lead performers to learn to explore rather than learning a predetermined model of skill based on an expert ideation (Hacques et al. 2020). Such exploratory behaviours are very pertinent to more effectively support learning on the part of the students. Exploration is messy and may result in the emergence of some irrelevant behaviours with reference to the expected task goal. However, it is through such exploration that the learner is able to search and experience what would work and what may not work. But importantly, this is actually when learning is taking place (i.e., the learning objective) and this will assist the learner to discover relevant information that underpins effective performance eventually. Again, the implication here for PE is about encouraging our students to become familiar with how their own Physical Literacy can be harnessed across different contexts. Designing learning activities in PE where there is meaningful representativeness to help students be attuned to the information and their corresponding actions would broaden their repertoire of movement competency that is more transferable to other movement contexts. This broadening 'competency' could also extend beyond movement as one can imagine how students may have the opportunity to reflect on and appreciate the value of moving and perhaps not constrained to move in a predetermined manner. This would possibly be appreciated by students who may inherently find the learning of movement skills more challenging and the removal of the threat to replicate some expected movement form could provide that safe environment to explore their own individualised movement solutions.

Some researchers have presented exploratory learning as a continuum, namely as a balance between exploration and stabilization rather than merely an expression of increased variability between two different behaviors (see Pacheco and Newell 2015). There seems to be an existence of an optimal balance between exploring and stabilizing movement patterns during learning for better learning outcomes (Pacheco and Newell 2015). In learning to swim

in PE, Komar et al. (2019) quantified the ratio between exploration and exploitation and the effect of different informational constraints following NLP principles. The authors showed that both the level of exploration and the nature of this exploration (i.e., which behaviours are explored) were highly individualised. During a learning intervention that lasted two months, it was shown that learners can successively use and explore up to 11 different behaviours before settling on a final functional movement solution. Most importantly, although the final movement solutions appeared more efficient than the initial ones, there was not a single unique movement solution preferred by all the learners at the end of the learning period despite achieving the same performance level. The application of NLP principles increased the level of exploration during learning that eventually led to a certain conformity of movement solutions that are aligned to general biomechanical principles of efficiency but with some individualized features (Komar, Sanders, Chollet and Seifert 2014). Learners should be given the opportunity to safely explore individual movement solutions and to be guided toward more reliable and functional information for action (Hacques et al. 2020). Notably, learning interventions underpinned by NLP principles may promote the discovery of exploratory actions that enhance the transfer of perceptual-motor skills.

Undoubtedly, the interest is in how NLP principles could be enacted in the school setting. How can teachers learn about NLP and how can they be supported to deliver NLP approach in the schools? In the following section, we discuss on how NLP is shared with teachers in the Singapore PE context.

The 'How' of NLP in the Singapore context: Working with teachers in the schools to implement NLP in professional practice

If NLP principles are to be understood and adopted in professional practice, there needs to be significant professional development programmes to prepare teachers and

coaches on how to use them effectively in organised PE and sports contexts respectively. In this section we seek to provide insights from an example of how NLP is being enacted in schools as a form of Professional Development and the initiatives put in place to encourage the implementation of NLP in Singapore. One of the key organisations within the PE professional community in the Ministry of Education (Singapore), is the PE and Sports Teacher Academy (PESTA). The academy is dedicated to the professional development of PE and Sports teachers in Singapore. It serves to enhance the professional development and practice of PE teachers and to strengthen their capacity to deliver quality PE lessons and sports coaching through its professional development programmes, mentoring opportunities and networks.

While PE teachers in Singapore are more familiar with the Teaching Games for Understanding and Games-Centered Approaches, PESTA recognizes NLP's relevance and application to meet the purpose of the Ministry of Education (MOE) PE Syllabus, that is, "to enable students to demonstrate individual and with others, the physical skills, practices and values to enjoy a lifetime of active, healthy living." (MOE, 2014, p. 1). The principles of NLP have the potential to augment and enhance Singapore PE teachers' pedagogical knowledge and skills for student-centred approaches, for more effective delivery of the PE Syllabus and sports coaching. Undoubtedly, there is also a need for more studies to be undertaken with reference to understanding the relationship between learning, NLP and enjoyment (or other concepts related to emotion development and motivation regulation in PE). Notably, exploration may be the key factor in increasing enthusiasm among learners and where the learner-environment interaction is critical in supporting learning (see Säfvenbom & Stjernvang 2020).

With the PE community that is relatively new to NLP, PESTA harnessed its officers who have been involved in collaborative research projects with the PE and Sports Science Department at the National Institute of Education on NLP. PESTA looked to work with teachers on NLP through a variety of professional development programmes designed to introduce NLP, deepen their knowledge and hone their teaching skills, through workshops, school support, and also sharing at zonal, cluster levels, networks and conferences (e.g., Professional Learning Zones, Teachers' Conference 2019, Coach Singapore Conference 2019). In this section, we would briefly highlight two key programmes of PESTA for NLP work with teachers.

Visiting Fellowship

A key programme for NLP was the engagement of Professor Keith Davids, as Visiting Fellow in 2019, for a period of 3 weeks. The overall aim of the programme of interactive presentations was to interact with delegates and provide information on the principles of NLP as well as the theoretical and practical implications of NLP. Importantly, valuable insights were shared on how the approach can be adopted effectively to the teaching of games, sports and physical activities, in the delivery of the 2014 PE Syllabus, to teachers, coaches, educators, administrators and even staff and students of higher education institutions in Singapore. During the Visiting Fellowship, there was a good balance of time spent in workshops, presentations, meetings, one-to-one discussions and observations of PE teachers at school sites, and follow-ups, to provide context for the Visiting Fellow.

The Visiting Fellow's sharing of key principles of NLP was well-received by a range of professional practitioners. Feedback from masterclass participants indicated that they found the NLP masterclasses beneficial and that the 'new' pedagogy was thought-provoking, insightful and enlightening. Participants found NLP to be refreshing and viewed NLP as a

very useful pedagogy to drive learning that encourages problem-solving. Reponses to what useful ideas that participants would like to apply and how they plan to implement them showed participants' intention to apply the key pedagogical principles in designing meaningful and engaging tasks to suit the different needs of students in PE and co-curricular activities; several professional practitioners indicated they would apply them for their lessons as well as to share with their colleagues. In general, participants could see the relevance of the key principles as a guide for their planning and teaching. The participants shared how it is important to give students autonomy than to be overly prescriptive in designing learning experiences.

Teachers involved in the school visits by the Visiting Fellow were appreciative of the opportunity to be involved in the rich dialogue which promoted reflections and useful takeaways for their PE lessons and/or coaching sessions. Teachers reflected how they viewed NLP as a powerful tool in capturing students' movement and designing effective PE lessons and how the sharing by the Visiting Fellow helped them to review their approaches in re-designing their lessons. Some teachers also shared how NLP gives them a framework which they can use to bridge that cognitive (tactical ideas) and physical (actions) gap through the thoughtful design of affordances.

PESTA workshops and school support

NLP workshop was also planned for teachers as part of PESTA's Professional Development initiative prior to the Visiting Fellow programme. Initially presented as part of a 1-day workshop to introduce NLP, it was extended to a full day workshop to provide more practical/ hands-on application for better theory-practice link. The purpose of the workshop was to provide an introduction to NLP and application of its pedagogical principles in designing lead-up and modified activities/games. Similar to feedback provided in

masterclasses by Visiting Fellow, participants found the approach, which is grounded in theory, very useful to teaching.

Some participants indicated their willingness to apply the learning and shared how the design principles for NLP definitely gave them the drive of wanting to design and then try out in their lessons, to explore whether the design work in enabling students to achieve the learning outcomes. They reflected that there was more focus on the learning outcomes rather than on one size fits all type of repetitive drills that could limit students in exploring how to play as well as enjoy the game.

To enhance the important link between theory and practice in the application of NLP, school-based collaboration by PESTA officers has also been planned to provide support, advice and mentorship to encourage PE teachers who have been introduced to NLP to become more effective learning designers, based on the NLP pedagogical principles. Initial effort with school-based collaboration was with two teachers from two schools (one primary and one secondary) by a PESTA Master Teacher. These school collaborations, which were on a weekly basis over 3-5 weeks, were based on a co-building and co-learning process; the format involved pre-post lesson discussions, lesson observations, co-planning and co-teaching. Such an approach has been evidenced as effective in a study by Moy, Renshaw, Davids and Brymer (2016) on how receptive student teachers are to alternative pedagogical approaches like NLP. Their findings suggested that opportunities to experience and observe NLP in action facilitates the student teachers' perception of the effectiveness of NLP.

The feedback from the teachers involved was generally positive, supporting the useful application of NLP's principles in their learning design. The teachers shared how the mentorship and the adoption of a co-plan/teach arrangement by the Master Teacher helped them to be more critical in their task designs and to think deeper about its intent or

application in teaching contexts. For example, one teacher shared how her younger pupils in Primary 4 understood quickly the concept of moving into space for a clear line of pass when she demonstrated these necessary spatial relations between passer and receiver with a laser pointer and she would continue to use this idea in teaching this concept. This example based on the key idea of external attentional focus, supports the power of a visual tool; it led her to think of and use more analogies (e.g., Captain America shield) for her lessons to help her pupils grasp concepts better and faster.

The co-planning/teaching approach, as mentioned by the teacher, may have been a reason why both pairs of teachers involved in the collaborations at two schools, did not surface the key challenges highlighted by Chow (2013). Chow (2013) highlighted key challenges such as 'level of expertise and competency of practitioner' and 'question of time' in implementing a NLP approach. It was noted that learning of movement skills situated within a game setting can create a huge pressure on the teacher as he/she needs to know how to manipulate appropriate task constraints to encourage the emergence of desirable movement behaviours that are individually functional and also to be able to identify teachable moments. The co-planning/teaching approach, may have provided support for the two pairs of teachers facing those challenges. One of the teachers shared how the whole process of their learning was always facilitated by a lot of questioning from the Master Teacher from the planning phase to the reflection phase. The process used by the Master Teacher in her facilitating the teachers' learning with questions to enhance their reflective skills in applying the NLP pedagogical principles in learning designs seemed to have help model how the NLP approach can be applied effectively in planning and implementation of lessons to enhance student learning. This, together with mutual support in their planning and implementation of NLP, could have contributed towards more appropriate manipulation of task constraints where

exploratory learning can be properly channelled for functional movement solutions to emerge.

In brief, it can be seen that a multi-pronged approach could be a sensible way to encourage the use of new initiatives/ pedagogical practices. Inviting external international experts in NLP coupled with strong and sustained local support in the form of mentoring, school-based collaboration and co-planning/teaching of NLP lessons can build a strong foundation for NLP within the PE landscape. Through the close support and partnership between the Ministry and the schools, effective professional development can be enacted. Critically, the effective sharing of NLP concepts/framework has made it possible for PE and coaches to re-consider practical ways in which they can (re)design PE and Co-curricular Activities programmes. It can potentially positively impact student learning and development through teachers'/practitioners' purposeful lesson planning and preparation, content and pedagogy, using the NLP concepts/pedagogical principles. NLP can possibly enhance current professional development and 'nonlinearize' practice of PE teachers and to strengthen their capacity to deliver quality PE lessons and sports coaching.

Conclusion

Empirical work and publications relevant to ideas of NLP have increased significantly in the past decade. This re-emphasis is testament to the interest that it has garnered in helping applied scientists and educational practitioners to enhance teaching from a learning design perspective. This update has hopefully provided further knowledge to trigger more discussion and thinking about the relevance of NLP to enhance learning in PE contexts. On a broader scale, some of the features of NLP could also be relevant or associated with other approaches to teaching (e.g., TGfU or Games Concept Approach) even though there may still be fundamental differences across various pedagogical approaches. The ability to make

connections could be useful for academics and practitioners in enhancing teaching and learning in the longer term. However, it is still critical to be cognisant that the theoretical underpinnings for NLP would be quite different from another like TGfU although there may be some perceived similarities on the surface (see Renshaw et al. 2016).

Undoubtedly, there are inherent challenges in this area of work and specifically, there is a need for more empirical studies in representative environment (schools and sports contexts respectively) to further examine its potential impact on teaching and learning within a PE setting. Critically, while we have presented examples where NLP is relevant to a PE domain, there is acknowledgement that more studies could be undertaken to examine the value of NLP in eliciting meaningfulness or joy in being involved in movement activities. It is also possible that game sports tend to dominate in PE although fundamental movement skills are covered comprehensively at the lower grades at the Primary School level. The teaching and learning of fundamental movement skills could also move away from being overly prescriptive on an optimal movement form which may be the typical expectation. Clearly more work is required to examine the impact of NLP on explorative aesthetic activities such as dance or parkour and how NLP may actually provide the bandwidth for students to be involved in more exploratory search for individualised movement solutions. Key questions of transfer of learning also remain as we begin to explore how specificity of practice designs can lead to different types of transfer of learning in sport, play, and PE (see Chow, Davids, Shuttleworth et al. 2020).

References

Araújo, Duarte, and Keith Davids. 2011. “What exactly is acquired during skill acquisition?” *Journal of Conscious Studies* 18: 7-23.

Button, Chris, Ludovic Seifert, Jia Yi Chow, Duarte Araújo, and Keith Davids. 2020. *Dynamics of skill acquisition. An ecological dynamics approach (2nd ed.)*. Champaign: Human Kinetics.

Chow, Jia Yi. 2013. “Nonlinear learning underpinning pedagogy: Evidence, challenges and implications.” *Quest,* 65: 469-484.

Chow, Jia Yi, and Matthew Atencio. (2014). "Complex and nonlinear pedagogy and the implications for physical education." *Sport, Education and Society* 19 (8): 1034-1054.

Chow, Jia Yi., Keith Davids, Chris Button, and Ian Renshaw. 2016. *Nonlinear Pedagogy in skill acquisition: An introduction*. London: Routledge.

Chow, Jia. Yi, Keith Davids, Robert Hristovski, Duarte Araújo, and Pedro Passos. 2011. “Nonlinear Pedagogy: Learning design for self-organizing neurobiological systems.” *New Ideas in Psychology* 29 (2): 189-200.

Chow, Jia Yi, Keith Davids, Ian Renshaw, and James Rudd. 2020. “Nonlinear Pedagogy.” In *Encyclopedia of Educational Innovation*, edited by Michael A. Peters & Richard Heraud, 1-7. Singapore: Springer.

Chow, Jia Yi., Keith Davids, Richard Shuttleworth, and Duarte Araújo. 2020. “*Ecological Dynamics and transfer from practice to performance in sport*.” In *Skill Acquisition in Sport,* edited by Nicola. Hodges and Mark Williams, 330-344. London: Routledge.

Chow, Jia Yi., Sock Miang Teo-Koh, Wee Keat Clara Tan, Benjamin Tan, Chris Button, Rens Meerhoff, Manu Kapur, and Corliss Zhi Yi Choo. 2019. “*Nonlinear Pedagogy*

and its Relevance for the New PE Curriculum" (NIE Research Brief Series No. 19-012). Singapore: National Institute of Education.

Correia, Vanda, João Carvalho, Duarte Araújo, Elsa Pereira, and Keith Davids. 2019. "Principles of nonlinear pedagogy in sport practice." *Physical Education and Sport Pedagogy* 24 (2): 117-132.

Davids Keith., Simon Bennett, and Karl M Newell. 2006. *Movement system variability*. Human Kinetics.

Davids, K. W., Button, C., & Bennett, S. J. (2008). *Dynamics of skill acquisition: A constraints-led approach*. Human Kinetics.

Delignières, Didier, Deborah Nourrit, Rim Sioud, Pierre Leroyer, Maurice Zattara, and Jean-Paul Micaleff. 1998. "Preferred Coordination Modes in the First Steps of the Learning of a Complex Gymnastics Skill." *Human Movement Science* 17 (2): 221–241. doi:10.1016/S0167-9457(97)00031-6.

Fitzpatrick, Anna, Keith Davids, and Joseph A Stone. 2018. "Effects of Scaling Task Constraints on Emergent Behaviours in Children's Racquet Sports Performance." *Human Movement Science*. doi:10.1016/j.humov.2018.01.007.

Gallahue, David L, & John C Ozmun. 2012. Understanding Motor Development Children Adolescent. In *McGraw Hill, Humanities, Social Sciences and Languages* 36; 533-544).

Glazier, Paul, and Keith Davids. 2009. "Constraints on the complete optimization of human motion." *Sports Medicine* 39 (1): 15-28.

Hacques, Guillaume, John Komar, Matt Dicks, and Ludovic Seifert. 2020. "Exploring to learn and learning to explore." *Psychological Research*. https://doi.org/10.1007/s00426-020-01352-x

Handford, Craig, Keith Davids, Simon Bennett, and Chris Button. 1997. “Skill acquisition in sport: Some applications of an evolving practice ecology.” *Journal of Sports Sciences* 15 (6): 621-640.

Henry, Francis M. 1958. “Specificity vs. generality in learning motor skills.” In *Annual Proceedings of the Physical Education Association*, 61, 126-128.

Hulteen, Ryan M., Philip J. Morgan, Lisa M. Barnett, David F. Stodden, and David R. Lubans. 2018. "Development of foundational movement skills: A conceptual model for physical activity across the lifespan." *Sports Medicine* 48 (7): 1533-1540.

Komar, John, Jia Yi Chow, Didier Chollet, and Ludovic Seifert. 2014. “Effect of Analogy Instructions with an Internal Focus on Learning a Complex Motor Skill.” *Journal of Applied Sport Psychology* 26 (1). Routledge: 17–32. doi:10.1080/10413200.2013.771386.

Komar, John, Yifei Ding, and Pier Paolo Iodice. 2020. “Exploring the Right Sport: How Much Information Really to Explore for Efficinet Climbing.” In *Proceedings of the 38th International Society of Biomechanics in Sports Conference*.

Komar, John, Francois Potdevin, Didier Chollet, and Ludovic Seifert. 2018. “Between exploitation and exploration of motor behaviours: unpacking the constraints-led approach to foster nonlinear learning in physical education.” *Physical Education and Sport Pedagogy* DOI: 10.1080/17408989.2018.1557133

Komar, John, Ross H Sanders, Didier Chollet, and Ludovic Seifert. 2014. “Do Qualitative Changes in Arm-Leg Coordination Lead to Effectiveness of Aquatic Locomotion Rather than Efficiency.” *Journal of Applied Biomechanics* 30 (2): 189–197. doi:10.1123/jab.2013-0073.

Lee, Miriam Chang Yi, Jia Yi Chow, Chris Button, and Clara Wee Keat Tan. 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.

Lee, Miriam Chang Yi., Jia Yi Chow, John Komar, Clara Wee Keat Tan, and Chris Button. 2014. "Nonlinear Pedagogy: An effective approach to cater for individual differences in learning a sports skill." *PloS ONE* 9 (8): e104744.

Metzler, Michael. 2017. *Instructional models in physical education*. Taylor & Francis.

Ministry of Education (2016). Physical Education Teaching & Learning Syllabus. Retrieved from https://www.moe.gov.sg/docs/default-source/document/education/syllabuses/physical-sports-education/files/physical_education_syllabus_2014.pdf

Moy, Brendan, Ian Renshaw, Keith Davids, and Eric Brymer. 2016. "Overcoming acculturation: physical education recruits' experiences of an alternative pedagogical approach to games teaching." *Physical Education and Sport Pedagogy* 21 (4) 386-406.

Newell, Karl M. 1986. "Constraints on the Development of Coordination." In *Motor Development in Children. Aspects of Coordination and Control*, edited by M G Wade and H T A Whiting, 341–360. Dordrecht, Netherlands: Martinus Nijhoff.

Newell, Karl M. 1996. "Change in Movement and Skill: Learning, Rentention and Transfer." In *Dexterity and Its Development*, edited by M L Latash and M T Turvey, 393–430. Mahwah, NJ: Erlbaum.

Newell, Karl M, and Yeou Teh Liu. 2012. "Functions of Learning and the Acquisition of Motor Skills (With Reference to Sport)." *The Open Sports Sciences Journal* 5: 17–25.

Nourrit, Deborah, Didier Delignières, Nicolas Caillou, Thibaut Deschamps, and Benoit

Lauriot. 2003. “On Discontinuities in Motor Learning: A Longitudinal Study of Complex Skill Acquisition on a Ski-Simulator.” *Journal of Motor Behavior* 35 (2): 151–170.

O’Sullivan, Mark, Keith Davids, Carl T. Woods, Martyn Rothwell, and James Rudd. 2020. "Conceptualizing physical literacy within an ecological dynamics framework." *Quest*: 1-15.

Orth, Dominic, John van der Kamp, and Chris Button. 2019. "Learning to be adaptive as a distributed process across the coach–athlete system: situating the coach in the constraints-led approach." *Physical Education and Sport Pedagogy* 24 (2): 146-161.

Ovens, Alan, Tim Hopper, and Joy Butler, eds. (2013). *Complexity thinking in physical education: Reframing curriculum, pedagogy, and research*. Routledge.

Pacheco, Matheus M, and Karl M Newell. 2015. “Transfer as a Function of Exploration and Stabilization in Original Practice.” *Human Movement Science* 44: 258–269. doi:doi: 10.1016/j.humov.2015.09.009.

Pinder, Ross A., and Ian Renshaw. 2019. "What can coaches and physical education teachers learn from a constraints-led approach in para-sport?" *Physical Education and Sport Pedagogy* 24 (2): 190-205.

Renshaw, Ian, Duarte Araújo, Chris Button, Jia Yi Chow, Keith Davids, and Brendan Moy. 2016. "Why the constraints-led approach is not teaching games for understanding: A clarification." *Physical Education and Sport Pedagogy* 21 (5): 459-480.

Renshaw, Ian, and Jia Yi Chow. 2019. “A constraint-led approach to sport and physical education pedagogy.” *Physical Education and Sport Pedagogy* 24 (2): 103-116.

Richard, Veronique, Jean-Charles Lebeau, Fabian Becker, Nataniel Boiangin, and Gershon Tenenbaum. 2018. "Developing cognitive and motor creativity in children through an

exercise program using nonlinear pedagogy principles." *Creativity Research Journal* 30 (4): 391-401.

Roberts, William M., Daniel J. Newcombe, and Keith Davids. 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): 162-175.

Rudd, James R., Caterina Pesce, Ben William Strafford, and Keith Davids. 2020. "Physical Literacy-A Journey of Individual Enrichment: An Ecological Dynamics Rationale for Enhancing Performance and Physical Activity in All." *Frontiers in Psychology* 11: 1904.

Säfvenbom, Reidar, and Guro Stjernvang. 2020. "Lifestyle sport contexts as self-organized epistemic cultures." *Sport, Education and Society* 25 (7): 829-841.

Tan, Clara Wee Keat, Jia Yi Chow, and Keith Davids. 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.

Vereijken, Beatrix, Richard E A Van Emmerik, Rob Bongaardt, W J Beek, and Karl M Newell. 1997. "Changing Coordinative Structures in Complex Skill Acquisition." *Human Movement Science* 16 (6): 823–844. doi:10.1016/S0167-9457(97)00021-3.

Withagen, Rob, Harjo J. De Poel, Duarte Araújo, and Gert-Jan Pepping. 2012. "Affordances can invite behavior: Reconsidering the relationship between affordances and agency." *New Ideas in Psychology* 30 (2): 250-258.

Woods, Carl T, Ian McKeown, Martyn Rothwell, Duarte Araújo, Sam Robertson, and Keith Davids. 2020. "Sport Practitioners as Sport Ecology Designers: How Ecological Dynamics Has Progressively Changed Perceptions of Skill "Acquisition" in the Sporting Habitat." *Frontiers in Psychology* 11:654. doi: 10.3389/fpsyg.2020.00654

Figure Captions

Figure 1. Nonlinear Pedagogy framework

Response to reviewers

Thank you for the affirmation that the revision undertaken previously have significantly improved the manuscript to be accepted for publication in PESP. Below, we highlight further minor revisions that have been recommended by both reviewers.

Response to Reviewer 1

Reviewer 1 has provided valuable comments to help enhance the manuscript and we appreciate the review. Particularly, Reviewer 1 has requested for greater clarity in terms of the structure and aims of the manuscript and importantly, to provide greater emphasis in relation to what this paper can contribute in helping teachers/students reflect on teaching and learning objectives in PE.

1) You introduce Physical Literacy in the introduction with capital letter P and L. For example on p. 5, line 5 you use small letter when you address physical literacy. Please be consistent throughout the paper	This has been revised throughout the manuscript.
2) In the introduction you use the abbreviation PE for Physical Education but for example on p. 5, line 2 and line 5 you write physical education (in the first case with small letters and in the second with capital letters). The same goes for your introduction of Nonlinear Pedagogy on p. 5, line 21. On p. 6 you write the whole word in some sentences and the abbreviation in some. Again, please be consistent throughout the paper	This has also been rectified throughout the manuscript.
3) P. 8, line 14: You suggest that an understanding concepts will lead to a love for physical activity and movement? Isn't that to promise a	The description has been toned down, See pp 8. lines 11 to 13.

bit too much? See for example Quennerstedt et al 2020 in Sport Education and Society for a critical analysis of what models-based learning (in that case Physical Literacy) can promise and deliver. Suggest that you tone down the love part.	"It has been proposed that a rich understanding of key concepts of ecological dynamics can provide a solid conceptual framework for practitioners to develop innovative learning design principles that can enhance skill in individuals (Chow et al. 2016)."
4) A comment to think about in relation to the authors' response to point 7 (reviewer 2's comment): I acknowledge the authors' will to focus on NLP and to avoid comparisons to other types of pedagogical models. I am not going to argue that the authors' should meet my suggestion of making links to, for example TGfU. However, looking from a broader perspective, I think we need more research in the field that also acknowledge similarities between pedagogical models. If we only focus on the specifics of the models we will risk building silos instead of seeing the big picture. This is just a comment for the authors to think about, and nothing that necessarily needs to be addressed in this paper.	Thank you for the comment. It is indeed useful to have a discourse on other pedagogical models. We have indicated a brief point on pp 26, lines 6 to 13, to highlight the relevance of making connections (where meaningful) across different pedagogical models. "On a broader scale, some of the features of NLP could also be relevant or associated with other approaches to teaching (e.g., TGfU or Games Concept Approach) even though there may still be fundamental differences across various pedagogical approaches. The ability to make connections could be useful for academics and practitioners in enhancing teaching and learning in the longer term. However, it is still critical to be cognisant that the theoretical underpinnings for NLP would be quite different from another like TGfU although there may be some perceived similarities on the surface (see Renshaw et al. 2016)"

Response to Reviewer 2

Reviewer 2 has further provided positive and constructive comments to enhance the manuscript.

1) Suggestion of a short paragraph to indicate NLP to be relevant within the PE domain and importantly beyond movement and movement activities.	New information to indicate the importance of NLP within the PE domain and how NLP is also relevant for students with reference to enhancing meaningfulness or joy of being involved in movement activities. See pp. 26, lines 14 to 19. "Undoubtedly, there are inherent challenges in this area of work and specifically, there is a need for more empirical studies in representative environment (schools and sports contexts respectively) to further examine its potential impact on teaching and learning within a PE setting. Critically, while we have presented examples where NLP is relevant to a PE domain, there is acknowledgement that more studies could be undertaken to examine the value of NLP in eliciting meaningfulness or joy in being involved in movement activities."
2) Some discussion on how NLP could be relevant for other explorative aesthetic activities such as parkour. Provide a short discussion on why some of these examples on these activities are not prominent and what this may mean.	More information have been included to indicate why non-games examples are less frequently cited and what could be done more in the future. See pp. 26, lines 19 to pp. 27 line 1. "It is also possible that game sports tend to dominate in PE although fundamental movement skills are covered comprehensively at the lower grades at the Primary School level. The teaching and learning of fundamental movement skills could also move away from being overly prescriptive on an optimal movement form which may be the typical expectation. Clearly more work is required to examine the impact of NLP on explorative aesthetic activities such as dance or parkour and how NLP may actually provide the bandwidth for students to be involved in more

	exploratory search for individualised movement solutions.”
3) Further elaboration on how exploration itself could be a learning objective.	More information have been included to explain exploration and its relevance to learning. See pp 18, lines 12 to 18. “Such exploratory behaviours are very pertinent to more effectively support learning on the part of the students. Exploration is messy and may result in the emergence of some irrelevant behaviours with reference to the expected task goal. However, it is through such exploration that the learner is able to search and experience what would work and what may not work. But importantly, this is actually when learning is taking place (i.e., the learning objective) and this will assist the learner to discover relevant information that underpins effective performance eventually.”
4) Point on broadening competency beyond movement skills. Reviewer pointed out that this broadening of competency may include students’ reflections and even appreciations with regard to movement.	More information have been added to suggest how NLP can potentially promote other aspects of competency beyond movement skills. See pp. 18, line 18 to pp. 19, line 3. “Again, the implication here for PE is about encouraging our students to become familiar with how their own Physical Literacy can be harnessed across different contexts. Designing learning activities in PE where there is meaningful representativeness to help students be attuned to the information and their corresponding actions would broaden their repertoire of movement competency that is more transferable to other movement contexts. This broadening ‘competency’ could also extend beyond movement as one can imagine how students may have the opportunity to reflect on and appreciate the value of moving and perhaps not constrained to move in a predetermined manner. This would possibly be appreciated by students who may inherently find the

	learning of movement skills more challenging and the removal of the threat to replicate some expected movement form could provide that safe environment to explore their own individualised movement solutions."
5) p.19 l.49 ("…..teachers and coaches on how to use them effectively in organised PE and sports context".) I suggest to add "respectively" at the end of this sentence - to emphasize that this can or should be done differently -depending on different learning outcomes.	Revision have been made. See pp. 20, line 10.
6) p. 20 l.30 (…..to demonstrate individual and with others, the physical skills, practices and values to enjoy a lifetime of active, healthy living."). The concept of enjoyment in the Singapore curriculum cannot be ignored because enjoyment seems to be the core of the aim. This means that we need more studies on the relationship between learning, NLP and enjoyment (or other concepts emphasizing emotions or motivational regulation in PE) in physical activity and physical education. Prior studies have shown that exploration may be the key variable to increase enthusiasm among students (see Säfvenbom & Stjernvang,2019).	Addition materials have been added. To indicate a need for more studies to understand the relationship between learning, NLP and enjoyment. Säfvenbom & Stjernvang (2020) was cited to support the discussions. See pp. 21, line 3 to 8. "Undoubtedly, there is also a need for more studies to be undertaken with reference to understanding the relationship between learning, NLP and enjoyment (or other concepts related to emotion development and motivation regulation in PE). Notably, exploration may be the key factor in increasing enthusiasm among learners and where the learner-environment interaction is critical in supporting learning (see Säfvenbom & Stjernvang 2020)."
7) p 25 l 40: (schools and sports contexts) I suggest that you add "respectively" : schools and sports contexts respectively)	This has been revised. See pp. 26, line 16.

1

2