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Background: In recent years, there has been considerable interest in the evolution of physical education teaching practice from a traditional *teacher-centred approach* to a *student-centred approach*. Consequently, research has focused on questions about the changing conceptions of the teaching and learning process, that is, from how 'we' teach to how 'they' learn. A contemporary theoretical model of the teaching and learning process could underpin learning design and delivery adopted in physical education. The Constraints Led Approach (CLA) is a viable alternative as its practice design and delivery is grounded in the contemporary motor learning theory of ecological dynamics within a nonlinear pedagogy framework. However, its implementation is thought to present unique challenges to physical education practitioners due to the dynamic individual learner-environment interactions from which learning occurs. For this reason, it has been suggested that researchers work symbiotically with practitioners to help facilitate the adoption of nonlinear pedagogies and provide valuable information regarding the application of theory into practice.

Purpose: This study sought to explore two PETE students' experiences learning to implement a nonlinear informed pedagogical approach, specifically the CLA, with physical education students in a school practicum setting. The two PETE students were provided with support from the primary researcher during the experience.

Participants and Setting: A purposive sample of two second-year PETE students from an Australian university were recruited for the study. Participant selection was based on meeting the pre-specified selection criteria of a demonstrated receptiveness to the CLA and a demonstrated confidence, ability and enthusiasm to implement the approach within a school setting. The two study participants were given the opportunity to implement the CLA within a supportive school culture while on their first physical education teaching practicum.

Data collection and analysis: The data collection methods utilised were documentary evidence, in the form of PETE students' post lesson written reflections, primary researcher observations with written reflections and semi-structured student interviews undertaken within 1 week of the culmination of the practicum. These data sources were analysed collectively using thematic analysis to identify repeated patterns of meaning within the data.

Findings: As expected, implementing the CLA presented significant challenges to novice practitioners, due to the complex nature of student learning within a nonlinear informed approach. Specifically, the PETE students rarely detected any of the multiple pupil responses that 'unexpectedly' emerged from their modified learning environments. They also had difficulty manipulating the learning environment to facilitate the emergence of learners' tactical problem solving behaviour through the natural learning processes underpinning the CLA. *Conclusion:* For an evolution of physical education teaching practice to progress, it is important that PETE educators work together with the physical education department of a local school to support PETE students to effectively implement nonlinear informed approaches in a school environment. Opportunities need to be provided to allow PETE students to progressively develop their experiential knowledge and conceptual understanding of the exploratory learning processes underpinning a nonlinear approach.

Keywords: physical education; nonlinear pedagogy; constraints-led approach; ecological dynamics.

Introduction

In recent years, there has been considerable interest in the evolution of physical education teaching practice from a traditional *teacher-centred approach* to a *student-centred approach.* Rather than the teacher emphasising the reproduction of technical skills in a highly structured, de-contextualised environment, in the student-centred approach teachers are facilitators and students are challenged to critically interpret the practice environment and solve problems through individual exploration (Davids, Chow, and Shuttleworth 2005; Lee 2003; Richard and Wallian 2005). Student-centred approaches, with their emphasis on learning design that addresses individual needs, are important for effective learning as all learners do not learn the same way or at the same rate and are capable of finding different movement solutions in the same learning environment (Chow et al. 2011, 2013). Consequently, research has focused on questions about the changing conceptions of the teaching and learning process, that is, from how 'we' teach to how 'they' learn (Renshaw et al. 2016; Thorpe 2005a).

A contemporary theoretical model of motor learning could underpin learning design and the delivery of instruction and feedback adopted in physical education (Chow et al. 2013; Davids et al. 2015). There is increasing evidence that motor learning is not a linear process due to the differences between individual learners and the dynamic and complex interactions that occur in learning environments (Chow et al. 2011, 2013). Sudden progressions and regressions in performance level accompanied by periods of an absence of change are typically observed during the learning of motor skills, suggesting that learners behave like nonlinear systems (Liu, Mayer-Kress, and Newell 2006). To acknowledge that learners behave like nonlinear, complex neurobiological systems is the platform for a nonlinear informed physical education teaching approach, such as the Constraints-Led Approach (CLA).

The CLA has similar practical operational principles to Teaching Games for Understanding (TGfU) as both approaches challenge learners to solve common tactical problems through active exploration of representative practice environments, modified to regulate skill level and to emphasise particular aspects of performance (Bunker and Thorpe 1982; Thorpe 2005a; Renshaw et al. 2009). The essential distinguishing feature of the CLA is that its practice design and delivery of feedback and instruction is grounded in the contemporary motor learning theory of ecological dynamics within a nonlinear pedagogy (NLP) framework (Chow et al. 2011, 2013). Because of this it can be more accurately described as a learner-environment-centred approach rather than a student-centred approach (Renshaw et al. 2016). There is extensive theoretically-informed and empirical research evidence to demonstrate that adopting the CLA in practice effectively meets the skill acquisition and psychological needs of the individual performer (Barris, Farrow, and Davids 2014; Chow et al. 2007; Moy, Renshaw, and Davids 2016; Pinder, Davids, and Renshaw 2012; Renshaw, Oldham, and Bawden 2012).

Whilst pedagogical approaches like TGfU and many of its derivatives such as Game Sense have been proposed as being underpinned by more cognitivist frameworks, they could also be categorised as nonlinear informed pedagogical approaches as the motor learning theory of ecological dynamics has been proposed to provide a comprehensive theoretical framework to support their learning design (see Chow et al. 2016; Renshaw et al. 2016; Stolz and Pill 2014; Storey and Butler 2013; Tan, Chow, and Davids 2012).

According to Chow (2013), the CLA offers potential for enhancing teacher education in the 21st century. However, implementing a nonlinear CLA is thought to present unique challenges to physical education practitioners. For example, there is some concern that 'the dense academic language associated with the approach is acting as a key barrier in the take up of the CLA and resulting in a limited understanding of the key underpinning concepts and hence poor implementation' (Renshaw and Chow 2019, 103). Unlike a 'linear' traditional approach where the teacher is in control of a learning environment that produces a single predetermined and predictable learning outcome (Tinning and Rossi 2013), the emergence of multiple learning outcomes that are not predetermined and are difficult to predict are hallmarks of the complex nature of learning within a nonlinear approach (Chow et al. 2013; Davids, Button, and Bennett 2008). These multiple, less predictable learning outcomes that emerge as a consequence of the dynamic individual learner-environment interactions are thought to present significant challenges to practitioners (Chow 2013; Renshaw and Chow 2019).

To successfully implement a nonlinear approach, research has suggested that it is necessary for practitioners to have a clear understanding of the pedagogical principles of the teaching approach and its underpinning learning theory, a competent level of expertise and experiential knowledge in the sport being taught, the ability to effectively manipulate relevant task constraints to channel the emergence of desirable movement behaviours, and advanced observational and analytical skills including the ability to identify key rate limiters to an individual's performance (Butler 2014; Chow 2013; Hopper, Butler, and Storey 2009; Howarth 2005; Renshaw et al. 2016).

Physical Education Teacher Education (PETE) programmes have been identified as a critical point in time in the professional development of teachers to encourage the exploration of innovative teaching approaches (Light 2002; Moy et al. 2016). Therefore, empirical research is needed to identify the specific challenges associated with the complex nature of learning and the practical implications facing novice practitioners when adopting the CLA in a school physical education context. This is an important step in supporting preservice teachers to learn how to implement this and other complex nonlinear pedagogical approaches.

To this point, there is no empirical research that has investigated physical education practitioners' experiences associated with the complex nature of learning when implementing the CLA. However, there is empirical research that has investigated the learning related challenges facing preservice physical education teachers learning to implement other nonlinear informed approaches such as TGfU and the Games Concept Approach. These studies have found that preservice teachers' inexperience with, and lack of conceptual knowledge and understanding of the innovative teaching approach and its underpinning learning theory made it challenging for them to design appropriate games and implement the approach authentically using skills such as questioning (Gurvitch et al. 2008; Howarth 2005; Li and Cruz 2008; McNeill et al. 2004; Rossi et al. 2007; Wang and Ha 2009, 2012; Wright et al. 2006; Wright, McNeill, and Fry 2009).

Due to the uniqueness and complexity of these challenges, to help facilitate the adoption of nonlinear pedagogies such as the CLA, Renshaw and colleagues (2016) have suggested the engagement of researchers in supporting practitioners in the application of theory into practice. These symbiotic interactions would provide valuable information to help facilitate the adoption of nonlinear pedagogies by pre- and in-service teachers (Renshaw et al. 2016). PETE students are ideal candidates for research that investigates practitioners' adoption of nonlinear pedagogies as researchers are readily available to support them during their experience.

Aim of the study

This study aimed to explore two PETE students' experiences associated with the complex nature of learning to implement a nonlinear informed pedagogical approach, specifically the CLA, in a school physical education practicum setting. Aligned with the potential barriers highlighted above, the two PETE students were provided with guidance and support from the primary researcher and their supervising/co-operating teacher during the experience. Even though this level of support is beyond what is considered normal during a practicum experience, it was provided to enable the focus to be on the examination of the teaching and learning processes associated with the key nonlinear pedagogical principles implemented through the CLA. The practical implications of these findings would inform and improve the design and delivery of PETE programmes in preparing and supporting students to overcome identified challenges and effectively and authentically implement a NLP on practicum and in their future teaching careers. This has the potential to result in opportunities for enhanced student learning and performance of motor skills in physical education classes.

Method

Study design

A qualitative, case study methodology was employed since this research method allowed a rich, detailed and in-depth insight of the PETE students' experiences and perceptions of implementing a CLA (Creswell 2002). A qualitative case study is defined as an empirical inquiry that investigates a contemporary phenomenon within its real-life context utilising qualitative methods (Yin 2009). The 2 PETE students were the sole participants in the study and an in-depth investigation was used to portray an accurate account of their experiences transitioning from learning the CLA in their PETE programme to implementing CLA lessons in the real-life and dynamic context of their practicum. To do this, multiple sources of evidence were collected and triangulated. The case study research design has previously been used to examine both PETE students' and in-service teachers' experiences when delivering alternative pedagogies (Deenihan and MacPhail 2013; Ingersoll, Jenkins, and Lux 2014; O'Leary 2014). The key pedagogical principles of NLP associated with the complex and less predictable nature of learning within the nonlinear CLA, guided data collection and analysis.

Previous research indicates the school practicum is not a good place for novice preservice teachers to experiment with innovative, alternative teaching approaches. This is because of resistant conservative cultures of schools and many other hindrances such as limited space, large class sizes, inadequate class time, poor student discipline, students limited physical skill and lack of guidance by cooperating teachers (Gurvitch et al. 2008; Howarth 2005; Light and Butler 2005; McNeill et al. 2004; Rossi et al. 2007; Tinning et al. 2001; Wang and Ha 2009; 2012; Wright et al. 2006; Wright, McNeill, and Fry 2009; Zeichner and Tabachnik 1981). To overcome the research-identified hindrances, the study participants' lack of teaching experience and the expected challenges associated with implementing an emergent nonlinear approach, the research design incorporated a supportive and simplified teaching environment. To that end, the practicum placement site was deliberately chosen as it possessed a culture that encouraged innovative practice and acted as a supportive partner in the study. For example, the school allowed the primary researcher to embed himself full-time into the school physical education department throughout the study. This environment allowed the study focus to be on the examination of the teaching and learning process associated with implementing a nonlinear pedagogy, rather than previous research identified contextual hindrances. Also, class sizes were small, adequate space, sports equipment and lesson time was provided, selected classes consisted of pupils who were well-behaved, and generally well-skilled and experienced in a variety of sports. In line with the recommendation of Thorpe (2005b), to facilitate PETE students' identification of relevant tactical concepts, the subsequent planning of relevant learning experiences to achieve intended tactical outcomes, and the observation, interpretation and adaptation of game play, each participant was allocated a familiar sport in which they had successful and extensive playing experience and a self-reported depth of game content and tactical knowledge and understanding.

Participants

The number of participants in the study was constrained by the partner school's Health and Physical Education department who stipulated that they could only take two students in the university practicum placement period. These two PETE teachers were selected from a purposive sample of second-year PETE students from an Australian university. Participant selection was based on meeting the pre-specified selection criteria of a demonstrated receptiveness to the CLA and a demonstrated confidence, ability, willingness and enthusiasm to implement the approach within a school setting (Denzin and Lincoln 2005). This selection criteria would allow the best possibility to establish acceptable fidelity of the CLA and therefore enable the study to accurately investigate the teaching and learning process. For this study, potential participants were identified from within a group of ten PETE students who were recruited for an earlier study by the same primary researcher (see Moy et al. 2016). That study explored the features of a constraints-based PETE games unit that appealed to PETE recruits who were highly successful products of the traditional physical education teaching approach (i.e. state or national representative in sporting games). From this group two PETE students who met the selection criteria were individually approached to participate in the research study via email and subsequently accepted.

Max (pseudonym) was 20 years old at the time of the study and had a successful and extensive sporting background in soccer, volleyball and basketball. Melinda (pseudonym) was 19 years old at the time of the study and had a successful and extensive sporting background particularly in basketball and volleyball. Both students were high achievers as reflected by their outstanding university grades, and had ongoing experience outside university working with secondary school aged pupils, Max as a school boarding master and Melinda as a coach of various school sporting teams. The benefit of this previous experience was evident in their confident manner and control over learning environments they demonstrated in peer teaching episodes in the university setting. Both students were products of a very sports-oriented family environment, Melinda's mother having represented Australia in basketball and Max's father a long-term physical education teacher and sports coach. Max and Melinda were initially exposed to the CLA approach in a games unit in the first year of their PETE course, and further exposed to the CLA in two second-year units, including a curriculum unit. In this curriculum unit, taken by the primary researcher, they successfully implemented the CLA in small peer teaching environments. Melinda also independently chose to experiment with the CLA in her basketball coaching at a local school. To improve their knowledge and conceptual understanding of the alternative pedagogy and to gain further practical experience in its implementation, both Max and Melinda worked as tutor assistants in the introductory constraints-based PETE games unit immediately prior to the practicum experience. This involved them working closely with the tutor as learning facilitators in 8 x 4-hour practical workshops that adopted the key pedagogical principles of NLP underpinning the CLA. It is important to note that gender played no part in the choice of the two students as we were only interested in how pre-service level teachers experienced the task of implementing a CLA into a school setting, not to see if gender mediated their experiences.

Setting

The school

The two study participants were given the opportunity to implement the CLA within a supportive school culture while on their first physical education teaching practicum. The head of Marcellin College's (pseudonym) physical education department offered the opportunity for the research study to be undertaken with the school's physical education classes, as he was a strong advocate of the CLA. At the time of the study the head of physical education was employed by the primary researcher as a tutor in the constraints-based PETE games unit and had also implemented the CLA in his physical education classes and sports coaching. Marcellin College is an independent boys college in an inner city suburb of an Australian capital city, comprising over 1500 students. The college has a proud sporting history and culture and is well resourced in terms of oval space, equipment and facilities to run an effective physical education program. The college has six full-time and three part time physical education teachers, all male, covering the teaching of over 30 classes of physical education from Years 5 (10 year olds) to year 12 (17 year olds).

Practicum supervising teacher mentors

The selection of supervising or cooperating teachers for the study was based on their eagerness to be exposed to a new alternative pedagogy and a commitment to working with the primary researcher and the study participants throughout the entire 4-week length of their practicum. This commitment allowed both Max and Melinda to experiment implementing the CLA in at least one of their physical education classes and allowing the primary researcher to supervise and give guidance during this implementation. Melinda's allocated supervising teacher, Peter (pseudonym) had over 25 years of experience teaching physical education, while Max's cooperating teacher, Bernie (pseudonym), had over 12 years of experience. Both Peter and Bernie self-reported, to the primary researcher, the predominant use of a traditional drill-based physical education teaching approach in their classes. They both admitted to having no practical experience implementing the alternative approach in their own classes. This restricted their capability to provide feedback or advice specific to the CLA during the practicum, thus their role was secondary to the primary researcher, giving feedback to students purely from an organisational and discipline perspective such as behaviour management strategies and teacher positioning.

University mentor (primary researcher)

The primary researcher possessed extensive experience within schools to qualify for the role of mentor to the study participants, having taught physical education for over 25 years in Australian schools and supervised numerous PETE students on practicum in that time. While initially a ‘traditional’ teacher, he has gained much experience in the CLA through spending the previous seven years researching and applying the CLA in the university setting. A further layer of support was provided to the primary researcher by a university colleague, considered an expert within the field of contemporary skill acquisition and NLP. This colleague was readily available to the primary researcher throughout the practicum to discuss any ideas or problems related to the study.

CLA games teaching units

Max was allocated 8 x 60 minute soccer lessons with a year 9 class of twenty 14-year-old students, and Melinda was allocated 8 x 60 minute basketball lessons with a year 10 class of eighteen 15-year-old students, in which to implement the CLA over the 4-week practicum. As the CLA is an emergent pedagogical approach (Davids, Button, and Bennett 2008), and each session builds on the specific learning that takes place in the previous lesson, rather than following a set scheme of work that determines in advance each session's aims and objectives, lessons were planned progressively to help learners solve identified game-related tactical problems. The PETE students observed pupils’ participation in games in the first lesson of their respective units. From these observations, and in collaboration with the primary researcher, the PETE students identified common examples of pupils’ lack of tactical awareness when responding to a tactical problem in a game. The associated possible causes of their poor tactical response were also identified. The desired pupil learning outcome for each lesson was then written in terms of this tactical problem-solving behaviour.

(Table 1 near here)

Lesson planning followed a supportive process to ensure that the CLA learning design and delivery was authentically represented. Initially the PETE students independently designed a lesson plan incorporating learning experiences to achieve the desired learning outcome. To assist them they were provided with tutor workbooks used in the constraints-based PETE games unit. These workbooks contained many examples of games manipulated by constraints to solve common basketball and soccer related tactical and technical problems. The day prior to the lesson, each PETE student individually met with the primary researcher, who would evaluate their learning experiences with respect to the application of the key pedagogical principles of NLP embedded into a CLA learning design. These key pedagogical principles were self-organisation under constraint manipulation, representative practice design, task simplification, and implicit learning aligned with feedback and instruction focusing on external movement outcomes of an action (Chow et al. 2016). When required the plan was accordingly modified and returned (see Table 1 for an example). During the latter stage of the practicum, when the PETE students demonstrated increasing competence, they were given the opportunity to independently design modified learning environments to facilitate the emergence of a predetermined movement solution to a tactical problem.

Fidelity (valid representation of CLA and its implementation)

When investigating learning outcomes associated with the implementation of an alternative pedagogy, such as NLP, the learning experience design and delivery need to be considered as authentically representative of that pedagogy (Hastie and Casey 2014; Smith and Ragan 1999). To ensure this authenticity the key operational and pedagogical principles of NLP, as outlined by Renshaw et al. (2009) and Tan, Chow, and Davids (2012), guided the design and delivery of learning environments to allow players the opportunity to learn to solve game-related tactical problems. As the study participants were novice teachers and had limited instructional experience with the CLA it was accepted that establishing an 'ideal' model of the CLA would initially be beyond them. Therefore, for this study, a 'ball park' model of the CLA was deemed acceptable, conditional on the presence of key pedagogical features. To establish acceptable fidelity of the CLA this study incorporated a systematic observation of classes using a validation tool (see Table 2) to verify that the key contextual, operational and pedagogical requirements of the CLA were present in lessons conducted by the PETE students (Metzler 2005). This checklist was specifically generated by the primary researcher for use by tutors when observing PETE students implementing the CLA in university classes. The primary researcher observed all lessons referring to the checklist to verify that features were sufficiently present in the learning experiences for inclusion in the study. Acceptable validity was also established using a method adopted in previous similar studies of an expert independent observer who viewed and verified randomly selected lessons (Harvey, Cushion, and Massa-Gonzalez 2010; Harvey et al. 2010). Upon completion of this process the researcher was confident of the fidelity of implementation of lessons representing the key features of the CLA.

(Table 2 near here)

Data collection

The data collection methods utilised were documentary evidence, in the form of PETE students' post lesson written reflections, primary researcher observations with written reflections and semi-structured student interviews undertaken within 1 week of the culmination of the practicum. Ethical approval to conduct this study was sought and granted by the lead author's university's ethics committee.

Post lesson written reflections (PETE students)

Detailed post lesson written reflections acted as a means of creating the narrative of the PETE students' experiences and perceptions in implementing the CLA in a physical education class. The students completed a personal reflection using a structured template provided by the primary researcher and submitted it within 24 hours of the lesson completion. The personal reflection template incorporated contextual information about the lesson including date, activity, year level, class size, lesson duration, lesson number in series, game-related problem to address, and desired pupil problem-solving behaviour. PETE students' reflective responses were guided by four questions/requests, which incorporated a critical incident reflection (Flanagan 1954): (i) Reflecting on your knowledge about the constraints-led approach itself please tell me about your personal experiences of the effectiveness of the learning experiences in achieving the desired pupil learning outcome? (What happened? What behaviour was emergent? Did the constraint work (were desired outcomes achieved)? Anything unexpected, i.e. were different outcome achieved? Please provide evidence.); (ii) Reflecting on your skills in planning, how well did you plan the constraints-based learning experiences? (Identification of specific game problem and possible causes, design of game with constraint to allow students to solve problem and for desired behaviour to emerge. Please provide evidence); (iii) Reflecting on your skills in implementing the constraints-led approach, please tell me about your personal experiences in the lesson today, i.e. how well did you implement the learning experiences? (Hands-off involvement, class organisation, observation of emergent behaviour, instruction); (iv) Describe one critical incident about the constraints-led approach that you found particularly significant during the lesson (made you excited, shocked, worried). Please explain why it was significant.

Observations and post lesson written reflections (primary researcher)

The primary researcher observed and reflected upon all intervention lessons. The purpose of lesson observations was threefold: (1) to allow the researcher to 'experience' the lessons from a PETE educators' perspective (Cohen, Manion, and Morrison 2007); (2) to observe incidents that may go unnoticed by the participants (Patton 2002); and (3), to compare what experiences the PETE student reported in their reflections with what was observed. During each lesson the primary researcher kept a written record of his immediate observations and interpretations, and any reflective notes specifically focusing on the implementation of the constraint-based learning experiences by the study participants and the associated emergent pupil responses. Within 24 hours of the lesson observation, the researcher recorded his reflective responses and interpretations based on the written observations and reflective notes using the same personal reflection template completed by the PETE students.

Post Practicum Semi-structured interviews (PETE students)

At the completion of the practicum the primary researcher separately interviewed each PETE student. The face-to-face interviews were semi-structured in nature, consisting of open-ended questions designed to allow PETE students to elaborate on their perceptions and overall experiences implementing the CLA. Each interview, which lasted approximately 60 minutes, was audio taped and later transcribed verbatim. The following are examples of interview prompts: How successful were you at observing pupils' emergent behaviours (i.e. the pupil responses to game constraints)? From your experiences over the last four weeks, what have you learned about the skill of designing practice environments using constraints to help achieve specific student learning outcomes?

Data analysis

For each lesson, the PETE students' and researcher's post lesson written reflection were combined so all data relevant to each lesson were together. These data sources and the transcribed interview data were analysed collectively using thematic analysis to identify repeated patterns of meaning within the data (Braun and Clark 2006). This process involved the following steps: (1) repeated reading to become familiar with data, (2) coding raw data, (3) collating similar codes together into tentative themes, (4) reviewing, reducing and refining themes, and (5), defining and naming themes. Identical methods of data collection and data analysis have been adopted in recent similar studies investigating pre-service and in-service teachers' experiences when implementing alternative pedagogies (Deenihan and MacPhail 2013; Ingersoll, Jenkins, and Lux 2014; O'Leary 2014; Stran, Sinelnikov, and Woodruff 2012).

Trustworthiness of data

Trustworthiness is established when research findings authentically and accurately represent meanings as described by the participants (Lincoln and Guba 1985). In this study trustworthiness was established, and consequently findings were strengthened, through the triangulation of data from multiple sources to cross check information and support similar themes (Patton 2002). Further strategies used in this study to establish trustworthiness included ongoing peer debriefing between the researcher and two colleagues experienced in qualitative methodologies to check and share interpretations of data and arrive at consensus

(Creswell 2007). Participants were also given the opportunity to verify the accuracy of the content and researcher interpretations of interview transcripts and lesson reflections (Merriam 1998). Finally, at the conclusion of the analysis, a competent qualitative researcher was asked to review the original data and subsequent analysis of it (Lincoln and Guba 1985).

Results and Discussion

This empirical research study aimed to explore PETE students' experiences associated with the complex nature of learning when implementing a nonlinear informed pedagogical approach, specifically the CLA, with physical education students in a school practicum setting. As predicted by Chow (2013), implementing the CLA presented significant challenges to novice practitioners, due to the complex nature of student learning as a consequence of the dynamic individual learner-environment interactions. Despite the potential barriers, the support structure put in place enabled the students to successfully implement a CLA, however, there were a number of challenges. The following section identifies two prominent themes that were established from the data analysis related to this aim, (i) the detection of less predictable emergent pupil responses, and (ii), the manipulation of the learning environment to channel learners' search towards predetermined emergent problem solving behaviours.

The detection of less predictable emergent pupil responses

The PETE students had little difficulty detecting and interpreting the single predetermined pupil response predicted to emerge through exploration of the modified learning environment. For example, a modified football or soccer game was designed to solve the identified problem of loss of possession, due to players taking too many individual touches when under defensive pressure. The task constraint (rule) of a maximum of 8 consecutive touches per team was introduced to guide individual learners to search for the desired solution of taking fewer individual touches when under pressure, while scanning the performance environment and making decisions related to passing to an unmarked teammate. Max detected and interpreted the successful achievement of the predetermined intended learning outcome by many pupils in the class.

> I noticed that a highly skilled student, who was identified as a dominant selfish player, who previously took too many individual touches, achieving success from this game. This problem was solved in this game because I noticed him and other less skilled players, who previously just 'booted' the ball without looking, taking a touch and looking up for teammates who were open/unmarked in space. This game directed him and others to play the ball to unmarked teammates. (Reflection, Max)

However, as suggested by Chow (2013), the less predictable and complex nature of student learning proved a significant challenge to our novice practitioners when implementing a NLP. The PETE students rarely detected any of the multiple pupil responses that 'unexpectedly' emerged from their modified learning environments. Their lack of practical experience, experiential knowledge and conceptual understanding of this complex and dynamic interacting emergent learning process made it challenging for them to detect and interpret their learners' complex and less predictable responses to the game structures they created. When questioned about how successful she was at observing pupil's behaviour Melinda's response highlighted such difficulties.

> I found that a little bit more difficult when I had to referee everything, and when I had to... I had a lot on my mind, so I'm watching them to make sure that they're doing the rules properly, then I'm watching them to make sure that they're enforcing the constraint that I wanted, and I felt like it was a little bit harder to actually step back and see if they were doing the behaviour. You're not

constantly observing for the emergent behaviour, you're more focused on everything as a whole. (Interview, Melinda)

These findings are consistent with previous research that has suggested this deep understanding of the learning process, and advanced observational and analytical skills, are necessities to successfully teach an emergent nonlinear curriculum (Butler 2014; Chow 2013; Hopper, Butler, and Storey 2009; Howarth 2005). According to Howarth (2005) these skills are more likely to be found in an expert teacher than in pre-service teachers. The primary researcher in this study, who is considered an expert teacher, is testimony to this assumption. He detected and interpreted multiple less predictable emergent responses when afforded the luxury of observing lessons without the distraction of lesson management. For example, after observing the maximum 8 team touches soccer game he reflected:

> In the 8-touch soccer/football game I observed many 'unexpected' emergent behaviours. Teammates, now expecting a pass, were no longer congested around the ball and spread out across the width of the field to offer passing options. They received the ball in space, which allowed them time on the ball. Some players were now passing long to gain as much ground as possible with fewer touches remaining. So as not to waste touches, many players' body shape adapted to side on to receive the ball, which also opened up their field of vision. Overall the passing was quicker and more accurate, in response to the defence applying more pressure on the ball. (Reflection, primary researcher)

These responses are difficult to predict as, operating as a nonlinear system, a learner's response emerges as a consequence of the dynamic individual learner-environment interactions within the complexities of a team game (Chow et al. 2013). These less predictable individual responses are a consequence of the complex interactions of the individual learner's intrinsic dynamics, the game environment and the task constraints, within the game context (Chow and Atencio 2014; Chow et al. 2011, 2013; Renshaw et al. 2010). For example, in the maximum 8 consecutive team touches soccer game, a player's passing response is difficult to predict, as it is a consequence of the complex interaction of the individual player's kicking ability, the playing surface, the positioning of opponents and teammates, and the number of team touches remaining.

Adding to the difficulty in predicting learning outcomes within a NLP theoretical framework is the notion that team games are complex adaptive dynamical systems made up of a number of interacting sub-systems that can abruptly change (Davids et al. 2003). Behaviour emerges in such complex systems as spontaneous patterns are formed from the interactions of individual players within the team game (Kauffman 1993). Within a team game, individual players function as part of this larger system co-adapting their actions to the actions of teammates and opposition players (Kauffman 1993; Passos et al. 2008; Passos and Davids 2015). For example, in the maximum 8 consecutive team touches soccer game the actions of the player in possession of the ball, their teammates, and opposition players are systematically related to each other, that is, when players started passing rather than dribbling, teammates responded by moving into space to receive the ball and opponents pressured the ball carrier. These co-adaptive and regulated interactions result in ongoing information that is emergent, necessitating emergent actions in response, thus making it difficult to predict or prescribe players' behaviours or sequences of play as a consequence of the introduction of a constraint. These player interactions can be further influenced by factors such as field location (Headrick et al. 2012). This unpredictability was highlighted and interpreted by Melinda in the following reflection:

> I think that the students did learn, however they did not often perform the way I intended or predicted, that is, they did not utilize the wide immunity zones. From this lesson, I learned that

> introducing a constraint can have several emergent behaviours, sometimes none of which are the desired one. (Reflection, Melinda)

Further complicating game play prediction for practitioners is that, from an ecological dynamics perspective, a player's behaviour is attuned to their own action capabilities and those of their teammates and opponents, making affordances subjective to the individual (Fajen, Riley, and Turvey 2009). Different opponents and teammates afford different movement possibilities and different game play patterns emerge when challenged to play with and against different opponents. For example, if a player has the capability to accurately pass long to a competently skilled teammate who is in space, the free player acts as an affordance for action. However, if the player in possession knows that the free player is poorly skilled at controlling a long pass and that the closest defender is quick and skilful at interception, the long pass may be considered, but not executed. To better understand and interpret players' responses a teacher needs to be able to perceive these affordances from the perspective of the players rather than their own **(**Fajen, Riley, and Turvey 2009).

However, with 2 weeks of experience of teaching a NLP, in combination with guidance from the primary researcher, the PETE students quickly developed a better understanding and awareness of the complex interactions that occur within the dynamics of a team game. This resulted in improved detection of these varied and less predictable emergent game play patterns. For example, to solve the problem of basketball players shooting from low percentage court positions, Melinda introduced the task constraint of extra points if a team scored from a shot taken from inside the keyway. As well as detecting the expected response of players shooting from closer to the basket, Melinda detected and interpreted the unpredicted emergent response from the offence of cutting towards the basket to receive the ball rather than waiting outside the keyway for the pass, as they had done previously. PETE students reported an improved ability to detect less predictable emergent behaviour with experience. For example, in response to a question about how successful he was at observing emerging behaviour over the four weeks, Max replied:

> I wasn't very successful at the start. I did get better as the prac went on. At the start I had to focus a lot about how to get the games going, and explaining the games, and refereeing the games. Once I was able to implement them more successfully and easier, and take more of a hands-off approach, I could just sit back and watch a game and really observe behaviours and adapt. So by the end of it I think I was getting quite good at it. (Interview, Max)

The manipulation of the learning environment

The ability to manipulate the learning environment to facilitate the emergence of learners' tactical problem solving behaviour is considered a crucial ingredient to successfully teach student-centred, game-based approaches (Howarth 2005). In the first 2 weeks of the practicum, to ensure that the CLA learning design and delivery was authentically represented, modified learning environments were either taken directly from resources used in the previously completed constraints-based PETE games unit or designed by the PETE students in collaboration with the primary researcher. These learning environments were generally successful in channelling learner's search towards predetermined emergent movement solutions to tactical problems. For example, when asked what helped him most in the initial weeks to design games Max responded:

> It would have to be the games unit booklet, really, because even sports and game designs that were in the games booklet, I could sometimes use the constraints from that for other sports. (Reflection, Max)

During the latter stage of the practicum the PETE students were given the opportunity to independently design and implement modified learning environments to achieve this same outcome, without any collaboration with the primary researcher. This task proved challenging for the PETE students as demonstrated by Max's quote below:

> ….because I was designing brand new games, to think of a basketball game and what behaviour was going to emerge was... it was quite tough, even for me who had experience in basketball and played quite a bit of basketball myself. (Interview, Max)

Although the modified learning environments they designed were often successful in generating the predetermined movement solution to a tactical problem, their task constraints provided limited opportunity for this problem-solving behaviour to emerge through the natural, exploratory learning processes underpinning the CLA. For example, a tactical problem identified in Melinda's basketball class was that the attacking players easily penetrated forward through the defence, as the nearest defender did not pressure their opponent with the ball when he threatened space in front of them. To achieve the desired problem solving behaviour of defensive pressure on the attacker with the ball, Melinda manipulated the game design by introducing the rule or instructional task constraint that, if the player with the ball is tagged, possession is transferred to the defending team. Her reasoning was that, by introducing a constraint that rewards defensive pressure, players would pressure the ball carrier and force the attack back or across or force an error. The result was that the nearest defending player constantly pressured the ball carrier.

> Prior to this lesson, students all stood around and allowed the person with the ball to dribble or pass forward without pressure. In this game, the desired behaviour emerged as students constantly pressured the player with the ball. (Reflection, Melinda)

Although this instructional task constraint was successful in generating the predetermined problem solving behaviour, it constructed a very narrow space for task exploration, provoking learners' search for an imposed single solution of pressuring the ball carrier. This happened regardless of the existence of the key affordance of an attacker threatening to penetrate forward through the defence. This design feature denied learners the opportunity to explore a range of possible solutions within a broader space for task exploration and for their individual functional movement solution to emerge implicitly through the process of self-organisation under interacting constraints (Chow 2013; Davids, Button, and Bennett 2008). Finding the right balance to ensure that task constraints provide a tight, controlled boundary, as well as opportunities for exploring functional problem solving behaviours is a challenge even for experienced learning designers (Chow et al. 2011). When the manipulated environment provokes learners' search for an imposed single 'selected' solution, players learn the technical skills associated with '*what*' to do, but do not have the opportunity to learn the perception and decision-making associated with that tactical response, that is, '*when*' to do it. This type of restrictive instructional task constraint is better used to pose a single tactical problem (key affordance) to the learner, necessitating the generation of exploratory problem solving behaviours in response (action).

PETE students' use of instructional constraints, that prescribed tactical movement solutions rather than facilitated opportunities for them to implicitly emerge, exposed a lack of conceptual understanding of the natural exploratory learning processes underpinning the CLA and the co-adaptive and regulated interactions that occur within the dynamics of a team game. This finding is consistent with previous research suggesting that a conceptual understanding of the learning process, necessary to successfully implement an emergent nonlinear curriculum, would unlikely be found in a pre-service teacher (Butler 2014; Chow 2013**;** Hopper, Butler, and Storey 2009; Howarth 2005).

However, with some weeks of experience implementing the CLA and observing and reflecting on pupil's responses, PETE students' game design demonstrated an improved understanding of the implicit learning process underpinning the CLA. For example, Max modified a soccer/football learning environment using a task (instructional) constraint of: 'when a player with the ball is tagged by an opponent they lose possession'. He did this to exaggerate the tactical problem or affordance of defensive pressure, and challenge the attacking team to search for functional movement solutions in response. When confronted with defensive pressure, players' responses included Max's desired co-adaptive emergent learning outcome of utilising the width of the field in attack to spread the defence as well as other responses such as the use of a back pass to an unmarked teammate. Exaggeration of affordances assists the learner in becoming more attuned to the pertinent environmental parameters within their search for functional movement solutions (Tan, Chow, and Davids 2012). PETE students reported an improved ability to design games that worked in facilitating the emergence of learners' tactical problem solving behaviour.

> I think I was fairly successful. I think I got better as it went along. Initially I was very reliant on the games booklet, but when I started teaching and started watching the students more and seeing what they were capable of it got a bit easier. And then eventually I was starting to adapt a lot of the games from the games booklet and use good constraints that worked well. (Interview, Melinda)

Study limitations and practical implications

This study was carried out with two participants over a relatively short duration of 4 weeks, thus restricting the generalisability of the findings. However, recognising these limitations, the study findings still achieved the aim of providing some useful insights for PETE practitioners and PETE practice. These implementation challenges facing practitioners can be used to inform and improve the design and delivery of PETE programmes in preparing and supporting PETE students to effectively implement the CLA and other nonlinear informed games based approaches in a school environment. Whilst the challenges of implementing nonlinear pedagogical approaches such as the CLA must not be under-estimated, that the two PETE students were able to become more effective highlights that implementation opportunities early in teaching careers are highly beneficial (Stran and Curtner-Smith, 2010). With the appropriate level of support novice teachers are able to implement a CLA without in-depth understanding of the theoretical model, however, this process should be seen as a journey and future research should follow the careers of preservice teachers to examine their future engagement with a CLA. In line with the findings of Atencio and colleagues (2014) on the implementation of the CLA in primary schools, and studies from other innovative pedagogies (e.g, Stran and Curtner-Smith, 2010 in Sport Education and Wang and Ha 2012 in TGfU) the results of this study go some way to allay fears that beginner level teachers need a high level of theoretical and pedagogical knowledge before they can (and should) be allowed to implement new pedagogical approaches such as CLA in their teaching practice.

These findings highlight the need for PETE students to develop their experiential knowledge and conceptual understanding of how to teach using a CLA through authentic games teaching experiences (Stran and Curtner-Smith 2010). To achieve this aim, university PETE programmes must provide students with ‘safe’ opportunities to work with children so they can understand the range of emergent behaviours possible within a constraint manipulated game, and incorporate opportunities for PETE students to develop their skills in the detection and interpretation of these multiple emergent player responses. This is a difficult task, particularly when considering the dynamic and complex interactions between teammates and opponents inherent in invasion games. Thus, these skills should be progressively developed, starting with simple environments, for example, observing a 1 v 1 game from the ‘sideline’, and working towards more complex observations and interpretations of small-sided team games from a teacher’s perspective. These observations and interpretations would help PETE students gain a practical understanding of the dynamic, complex, and interacting nature of a player’s emergent individual response resulting from exposure to constraints.

PETE programmes must also incorporate opportunities for students to learn to design modified learning environments that enable learners to attune to key information sources in their search for solutions to a tactical or technical problem. This rigorous learning design must follow a structure that incorporates the careful manipulation of representative practice environments using task constraints that: (i) emphasise (exaggerate) the tactical problem or key affordances for the desired action/outcome, to make them obviously detectable and challenge learners to search for a solution, and (ii), channel learners’ search within a narrower area (limited number of movement solutions) of the modified practice environment towards ‘selected’ and more ‘obvious’ functional movement solutions (the ‘to-be-taught’ concept). These modified learning environments then should be implemented by PETE students, ensuring that constraints are properly in place, and interpreted in terms of the emergence of predetermined and less predictable solutions in accordance with the implicit learning process of system self-organisation under interacting constraints.

Future research

For physical education teaching practice to progress, it is important that the learning-related practical recommendations from this research study are embedded into a PETE programme and future research investigates their effectiveness in preparing PETE students to authentically implement the CLA in a school environment. To support this process, PETE educators need to work together with the physical education department of a local school to provide opportunities for PETE students to independently apply their newly developed skills, experiential knowledge and conceptual understanding of the CLA with smaller groups of students in a physical education lesson. From such research, the effectiveness of the learning-related practical recommendations can be evaluated and further issues surrounding the practical challenges associated with the authentic design and delivery of a NLP in the school environment can be identified.

Conclusion

This study has identified the challenges associated with implementing a NLP within a CLA in a school setting. In contrast to popular traditional 'linear' pedagogies the physical education teacher implementing a NLP must relinquish 'control' over the learning environment, and be prepared for learning outcomes that are less predictable due to the dynamic individual learner-environment interactions from which learning occurs. This is a difficult process of change for practitioners comfortable in the predictability of traditional teaching environments. However, unlike the traditional 'linear' pedagogies, NLP provides a sound theoretical model of the learning process, which can inform learning design and delivery within physical education. Incorporating these study recommendations into a PETE programme can support students to effectively implement the CLA and other nonlinear informed games based approaches in a school environment. The potential of a nonlinear pedagogical approach for enhanced student learning of motor skills in physical education is evident in a response by Max in summing up his practicum experience:

> I believe in the constraints-led approach, because yeah, whenever I talk to anyone about it or teach it in class, I really believe that it's the best way to go. And my background being so traditional and drill-based, to go and teach these boys this new approach, and to see the learning that occurs implicitly, without me telling them to do anything, you know it still blows me away to this day.

Yeah. I saw it... like I've seen it working at uni now, and I've seen it working in schools, and I've seen kids enjoying it. (Interview, Max)

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Table 1. Example of learning environment designed to solve an identified common game-related problem, guided by key NLP pedagogical principles.

Lesson Context:
Sport: Soccer/Football **Year Level:** 10 **CLASS SIZE:** 20 **Duration:** 60 mins

Principle of Play: Maintaining Possession

Common Student Tactical Awareness Problem: When players in possession of the ball are confronted with the tactical problem of defensive pressure they often surrender ball possession.

Possible Cause Of Problem: Support – Players do not have time to scan for available passing options, thus rush the pass.

Desired Pupil Tactical Problem Solving Behaviour: When a defender pressures the player with the ball (problem), they scan for opportunities and pass to an unmarked teammate (solution).

Modified Representative Practice Task: "Safe Passing" (6 v 6, normal rules)

Task Constraint to present 'obvious' solution (affordance/opportunity for action):
First touch immunity: Players with ball have a maximum of 3 touches before losing possession. However, after the first touch they are allowed 3 seconds of immunity, i.e. cannot be tackled by defenders who must retreat 1 metre.
Task Simplification: Floating player who plays on attacking team, creating 7 v 6

Justification of Constraint, i.e. how it emphasises the problem and channels students search towards the selected student learning outcome

The task constraint of a maximum of 3 touches will emphasise the problem of the player with the ball being under pressure to pass, channelling them to pass to a teammate to maintain possession. The attacking teammates should detect this affordance for action and support their teammate by moving into space off the ball to provide forward, lateral and backward passing options. The 3 second immunity allows players time and space to scan and look for unmarked teammates to pass to.

Table 2. CLA Lesson Observation Checklist (adapted from Chow et al. 2016)

Key Contextual, Operational and Pedagogical Requirements of the CLA	√

Key Contextual, Operational and Pedagogical Requirements of the CLA	√
Practice Environment Representative of Performance Environment:	
• Key information sources present (e.g. defenders)	
• Simplified environment (e.g. small-sided game; immunity; floating player)	
Task constraints in place to:	
• Emphasise (exaggerate) the tactical problem	
• Present 'obvious' solution to the tactical problem (affordance)	
Exploratory Facilitation	
• Teacher uses 'hands off' approach	
• Learners given the freedom & time to subconsciously explore environment	
• Problem solving behaviour allowed to emerge implicitly	
Teacher Instruction and Feedback:	
• Performance outcome oriented (tell pupils what to do, not how to do it)	
• Focus on external movement outcomes of action (e.g. kick ball at target)	