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1 **Preservice teachers implementing a nonlinear physical education**
2 **pedagogy**

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1 **Preservice teachers implementing a nonlinear physical education pedagogy**

2
3 *Background:* In recent years, there has been considerable interest in the evolution of physical education teaching
4 practice from a traditional *teacher-centred approach* to a *student-centred approach*. Consequently, research has
5 focused on questions about the changing conceptions of the teaching and learning process, that is, from how
6 ‘we’ teach to how ‘they’ learn. A contemporary theoretical model of the teaching and learning process could
7 underpin learning design and delivery adopted in physical education. The Constraints Led Approach (CLA) is a
8 viable alternative as its practice design and delivery is grounded in the contemporary motor learning theory of
9 ecological dynamics within a nonlinear pedagogy framework. However, its implementation is thought to present
10 unique challenges to physical education practitioners due to the dynamic individual learner-environment
11 interactions from which learning occurs. For this reason, it has been suggested that researchers work
12 symbiotically with practitioners to help facilitate the adoption of nonlinear pedagogies and provide valuable
13 information regarding the application of theory into practice.

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

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

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

27 *Findings:* As expected, implementing the CLA presented significant challenges to novice practitioners, due to
28 the complex nature of student learning within a nonlinear informed approach. Specifically, the PETE students
29 rarely detected any of the multiple pupil responses that ‘unexpectedly’ emerged from their modified learning

1 environments. They also had difficulty manipulating the learning environment to facilitate the emergence of
2 learners' tactical problem solving behaviour through the natural learning processes underpinning the CLA.

3 *Conclusion:* For an evolution of physical education teaching practice to progress, it is important that PETE
4 educators work together with the physical education department of a local school to support PETE students to
5 effectively implement nonlinear informed approaches in a school environment. Opportunities need to be
6 provided to allow PETE students to progressively develop their experiential knowledge and conceptual
7 understanding of the exploratory learning processes underpinning a nonlinear approach.

8
9 **Keywords:** physical education; nonlinear pedagogy; constraints-led approach; ecological dynamics.

10

1 **Introduction**

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

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

24 The CLA has similar practical operational principles to Teaching Games for
25 Understanding (TGfU) as both approaches challenge learners to solve common tactical

1 problems through active exploration of representative practice environments, modified to
2 regulate skill level and to emphasise particular aspects of performance (Bunker and Thorpe
3 1982; Thorpe 2005a; Renshaw et al. 2009). The essential distinguishing feature of the CLA is
4 that its practice design and delivery of feedback and instruction is grounded in the
5 contemporary motor learning theory of ecological dynamics within a nonlinear pedagogy
6 (NLP) framework (Chow et al. 2011, 2013). Because of this it can be more accurately described
7 as a learner-environment-centred approach rather than a student-centred approach (Renshaw et
8 al. 2016). There is extensive theoretically-informed and empirical research evidence to
9 demonstrate that adopting the CLA in practice effectively meets the skill acquisition and
10 psychological needs of the individual performer (Barris, Farrow, and Davids 2014; Chow et al.
11 2007; Moy, Renshaw, and Davids 2016; Pinder, Davids, and Renshaw 2012; Renshaw,
12 Oldham, and Bawden 2012).

13 Whilst pedagogical approaches like TGfU and many of its derivatives such as Game
14 Sense have been proposed as being underpinned by more cognitivist frameworks, they could
15 also be categorised as nonlinear informed pedagogical approaches as the motor learning theory
16 of ecological dynamics has been proposed to provide a comprehensive theoretical framework
17 to support their learning design (see Chow et al. 2016; Renshaw et al. 2016; Stolz and Pill
18 2014; Storey and Butler 2013; Tan, Chow, and Davids 2012).

19 According to Chow (2013), the CLA offers potential for enhancing teacher education in
20 the 21st century. However, implementing a nonlinear CLA is thought to present unique
21 challenges to physical education practitioners. For example, there is some concern that ‘the
22 dense academic language associated with the approach is acting as a key barrier in the take up
23 of the CLA and resulting in a limited understanding of the key underpinning concepts and
24 hence poor implementation’ (Renshaw and Chow 2019, 103). Unlike a ‘linear’ traditional
25 approach where the teacher is in control of a learning environment that produces a single

1 predetermined and predictable learning outcome (Tinning and Rossi 2013), the emergence of
2 multiple learning outcomes that are not predetermined and are difficult to predict are hallmarks
3 of the complex nature of learning within a nonlinear approach (Chow et al. 2013; Davids,
4 Button, and Bennett 2008). These multiple, less predictable learning outcomes that emerge as
5 a consequence of the dynamic individual learner-environment interactions are thought to
6 present significant challenges to practitioners (Chow 2013; Renshaw and Chow 2019).

7 To successfully implement a nonlinear approach, research has suggested that it is
8 necessary for practitioners to have a clear understanding of the pedagogical principles of the
9 teaching approach and its underpinning learning theory, a competent level of expertise and
10 experiential knowledge in the sport being taught, the ability to effectively manipulate relevant
11 task constraints to channel the emergence of desirable movement behaviours, and advanced
12 observational and analytical skills including the ability to identify key rate limiters to an
13 individual's performance (Butler 2014; Chow 2013; Hopper, Butler, and Storey 2009; Howarth
14 2005; Renshaw et al. 2016).

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

22 To this point, there is no empirical research that has investigated physical education
23 practitioners' experiences associated with the complex nature of learning when implementing
24 the CLA. However, there is empirical research that has investigated the learning related
25 challenges facing preservice physical education teachers learning to implement other nonlinear

1 informed approaches such as TGfU and the Games Concept Approach. These studies have
2 found that preservice teachers' inexperience with, and lack of conceptual knowledge and
3 understanding of the innovative teaching approach and its underpinning learning theory made
4 it challenging for them to design appropriate games and implement the approach authentically
5 using skills such as questioning (Gurvitch et al. 2008; Howarth 2005; Li and Cruz 2008;
6 McNeill et al. 2004; Rossi et al. 2007; Wang and Ha 2009, 2012; Wright et al. 2006; Wright,
7 McNeill, and Fry 2009).

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

15

16 *Aim of the study*

17 This study aimed to explore two PETE students' experiences associated with the complex
18 nature of learning to implement a nonlinear informed pedagogical approach, specifically the
19 CLA, in a school physical education practicum setting. Aligned with the potential barriers
20 highlighted above, the two PETE students were provided with guidance and support from the
21 primary researcher and their supervising/co-operating teacher during the experience. Even
22 though this level of support is beyond what is considered normal during a practicum
23 experience, it was provided to enable the focus to be on the examination of the teaching and
24 learning processes associated with the key nonlinear pedagogical principles implemented
25 through the CLA. The practical implications of these findings would inform and improve the

1 design and delivery of PETE programmes in preparing and supporting students to overcome
2 identified challenges and effectively and authentically implement a NLP on practicum and in
3 their future teaching careers. This has the potential to result in opportunities for enhanced
4 student learning and performance of motor skills in physical education classes.

5

6 **Method**

7 *Study design*

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

21 Previous research indicates the school practicum is not a good place for novice
22 preservice teachers to experiment with innovative, alternative teaching approaches. This is
23 because of resistant conservative cultures of schools and many other hindrances such as limited
24 space, large class sizes, inadequate class time, poor student discipline, students limited physical
25 skill and lack of guidance by cooperating teachers (Gurvitch et al. 2008; Howarth 2005; Light

1 and Butler 2005; McNeill et al. 2004; Rossi et al. 2007; Tinning et al. 2001; Wang and Ha
2 2009; 2012; Wright et al. 2006; Wright, McNeill, and Fry 2009; Zeichner and Tabachnik 1981).
3 To overcome the research-identified hindrances, the study participants' lack of teaching
4 experience and the expected challenges associated with implementing an emergent nonlinear
5 approach, the research design incorporated a supportive and simplified teaching environment.
6 To that end, the practicum placement site was deliberately chosen as it possessed a culture that
7 encouraged innovative practice and acted as a supportive partner in the study. For example, the
8 school allowed the primary researcher to embed himself full-time into the school physical
9 education department throughout the study. This environment allowed the study focus to be on
10 the examination of the teaching and learning process associated with implementing a nonlinear
11 pedagogy, rather than previous research identified contextual hindrances. Also, class sizes were
12 small, adequate space, sports equipment and lesson time was provided, selected classes
13 consisted of pupils who were well-behaved, and generally well-skilled and experienced in a
14 variety of sports. In line with the recommendation of Thorpe (2005b), to facilitate PETE
15 students' identification of relevant tactical concepts, the subsequent planning of relevant
16 learning experiences to achieve intended tactical outcomes, and the observation, interpretation
17 and adaptation of game play, each participant was allocated a familiar sport in which they had
18 successful and extensive playing experience and a self-reported depth of game content and
19 tactical knowledge and understanding.

20

21 *Participants*

22 The number of participants in the study was constrained by the partner school's Health and
23 Physical Education department who stipulated that they could only take two students in the
24 university practicum placement period. These two PETE teachers were selected from a
25 purposive sample of second-year PETE students from an Australian university. Participant

1 selection was based on meeting the pre-specified selection criteria of a demonstrated
2 receptiveness to the CLA and a demonstrated confidence, ability, willingness and enthusiasm
3 to implement the approach within a school setting (Denzin and Lincoln 2005). This selection
4 criteria would allow the best possibility to establish acceptable fidelity of the CLA and
5 therefore enable the study to accurately investigate the teaching and learning process. For this
6 study, potential participants were identified from within a group of ten PETE students who
7 were recruited for an earlier study by the same primary researcher (see Moy et al. 2016). That
8 study explored the features of a constraints-based PETE games unit that appealed to PETE
9 recruits who were highly successful products of the traditional physical education teaching
10 approach (i.e. state or national representative in sporting games). From this group two PETE
11 students who met the selection criteria were individually approached to participate in the
12 research study via email and subsequently accepted.

13 Max (pseudonym) was 20 years old at the time of the study and had a successful and
14 extensive sporting background in soccer, volleyball and basketball. Melinda (pseudonym) was
15 19 years old at the time of the study and had a successful and extensive sporting background
16 particularly in basketball and volleyball. Both students were high achievers as reflected by their
17 outstanding university grades, and had ongoing experience outside university working with
18 secondary school aged pupils, Max as a school boarding master and Melinda as a coach of
19 various school sporting teams. The benefit of this previous experience was evident in their
20 confident manner and control over learning environments they demonstrated in peer teaching
21 episodes in the university setting. Both students were products of a very sports-oriented family
22 environment, Melinda's mother having represented Australia in basketball and Max's father a
23 long-term physical education teacher and sports coach. Max and Melinda were initially
24 exposed to the CLA approach in a games unit in the first year of their PETE course, and further
25 exposed to the CLA in two second-year units, including a curriculum unit. In this curriculum

1 unit, taken by the primary researcher, they successfully implemented the CLA in small peer
2 teaching environments. Melinda also independently chose to experiment with the CLA in her
3 basketball coaching at a local school. To improve their knowledge and conceptual
4 understanding of the alternative pedagogy and to gain further practical experience in its
5 implementation, both Max and Melinda worked as tutor assistants in the introductory
6 constraints-based PETE games unit immediately prior to the practicum experience. This
7 involved them working closely with the tutor as learning facilitators in 8 x 4-hour practical
8 workshops that adopted the key pedagogical principles of NLP underpinning the CLA. It is
9 important to note that gender played no part in the choice of the two students as we were only
10 interested in how pre-service level teachers experienced the task of implementing a CLA into
11 a school setting, not to see if gender mediated their experiences.

12

13 *Setting*

14 *The school*

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

1 covering the teaching of over 30 classes of physical education from Years 5 (10 year olds) to
2 year 12 (17 year olds).

3

4 *Practicum supervising teacher mentors*

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

20

21 *University mentor (primary researcher)*

22 The primary researcher possessed extensive experience within schools to qualify for the role
23 of mentor to the study participants, having taught physical education for over 25 years in
24 Australian schools and supervised numerous PETE students on practicum in that time. While
25 initially a 'traditional' teacher, he has gained much experience in the CLA through spending

1 the previous seven years researching and applying the CLA in the university setting. A further
2 layer of support was provided to the primary researcher by a university colleague, considered
3 an expert within the field of contemporary skill acquisition and NLP. This colleague was
4 readily available to the primary researcher throughout the practicum to discuss any ideas or
5 problems related to the study.

6

7 *CLA games teaching units*

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

21

22

(Table 1 near here)

23

24

25

Lesson planning followed a supportive process to ensure that the CLA learning design
and delivery was authentically represented. Initially the PETE students independently designed

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

15

16 ***Fidelity (valid representation of CLA and its implementation)***

17 When investigating learning outcomes associated with the implementation of an alternative
18 pedagogy, such as NLP, the learning experience design and delivery need to be considered as
19 authentically representative of that pedagogy (Hastie and Casey 2014; Smith and Ragan 1999).
20 To ensure this authenticity the key operational and pedagogical principles of NLP, as outlined
21 by Renshaw et al. (2009) and Tan, Chow, and Davids (2012), guided the design and delivery
22 of learning environments to allow players the opportunity to learn to solve game-related tactical
23 problems. As the study participants were novice teachers and had limited instructional
24 experience with the CLA it was accepted that establishing an 'ideal' model of the CLA would
25 initially be beyond them. Therefore, for this study, a 'ball park' model of the CLA was deemed

1 acceptable, conditional on the presence of key pedagogical features. To establish acceptable
2 fidelity of the CLA this study incorporated a systematic observation of classes using a
3 validation tool (see Table 2) to verify that the key contextual, operational and pedagogical
4 requirements of the CLA were present in lessons conducted by the PETE students (Metzler
5 2005). This checklist was specifically generated by the primary researcher for use by tutors
6 when observing PETE students implementing the CLA in university classes. The primary
7 researcher observed all lessons referring to the checklist to verify that features were sufficiently
8 present in the learning experiences for inclusion in the study. Acceptable validity was also
9 established using a method adopted in previous similar studies of an expert independent
10 observer who viewed and verified randomly selected lessons (Harvey, Cushion, and Massa-
11 Gonzalez 2010; Harvey et al. 2010). Upon completion of this process the researcher was
12 confident of the fidelity of implementation of lessons representing the key features of the CLA.

13
14 (Table 2 near here)

15 16 ***Data collection***

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

22 23 ***Post lesson written reflections (PETE students)***

24 Detailed post lesson written reflections acted as a means of creating the narrative of the PETE
25 students' experiences and perceptions in implementing the CLA in a physical education class.

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

21

22 *Observations and post lesson written reflections (primary researcher)*

23 The primary researcher observed and reflected upon all intervention lessons. The purpose of
24 lesson observations was threefold: (1) to allow the researcher to 'experience' the lessons from
25 a PETE educators' perspective (Cohen, Manion, and Morrison 2007); (2) to observe incidents

1 that may go unnoticed by the participants (Patton 2002); and (3), to compare what experiences
2 the PETE student reported in their reflections with what was observed. During each lesson the
3 primary researcher kept a written record of his immediate observations and interpretations, and
4 any reflective notes specifically focusing on the implementation of the constraint-based
5 learning experiences by the study participants and the associated emergent pupil responses.
6 Within 24 hours of the lesson observation, the researcher recorded his reflective responses and
7 interpretations based on the written observations and reflective notes using the same personal
8 reflection template completed by the PETE students.

9

10 *Post Practicum Semi-structured interviews (PETE students)*

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

20

21 *Data analysis*

22 For each lesson, the PETE students' and researcher's post lesson written reflection were
23 combined so all data relevant to each lesson were together. These data sources and the
24 transcribed interview data were analysed collectively using thematic analysis to identify
25 repeated patterns of meaning within the data (Braun and Clark 2006). This process involved

1 the following steps: (1) repeated reading to become familiar with data, (2) coding raw data, (3)
2 collating similar codes together into tentative themes, (4) reviewing, reducing and refining
3 themes, and (5), defining and naming themes. Identical methods of data collection and data
4 analysis have been adopted in recent similar studies investigating pre-service and in-service
5 teachers' experiences when implementing alternative pedagogies (Deenihan and MacPhail
6 2013; Ingersoll, Jenkins, and Lux 2014; O'Leary 2014; Stran, Sinelnikov, and Woodruff 2012).

7 *Trustworthiness of data*

8 Trustworthiness is established when research findings authentically and accurately represent
9 meanings as described by the participants (Lincoln and Guba 1985). In this study
10 trustworthiness was established, and consequently findings were strengthened, through the
11 triangulation of data from multiple sources to cross check information and support similar
12 themes (Patton 2002). Further strategies used in this study to establish trustworthiness included
13 ongoing peer debriefing between the researcher and two colleagues experienced in qualitative
14 methodologies to check and share interpretations of data and arrive at consensus (Creswell
15 2007). Participants were also given the opportunity to verify the accuracy of the content and
16 researcher interpretations of interview transcripts and lesson reflections (Merriam 1998).
17 Finally, at the conclusion of the analysis, a competent qualitative researcher was asked to
18 review the original data and subsequent analysis of it (Lincoln and Guba 1985).

19

20 **Results and Discussion**

21 This empirical research study aimed to explore PETE students' experiences associated with the
22 complex nature of learning when implementing a nonlinear informed pedagogical approach,
23 specifically the CLA, with physical education students in a school practicum setting. As
24 predicted by Chow (2013), implementing the CLA presented significant challenges to novice
25 practitioners, due to the complex nature of student learning as a consequence of the dynamic

1 individual learner-environment interactions. Despite the potential barriers, the support
2 structure put in place enabled the students to successfully implement a CLA, however, there
3 were a number of challenges. The following section identifies two prominent themes that were
4 established from the data analysis related to this aim, (i) the detection of less predictable
5 emergent pupil responses, and (ii), the manipulation of the learning environment to channel
6 learners' search towards predetermined emergent problem solving behaviours.

7

8 *The detection of less predictable emergent pupil responses*

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

19

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

25 (Reflection, Max)

26

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

10
11 I found that a little bit more difficult when I had to referee everything, and when I had to... I had a
12 lot on my mind, so I’m watching them to make sure that they’re doing the rules properly, then I’m
13 watching them to make sure that they’re enforcing the constraint that I wanted, and I felt like it
14 was a little bit harder to actually step back and see if they were doing the behaviour. You’re not
15 constantly observing for the emergent behaviour, you’re more focused on everything as a whole.
16 (Interview, Melinda)

17
18 These findings are consistent with previous research that has suggested this deep
19 understanding of the learning process, and advanced observational and analytical skills, are
20 necessities to successfully teach an emergent nonlinear curriculum (Butler 2014; Chow 2013;
21 Hopper, Butler, and Storey 2009; Howarth 2005). According to Howarth (2005) these skills
22 are more likely to be found in an expert teacher than in pre-service teachers. The primary
23 researcher in this study, who is considered an expert teacher, is testimony to this assumption.
24 He detected and interpreted multiple less predictable emergent responses when afforded the
25 luxury of observing lessons without the distraction of lesson management. For example, after
26 observing the maximum 8 team touches soccer game he reflected:

1
2 In the 8-touch soccer/football game I observed many 'unexpected' emergent behaviours.
3 Teammates, now expecting a pass, were no longer congested around the ball and spread out across
4 the width of the field to offer passing options. They received the ball in space, which allowed them
5 time on the ball. Some players were now passing long to gain as much ground as possible with
6 fewer touches remaining. So as not to waste touches, many players' body shape adapted to side on
7 to receive the ball, which also opened up their field of vision. Overall the passing was quicker and
8 more accurate, in response to the defence applying more pressure on the ball. (Reflection, primary
9 researcher)

10
11 These responses are difficult to predict as, operating as a nonlinear system, a learner's
12 response emerges as a consequence of the dynamic individual learner-environment interactions
13 within the complexities of a team game (Chow et al. 2013). These less predictable individual
14 responses are a consequence of the complex interactions of the individual learner's intrinsic
15 dynamics, the game environment and the task constraints, within the game context (Chow and
16 Atencio 2014; Chow et al. 2011, 2013; Renshaw et al. 2010). For example, in the maximum 8
17 consecutive team touches soccer game, a player's passing response is difficult to predict, as it
18 is a consequence of the complex interaction of the individual player's kicking ability, the
19 playing surface, the positioning of opponents and teammates, and the number of team touches
20 remaining.

21 Adding to the difficulty in predicting learning outcomes within a NLP theoretical
22 framework is the notion that team games are complex adaptive dynamical systems made up of
23 a number of interacting sub-systems that can abruptly change (Davids et al. 2003). Behaviour
24 emerges in such complex systems as spontaneous patterns are formed from the interactions of
25 individual players within the team game (Kauffman 1993). Within a team game, individual
26 players function as part of this larger system co-adapting their actions to the actions of
27 teammates and opposition players (Kauffman 1993; Passos et al. 2008; Passos and Davids

1 2015). For example, in the maximum 8 consecutive team touches soccer game the actions of
2 the player in possession of the ball, their teammates, and opposition players are systematically
3 related to each other, that is, when players started passing rather than dribbling, teammates
4 responded by moving into space to receive the ball and opponents pressured the ball carrier.
5 These co-adaptive and regulated interactions result in ongoing information that is emergent,
6 necessitating emergent actions in response, thus making it difficult to predict or prescribe
7 players' behaviours or sequences of play as a consequence of the introduction of a constraint.
8 These player interactions can be further influenced by factors such as field location (Headrick
9 et al. 2012). This unpredictability was highlighted and interpreted by Melinda in the following
10 reflection:

11

12 I think that the students did learn, however they did not often perform the way I intended or
13 predicted, that is, they did not utilize the wide immunity zones. From this lesson, I learned that
14 introducing a constraint can have several emergent behaviours, sometimes none of which are the
15 desired one. (Reflection, Melinda)

16

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

1 needs to be able to perceive these affordances from the perspective of the players rather than
2 their own (Fajen, Riley, and Turvey 2009).

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

16

17 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
18 lot about how to get the games going, and explaining the games, and refereeing the games. Once I
19 was able to implement them more successfully and easier, and take more of a hands-off approach, I
20 could just sit back and watch a game and really observe behaviours and adapt. So by the end of it I
21 think I was getting quite good at it. (Interview, Max)

22

23 ***The manipulation of the learning environment***

24 The ability to manipulate the learning environment to facilitate the emergence of learners'
25 tactical problem solving behaviour is considered a crucial ingredient to successfully teach
26 student-centred, game-based approaches (Howarth 2005). In the first 2 weeks of the practicum,

1 to ensure that the CLA learning design and delivery was authentically represented, modified
2 learning environments were either taken directly from resources used in the previously
3 completed constraints-based PETE games unit or designed by the PETE students in
4 collaboration with the primary researcher. These learning environments were generally
5 successful in channelling learner's search towards predetermined emergent movement
6 solutions to tactical problems. For example, when asked what helped him most in the initial
7 weeks to design games Max responded:

8

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

12

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

17

18because I was designing brand new games, to think of a basketball game and what behaviour
19 was going to emerge was... it was quite tough, even for me who had experience in basketball and
20 played quite a bit of basketball myself. (Interview, Max)

21

22 Although the modified learning environments they designed were often successful in
23 generating the predetermined movement solution to a tactical problem, their task constraints
24 provided limited opportunity for this problem-solving behaviour to emerge through the natural,
25 exploratory learning processes underpinning the CLA. For example, a tactical problem
26 identified in Melinda's basketball class was that the attacking players easily penetrated forward

1 through the defence, as the nearest defender did not pressure their opponent with the ball when
2 he threatened space in front of them. To achieve the desired problem solving behaviour of
3 defensive pressure on the attacker with the ball, Melinda manipulated the game design by
4 introducing the rule or instructional task constraint that, if the player with the ball is tagged,
5 possession is transferred to the defending team. Her reasoning was that, by introducing a
6 constraint that rewards defensive pressure, players would pressure the ball carrier and force the
7 attack back or across or force an error. The result was that the nearest defending player
8 constantly pressured the ball carrier.

9

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

13

14 Although this instructional task constraint was successful in generating the
15 predetermined problem solving behaviour, it constructed a very narrow space for task
16 exploration, provoking learners' search for an imposed single solution of pressuring the ball
17 carrier. This happened regardless of the existence of the key affordance of an attacker
18 threatening to penetrate forward through the defence. This design feature denied learners the
19 opportunity to explore a range of possible solutions within a broader space for task exploration
20 and for their individual functional movement solution to emerge implicitly through the process
21 of self-organisation under interacting constraints (Chow 2013; Davids, Button, and Bennett
22 2008). Finding the right balance to ensure that task constraints provide a tight, controlled
23 boundary, as well as opportunities for exploring functional problem solving behaviours is a
24 challenge even for experienced learning designers (Chow et al. 2011). When the manipulated
25 environment provokes learners' search for an imposed single 'selected' solution, players learn
26 the technical skills associated with '*what*' to do, but do not have the opportunity to learn the

1 perception and decision-making associated with that tactical response, that is, ‘*when*’ to do it.
2 This type of restrictive instructional task constraint is better used to pose a single tactical
3 problem (key affordance) to the learner, necessitating the generation of exploratory problem
4 solving behaviours in response (action).

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

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

1 improved ability to design games that worked in facilitating the emergence of learners' tactical
2 problem solving behaviour.

3

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

8

9 *Study limitations and practical implications*

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

1 high level of theoretical and pedagogical knowledge before they can (and should) be allowed
2 to implement new pedagogical approaches such as CLA in their teaching practice.

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

18 PETE programmes must also incorporate opportunities for students to learn to design
19 modified learning environments that enable learners to attune to key information sources in
20 their search for solutions to a tactical or technical problem. This rigorous learning design must
21 follow a structure that incorporates the careful manipulation of representative practice
22 environments using task constraints that: (i) emphasise (exaggerate) the tactical problem or key
23 affordances for the desired action/outcome, to make them obviously detectable and challenge
24 learners to search for a solution, and (ii), channel learners’ search within a narrower area
25 (limited number of movement solutions) of the modified practice environment towards

1 'selected' and more 'obvious' functional movement solutions (the 'to-be-taught' concept).
2 These modified learning environments then should be implemented by PETE students,
3 ensuring that constraints are properly in place, and interpreted in terms of the emergence of
4 predetermined and less predictable solutions in accordance with the implicit learning process
5 of system self-organisation under interacting constraints.

6

7 ***Future research***

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

19

20 **Conclusion**

21

22 This study has identified the challenges associated with implementing a NLP within a CLA in
23 a school setting. In contrast to popular traditional 'linear' pedagogies the physical education
24 teacher implementing a NLP must relinquish 'control' over the learning environment, and be
25 prepared for learning outcomes that are less predictable due to the dynamic individual learner-
26 environment interactions from which learning occurs. This is a difficult process of change for

1 practitioners comfortable in the predictability of traditional teaching environments. However,
2 unlike the traditional ‘linear’ pedagogies, NLP provides a sound theoretical model of the
3 learning process, which can inform learning design and delivery within physical education.
4 Incorporating these study recommendations into a PETE programme can support students to
5 effectively implement the CLA and other nonlinear informed games based approaches in a
6 school environment. The potential of a nonlinear pedagogical approach for enhanced student
7 learning of motor skills in physical education is evident in a response by Max in summing up
8 his practicum experience:

9
10 I believe in the constraints-led approach, because yeah, whenever I talk to anyone about it or teach
11 it in class, I really believe that it’s the best way to go. And my background being so traditional and
12 drill-based, to go and teach these boys this new approach, and to see the learning that occurs
13 implicitly, without me telling them to do anything, you know it still blows me away to this day.
14 Yeah. I saw it... like I’ve seen it working at uni now, and I’ve seen it working in schools, and I’ve
15 seen kids enjoying it. (Interview, Max)

16

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

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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.

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

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Key Contextual, Operational and Pedagogical Requirements of the CLA	√
Practice Environment Representative of Performance Environment:	
<ul style="list-style-type: none">• Key information sources present (e.g. defenders)• Simplified environment (e.g. small-sided game; immunity; floating player)	
Task constraints in place to:	
<ul style="list-style-type: none">• Emphasise (exaggerate) the tactical problem• Present ‘obvious’ solution to the tactical problem (affordance)	
Exploratory Facilitation	
<ul style="list-style-type: none">• 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:	
<ul style="list-style-type: none">• 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)	

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