‘How does TGfU work?’: examining the relationship between learning design in TGfU and a nonlinear pedagogy

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(Received 24 June 2010; final version received 9 March 2011)

Background: In the last few decades, conceptions about teaching and learning in physical education have evolved from a teacher-centred approach to a more student-centred approach where learners are encouraged to develop problem-solving skills, critical thinking and autonomy of thought. A popular model advocating this approach in physical education, Teaching Games for Understanding (TGfU), has attracted widespread attention. Although advocates of TGfU have provided some empirical and anecdotal evidence to support the ‘tactical over technical approach’ to games teaching, recent work has highlighted that to date, the question ‘Does TGfU work?’ has remained largely unanswered. Therefore, there is a need to research the intuitive assumptions about how students learn to play games and to understand how the TGfU approach might work for games teaching and learning.

Purpose: The purpose of this paper is to provide insights to further our understanding of the possible processes underpinning the pedagogical principles of TGfU in games teaching. In this regard, we outline how a Nonlinear Pedagogy approach could provide a theoretical rationale to explain how the principles of TGfU might support learning design for games teaching. To achieve this aim, we examined the viability of the four key pedagogical principles of the TGfU model and highlighted the theoretical and practical implications of Nonlinear Pedagogy, considered with some empirical evidence from the motor learning literature.

Findings: The theoretical ideas emanating from an ecological dynamics perspective, such as constraints manipulation, importance of maintaining information-movement coupling and harnessing movement variability, can underpin a Nonlinear Pedagogy approach. It has been proposed that research evidence from the motor learning literature can provide a suitable theoretical grounding to support the viability of the four main pedagogical principles of the TGfU model (i.e., sampling, tactical complexity, representation and exaggeration) and can contribute insights to the possible processes of TGfU in games teaching.

Summary: A Nonlinear Pedagogy approach has the potential to provide researchers and physical educators with an understanding of the theoretical and practical work on TGfU, in association with its pedagogical principles. Understanding the underlying processes linked to the key pedagogical principles in learning design is critical for addressing pedagogy and curriculum concerns in physical education to enhance student learning. The ideas raised in this paper provided some rationale for the efficacy of the model, and also a platform for researchers and practitioners to more effectively engage students using the TGfU model.

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Keywords: TGfU; pedagogical principles; nonlinear pedagogy; learning design; physical education

Introduction

In the last few decades, conceptions about teaching and learning in physical education have changed. The perspective of the teaching-learning process has evolved from a teacher-centred approach to a more student-centred approach where students are encouraged to develop problem-solving skills, critical thinking and autonomy of thought (e.g., Lee 2003; Richard and Wallian 2005). Constructivist approaches in physical education have conceptualised students as active learners, with individual needs, and teachers as facilitators in physical education (Lee 2003). Consequently, there has been a shift in research focus from the ‘process/product’ paradigm, subject-matter knowledge and assessment modalities, to questions about how learners individually construct their knowledge in relation to their learning environment (Richard and Wallian 2005).

One particular constructivist model in physical education, Teaching Games for Understanding (TGfU) (Bunker and Thorpe 1982; Thorpe and Bunker 1989; Thorpe, Bunker, and Almond 1984), has become popular, attracting widespread attention. TGfU is a game- and learner-centred model to learning games. The original six-step TGfU model, coupled with four fundamental pedagogical principles (sampling, representation, exaggeration and tactical complexity), was presented as a curriculum model for developing decision making and skill performance in games (Thorpe and Bunker 1989; Thorpe, Bunker, and Almond 1984). In recent years, the TGfU model has been simplified by Griffin, Mitchell, and Oslin (1997) to a three-stage model that focuses on three essential lesson components of the model (i.e., game form, tactical awareness and skill execution) for practitioners when teaching for tactical awareness and skill acquisition. There have also been attempts by Holt, Strean, and Bengoechea (2002) and Kirk and MacPhail (2002) to clarify the model’s conceptual underpinnings (Mitchell 2003). To summarise, the TGfU model has shifted games learning from a traditional highly structured, technique-based emphasis with a focus on technical development or knowledge content, to a more student-based approach that teaches both tactics and skills in small-game learning contexts (Bunker and Thorpe 1982; Thorpe and Bunker 1989).

Some advocates of TGfU (e.g., Berkowitz 1996; Booth 1983; Burrows 1986) have tended to rely on anecdotal evidence to support the tactical over a technical approach to games teaching. However, TGfU research, which has remained somewhat fixated on comparing its relative benefits compared to more traditional methods (i.e., teaching tactics or techniques first) to determine which is superior, has provided somewhat equivocal findings. Although some studies (e.g., Mitchell, Griffin, and Oslin 1995; Turner and Martinek 1999) have reported that the tactical approach resulted in better performance outcome measures for some aspects of skill execution and cognitive processes, other work has found both approaches to be equally effective with few significant differences between them (e.g., French et al. 1996; Mitchell et al. 1995; Turner 1996; Turner and Martinek 1992).

In recent years, researchers have been challenged to go beyond the dualist debate concerning technical vs. tactical approaches, to examine and understand the processes underlying games learning and teaching, more generally. As argued by Rink (2001, 123), ‘when you spend all of your effort proving that a particular kind of teaching is better than another kind of teaching, you limit what you can learn about the very complex teaching/learning process’. While previous TGfU work highlighted that the model, similar to other models such as Sport Education, has been interpreted and adopted in many and varied ways,
Griffin and Patton (2005) noted that the TGfU model and associated pedagogical principles have only recently begun to receive some much needed critical evaluation, close examination and re-conceptualisation. To this end, recent work on TGfU (e.g., Butler, Griffin, and Nastasi 2003; Griffin and Patton 2005; Rink 2001) has stressed the importance of examining and understanding the processes involved in learning with that method.

A key issue noted by Rink (2001) was the lack of discussion about the viability of problem-solving methodologies and inadequate attention paid to the validity of assumptions about what children learn and how they learn it. Recent work has highlighted the absence from current discourse of support for assumptions about learning design in TGfU (e.g., Butler et al. 2008; Griffin and Patton 2005). In this sense, it could be argued that analyses of TGfU processes have tended to have a stronger operational, rather than theoretical focus. Although TGfU has been predicated on a constructivist theory of knowledge and learning, more empirical support is needed to support the somewhat intuitive assumptions that the approach works for games teaching and learning (Butler et al. 2008; Griffin, Brooker, and Patton 2005; Griffin and Patton 2005). In fact, Butler et al. (2008) have proposed that to date, Thorpe and Bunker’s (1986) question to researchers, ‘Does TGfU work?’ has remained largely unanswered. However, it is clear that previous work on TGfU has provided some responses to Thorpe and Bunker’s (1986) question ‘Does TGfU work?’ It could be argued that the notion of whether TGfU works or not is perhaps dependent on the agreement of the desired outcomes of the approach (e.g., affective outcomes such as more enjoyment or performance outcome such as skill acquisition). It is apparent that TGfU, similar to other models, can be used with varying agendas. As such, it is important for this variation to be considered when addressing whether the approach ‘works’ or not.

In recent years, several researchers (e.g., Butler et al. 2008; Griffin et al. 2005; Griffin and Patton 2005) have suggested a number of potential theoretical perspectives to examine the assumptions of the TGfU model and to further our understanding of the processes involved in TGfU. Three possible theoretical frameworks, namely achievement goal theory, information processing and situated learning, have been proposed as a relevant grounding for examining the efficacy of TGfU as a pedagogical approach (Griffin, Brooker, and Patton 2005). However, these proposed theoretical explanations have also drawn some criticism. For example, while Chow et al. (2007) acknowledged that these three theoretical frameworks have provided some relevant theoretical support for the efficacy of TGfU, they also drew attention to some shortcomings of these theoretical frameworks.

With regard to achievement goal theory, Chow et al. (2007) commented that this explanation seemed to provide a limited picture, from a psychological and affective perspective, to further our understanding of the underlying theoretical processes of TGfU. A significant criticism was that the theory lacked an explanation of the acquisition of appropriate movement and decision-making skills during games teaching. With regards to empirical work on TGfU that have been shaped by information processing approaches (e.g., French et al. 1996; Turner 1996; Turner and Martinek 1999), Chow et al. (2007) noted that these studies have provided some relevant insights into the acquisition of knowledge. However, a perceived limitation was that they may not have provided an accurate picture of how decision-making skills occur and develop in TGfU. More specifically, work from the information-processing approaches have tended to emphasize an examination of learning at a micro-level, by focusing to a great extent on the construction of knowledge by the learner without taking into consideration the important dynamic environmental interactions that occur in most learning programmes (Chow et al. 2007; Kelso 1995; Thelen
1995; Van Gelder and Port 1995). Recent work using situated learning perspectives (e.g., McNeil et al. 2004; Rovegno, Nevett, Brock and Babiarz 2001; Wright et al. 2005) has permitted TGfU to be examined at a macro-level by taking into consideration the multitude of physical, cognitive, social and environmental factors present in the learning environment. While research from this perspective has provided a viable description of learning processes by considering learner-environment interactions, there seemed to be a lack of information on how learning or goal-directed behaviour could result from such interactions (for detailed discussion see Chow et al. 2007).

Here we attempt to show how recent advances in the motor learning literature from an ecological dynamics perspective might build on past theoretical analyses of TGfU, to contribute a suitable theoretical grounding to advance understanding of learning design in TGfU by emphasising the role of learner–environment interactions (Chow et al. 2007; Chow and Tan 2009; Davids, Button, and Bennett 2008; Renshaw et al. 2010). Ecological dynamics has provided relevant insights and understanding of learning processes in sport and physical education (e.g., see Chow et al. 2007; Renshaw et al. 2010; Rink 2001; Rovegno, Nevett, and Babiarz 2001; Chow et al. 2011). Within that framework, a constraints-led perspective has been proposed for understanding skill acquisition and game play. In a recent issue of *PESP*, Renshaw et al. (2010) provided an overview of a constraints-led perspective and discussed how it might support a nonlinear pedagogical approach, in which learners are considered to exemplify nonlinear dynamical systems, exhibiting key characteristics such as stability and instabilities in behaviour and the capacity to exploit inherent self-organisation processes during learning. It was proposed that learning design in physical education could be based on learners’ emergent capacity to uniquely satisfy task, environment and performer constraints.

The current paper aims to draw the links between theoretical ideas underpinning Nonlinear Pedagogy and learning design in TGfU. To achieve this aim, it extends Renshaw et al.’s (2010) discussion to further understanding of the processes that might underpin the *four key pedagogical principles* (sampling, tactical complexity, representation and exaggeration) of TGfU in games teaching. Through analysis of the relationship between theoretical ideas of nonlinear pedagogy and pedagogical principles in TGfU, we examine insights on learning design in physical education with respect to games teaching. For example, there have been attempts to apply the pedagogical principles to provide developmentally appropriate teaching materials and resources for curriculum development (e.g., progressions of activities, modified games, and frameworks for games) to enhance student learning (e.g., Mandigo and Anderson 2003; Mitchell, Oslin, and Griffin 2003, 2006). Holt, Strean, and Bengoechea (2002) have argued that the four fundamental pedagogical principles, associated with TGfU, need to be more widely considered in the physical education literature, since there is generally a lack of empirical research to support the viability of these key pedagogical principles in learning design. Indeed, more work on the pedagogical principles needs to be undertaken in order to guide the practice of planning games curriculum (Butler et al. 2008). We start by providing an overview of theoretical ideas underpinning a nonlinear pedagogical approach and relevant empirical findings before discussing the relationship of key concepts with the pedagogical principles of TGfU.

### A nonlinear pedagogical approach to teaching and learning in PE

Elsewhere the value of considering learners in physical education to exemplify nonlinear dynamical systems in nature has been addressed (e.g., see Davids, Chow, and Shuttleworth 2005; Chow et al. 2007). These theoretical analyses revealed ubiquitous characteristics of
nonlinear dynamical systems, such as weather systems, global financial markets, colonies of ants and schools of fish, and neurobiological systems, including the capacity for periods where such systems experience stability and instability, transitions from one pattern of behaviour to another when perturbed, and inherent self-adjustment processes under constraints (Chow et al. 2009). A key role in nonlinear pedagogy is played by the constraints that each individual learner needs to satisfy during learning and performance of games skills (see extensive work in physical education by Rovegno and colleagues e.g., Rovegno 2006; Rovegno and Kirk 1995; Rovegno et al. 2001).

According to Newell’s constraints model (1986, 1996), learners in physical education face a number of constraints which shape the acquisition of new coordination patterns and movement behaviours (Newell 1996). These constraints can generally be classified into three distinct categories: performer, environment and task constraints (Newell 1986).

Performer constraints refer to the specific structural and functional characteristics of learners and include factors related to their physical, physiological, emotive and psychological disposition (Newell 1986). For example, learners’ fitness levels and technical abilities, as well as psychological factors such as motivation to learn, may influence how they solve particular task problems or acquire unique movement behaviours that are individual-specific. Environmental constraints refer to physical factors such as visual and auditory information surrounding the performer (e.g., the amount of light or level of noise in the learning environment, ambient temperature and altitude or practice surfaces). Other environmental constraints incorporate social influences such as peer groups, societal and cultural expectations in the community, family support and availability of facilities; these factors are of particular relevance for young learners as their motor performance is often strongly influenced by the presence of critical group members such as the teacher or peers. Task constraints comprise the goal of the task, rules of the activity, the learning location, and the implements or equipment used during the learning experience. Task constraints are typically controlled by a teacher in a professional role related to learning design.

An important point is that constraints in these three key categories do not act independently of each other. Instead, the emergence of movement patterns in learners occurs within an embodied framework where the performer, environment and task play significant roles in shaping the development of movement outcomes and the acquisition of skill (Chow et al. 2007; Newell 1996; Renshaw et al. 2010). Specifically, the dynamic interactions among the confluence of constraints in the learning situation direct the learner to seek out functional behaviours that are likely to achieve behavioural goals during learning. These dynamic interactions are a key phenomenon of nonlinear systems and learners certainly behave as complex neurobiological systems (Chow et al. 2009), as they search for stable and functional movement solutions present among different possibilities for behaving (Newell 1986).

In a nonlinear pedagogical approach, the ideas of self-adjustment under interacting constraints, the interwoven relationship between information and movement, as well as the role of movement variability in adapting to changing task and environmental constraints, are relevant for our understanding of learning design in TGfU. We elucidate these key ideas in the following sections, before exemplifying how they might explain the main pedagogical principles underpinning the TGfU approach.

**Inherent information guides movement**

From a nonlinear pedagogical perspective, knowledge about a movement or tactical decision to be made is not ‘constructed’ based on the existence of some internal
representations located at higher levels of the human movement system (see Davids, Button, and Bennett 2008). Instead, the importance of learner-environment interactions is emphasised. With practice (i.e., game play or skill practice), a learner is able to increasingly couple the information available in the practice environment to the actions required to achieve a specific task goal.

An important factor to consider is the relationship between the information available in specific performance contexts and learners’ actions. It has been argued that biological organisms, including humans, are surrounded by huge arrays of energy flows that can act as information sources to support goal-directed behaviour, including decision making, planning and the organisation of actions. In order to access this information (e.g., through sight, sound, touch), learners need to act. The relationship between information and action supports the recognition that humans must perceive in order to move, but must also move in order to perceive (Gibson 1979). Learners can attune their movements to critical sources of information during practice to establish strong ‘information-movement couplings’ (i.e., they can form a strong relationship between the information required for movement and movement needed to generate more information) to guide their behaviours.

This potential for information-movement coupling should inform learning design in physical education. Separating information and movement in order to help learners manage the learning environment is a weakness in traditional teaching techniques. For example, in physical education, teaching the run-up separately from an action like long jumping or throwing a javelin, or the tennis or volleyball serving action separately from the toss, is a fallacy which encourages information-movement decoupling. Such a teaching approach is commonly known as task decomposition. Instead, task simplification, where the difficulty level of the performing action is reduced while keeping the critical temporal-spatial relationship intact should be encouraged (see Renshaw et al. 2010). The key point here is that task simplification, rather than decomposition, allows information to guide movement and in turn, movement produces the necessary information for further action.

Research in movement science has provided empirical support for the concept of ‘information-movement coupling’. For example, Bootsma and van Wieringen (1990) examined participants executing the table-tennis forehand stroke and found that while the initiation of the stroke was quite variable, the point of bat to ball contact was generally very consistent. Continual guidance of action by perceptual information was suggested to be present as participants performed compensatory movement execution to allow for precise direction as the arm moves towards the point of ball-bat contact. Similar support for the importance of information and movement coupling in the generation and control of movement has also been observed in volleyball serves (Temprado et al. 1997) and one-handed catching (Button et al. 2002).

From the perspective of task decomposition, even the use of ball projection machines in practising games skills such as batting in cricket has come under close scrutiny since advance information from a bowler’s actions is eliminated in such learning environments (see Pinder, Renshaw, and Davids 2009). It needs to be understood that such learning designs skew the nature of information-movement couplings formed by learners so that they are predicated on ball flight information only, without reference to advance information (pre-ball release) from a bowler’s actions (Pinder, Renshaw, and Davids 2009).

Shaping the development of movement outcomes through movement variability
In the development of movement outcomes related to games teaching, recent work suggests that learning is more than merely observing a permanent behavioural change. It is also
about adaptive change or behaviour change in relation to a specific task goal (see Chow et al. 2007; Renshaw et al. 2010). Although movement variability (often seen as a sign of inconsistency in movement performance outcomes) has traditionally been viewed as ‘noise’ in the central nervous system, it is now clear that movement pattern variability can actually play a functional role in helping learners adapt to dynamic performance environments (Davids, Bennett, and Newell 2006; Riley and Turvey 2002).

A nonlinear pedagogical approach views movement variability as an intrinsic feature of skilled motor performance since it provides the flexibility required to adapt to complex dynamic sport environments (Davids, Button, and Bennett 2008). From a pedagogical perspective, movement variability facilitates free exploration in specific performance contexts (see Renshaw et al. 2010). While a movement itself may not be repeated in an identical manner, it is important for learners to be allowed to explore different ways to achieve a similar outcome.

For example, research has shown that it is impossible to kick a ball in exactly the same way with every attempt since there will always be minute differences in limb movement speeds or joint angle motion, although the performance outcome could be the same (i.e., accurately hitting a pre-assigned target) (see Chow et al. 2006). Even among expert javelin throwers, Schöllhorn (1998) found that there were no common movement pattern and that variability in movement was inherent, showing that it was impossible for even elite performers to repeat exactly the same movement between throwing trials. This feature of ‘repetition without repetition’ (Bernstein 1967) in human movement systems actually provides learners with the capacity to invent novel ways to solve typical performance problems. Importantly, variability in movement is critical to allow learners to explore and make changes to their movement behaviours to progressively meet their assigned task goals in learning situations.

Some recent work in the motor learning literature has shown that movement variability is a critical phenomenon for change in movement behaviours to occur. For example, Chow, Davids, Button, and Rein (2008) reported how adult male novices in a soccer kicking task demonstrated high levels of kicking pattern variability between the transition from one preferred kicking pattern to a new preferred kicking pattern over four weeks of practice (570 kicking trials per learner). It was also determined that the least successful learners demonstrated the least amount of kicking pattern variability and showed very little exploration in kicking patterns during the practice phase.

In relation to team game performance contexts, Araújo and colleagues (2004) found that in a 1 v 1 basketball dribbling game, successful dribblers demonstrated increased movement variability nearer to the defender when they effectively dribbled past the defender towards the basket. Attackers with relatively small amounts of movement variability exhibited less success in the 1 v 1 task. In a recent study, Schöllhorn et al. (2009) discussed ideas relating to how variability can be incorporated into skill practices. Particularly, it was pointed out that different practice conditions of variability can lead to different amounts of learning. Ideas like variable practice, where different variations of the same skill can be presented (e.g., serving to the right, centre and left in tennis) can result in higher contextual interference (i.e., interference that occurs as a consequence of performing different tasks or skills within a practice session [Battig 1979]) as compared to, for example, constant practice schedules. Notably, greater interference could have a beneficial learning effect during retention and transfer contexts (Brady 1998). Interestingly, Schöllhorn et al. (2009) emphasised the need for differentiated contextual interference for different learners. More specifically, they suggested that children or novice learners should be exposed to practice schedules with lower levels of contextual interference while adults or more
skilled learners should be presented with practice schedules with higher contextual interference. So, even though variability may be functional, the amount of variability designed into practice conditions needs to be adjusted to suit different learners, possibly at various learning stages.

Newell’s model of motor learning (1985) identified that various stages of learning (Coordination, Control and Skill stage) could be a suitable platform to explore how teaching of motor skills can be adjusted for learners of various skill levels. This model of learning, which has been closely associated with the nonlinear pedagogical approach (see Chow et al. 2007; Renshaw et al. 2010), will be further elucidated in subsequent sections to highlight its relevance to the pedagogical principles underpinning the TGfU approach.

In summary, recent research suggests that educators need to view movement variability as an integral process in learning and acquiring effective movement patterns specific to a task goal. A nonlinear pedagogical approach to teaching games skills provides learners with opportunities to explore and find movement solutions within a set of specific constraints (especially task constraint) designed by physical educators. The key role of physical educators, however, is not to simply allow ‘freedom of play’ during lessons, but rather to carefully manipulate task constraints through rigorous learning design to guide learners in adapting their movements to overcome specific movement challenges in modified games.

A nonlinear pedagogy and learning design in TGfU

As discussed earlier, key ideas in nonlinear pedagogy can offer new conceptual insights into understanding learning design issues in TGfU (Chow et al. 2007). Similar to a situated learning perspective, nonlinear pedagogy adequately captures the rich range of diverse constraints in skills learning and participation in games present in physical education. This approach emphasises the nature of the learner-environment interactions through the use of modified games to better situate learning within the context of the learning environment. In this section we outline how a nonlinear pedagogy can provide insights on learning designs incorporating the four main pedagogical principles of the TGfU approach (i.e., sampling, task complexity, representation and exaggeration), providing some rationale for the efficacy of the model.

Sampling

The principle of sampling is based on the premise that games selected for learning should offer a variety of experiences with possibilities to show similarities and differences between apparently dissimilar and similar games, respectively (Thorpe, Bunker, and Almond 1984; Thorpe and Bunker 1989). Systems of games classification (e.g., Almond 1986; Ellis 1983) have been devised to illustrate where the similarities lie. These systems have proved valuable in facilitating the integration of games with similar tactical possibilities within the sampling procedure (Thorpe, Bunker, and Almond 1984; Thorpe and Bunker 1989). Specifically, games within the same category have common tactical elements and employ strikingly similar strategies to achieve similar goals. These elements or strategies, when understood by students, can be transferred from one game to another, within the same games category. To provide students with a deeper tactical learning and improved game performance, Mitchell, Oslin, and Griffin (2006) added that teachers should select from within rather than across games categories, by identifying similarities among games within each category. For example, football and field hockey, both invasion/territorial games, share similar characteristics even though the specific rules and equipment used in both games
Students who understand tactics related to the principle of ‘advancement’ into the opposing team’s playing area to score a goal in football, for example, are likely to be able to transfer that understanding to field hockey game play. As such, sampling from different types of games can expose students to a variety of game forms and experiences to help them learn to transfer their learning from one game to another and gain greater understanding of game play in general (Thorpe et al. 1984; Thorpe and Bunker 1989).

The principle of sampling has received support from research literature on transfer of learning. Findings from different educational areas (e.g., literacy, technology, motor skill acquisition) as well as anecdotal evidence from practitioners support the views that understanding of game characteristics can transfer positively between tactically similar games (e.g., Beard 1993; Dan Ota and Vickers 1998; McAloon 1994). However, as noted by Mitchell, Oslin, and Griffin (2006), there are only a few studies that have investigated and supported the transfer of understanding in physical activity (e.g., Martin 2004; Mitchell and Oslin 1999).

In nonlinear pedagogy the principle of sampling can be explained with respect to the relationship between the dynamics of a specific task (to be learned) and the individual learner’s existing intrinsic dynamics. Intrinsic dynamics can be broadly defined as the current dispositions for performance in a specific physical activity in each individual that are shaped by important constraints such as genes, developmental experiences and learning (Davids, Button, and Bennett 2008). For example, good games players need functional genetic propensity (e.g., for power or speed endurance), appropriate developmental experiences during growth and maturation and task-specific learning in a particular sport. These constraints shape the intrinsic dynamics of an individual so that they become a stable part of an individual’s performance capacity.

Where the task dynamics for two games are similar (e.g., futsal and football or rugby league and rugby union), they will lead to cooperation with the existing intrinsic dynamics of an individual learner seeking to transfer between the games. Positive transfer can occur because the intrinsic dynamics of the learner can support learning and performance in both games. Where the task dynamics of a ‘to-be-learned’ game (e.g., badminton) differ from the intrinsic dynamics of a learner (e.g., who has learned to play tennis to a high level of performance), there will be competition between the two sets of dynamics. The nature of the relationship between task dynamics and intrinsic dynamics of learners captures the potential for transfer of movement behaviours across games. When critical elements of relevant task constraints (e.g., rules of the game, use of equipment and playing area) within two games are similar (e.g., invasion games such as field hockey and football), a stable platform is provided for movement behaviours to be positively transferred from one game to another.

In this way, the pedagogical principle of sampling in TGfU is relevant and effective in learning design for exposing students to similar tactical characteristics within different games to lead learners to harness their existing intrinsic dynamics to facilitate successful learning and performance. Such ideas are congruent with the suggestion by Mitchell, Oslin, and Griffin (2006) that, in planning programme design in games teaching, teachers should select from within rather than across games categories to support deeper tactical learning and improved game performance. Practitioners need to sample key common features within the different categories based on the games classification systems, so that positive transfer of learning can occur from one game to another as learners harness their existing system intrinsic dynamics to positive effect.

Another useful example of sampling task dynamics in learning design to harness existing system dynamics occurs in the acquisition of some ‘techniques’ in different game categories to support transfer across these games categories. For example, the overhead throwing action
can form the basis of movement patterns for performing various specific technical skills in
different game categories. If the intrinsic dynamics of an individual are stable with reference
to the overhead throwing action, it can be used as a basis for learning other related technical
movements such as the volleyball overhead serve, the tennis serve and the badminton over-
head smash. However, the specific execution of these different movements will still need to be
further adjusted and refined for the specific performance contexts, with the overhead throwing
action as the foundational movement pattern. It has been highlighted that the closer the con-
trolled environment is to the context of the game, the greater the likelihood of effective trans-
fer taking place (Rink, French, and Graham 1996). Nevertheless, substantial empirical
evidence needs to be collected to determine the extent of transfer that can occur across
game categories (Rink, French, and Graham 1996).

*Tactical complexity*

The pedagogical principle of complexity in TGfU involves designing and matching the
game forms to the developmental level of the student, so that the tactical problems pre-
sented may not be too complex for the learners to understand. As highlighted by Thorpe,
Bunker, and Almond (1984) and Thorpe and Bunker (1989), it is logical to start with
simpler games if our objective is to ensure that children or novice players understand the
games they play; that is, games with less tactical complexity should be taught first before
games with greater complexity.

Designing a progression of game forms with increasing tactical complexity can occur at
two levels, *within* and *across* the game categories. *Within* the game categories, Mitchell
et al. (2003, 2006) proposed levels of game complexity (i.e., levels I, II and III) with
increasing tactical complexities. Complexity can also be perceived *across* categories. Of
the four game categories, target games considered less complex, are usually recommended
to be taught first, followed by net/barrier or fielding games, and then invasion/territorial
games (e.g., Thorpe, Bunker, and Almond 1984; Thorpe and Bunker 1989; Werner, Thorpe
and Bunker 1996).

The sequence of selecting to teach less complex games first (both *within* and *across* the
games categories) is relevant to the idea of accommodating task complexity to different skill
levels and constitutes a key aspect of learning design in physical education. Newell’s (1985)
model of learning, mentioned earlier in the discussion on variability, has application here.
The model proposed that there are three stages of learning: Coordination, Control and Skill
stages. In the early stage of learning (Coordination stage), a movement skill challenges a
learner to assemble an approximate movement behaviour to the target pattern. The
learner seeks to harness the existing individual (intrinsic dynamics) to find stable and pre-
ferred movement solutions to specific motor problems. The successful search for a func-
tional coordination pattern allows performance of the task to a basic level, as the learner
assembles component relations between relevant parts of the body. Because of the
pattern assembly challenge, at the Coordination stage, it may be more useful to introduce
less complex games involving a smaller number of task and environmental constraints
like target games or net/barrier games. For example, less complex target games (e.g.,
arrows, dart throwing) which require simpler movement patterns involving fewer limb seg-
ments, are less demanding for individuals to assemble. Such simpler movements could be
more functional at the early stage of learning to produce goal-directed behaviour.

Performers at the next stage of learning, the Control stage, can flexibly adapt a stable
movement pattern to approximately fit changing performance environments (Newell
1985). Chow, Davids, Button, and Koh (2008) observed how skilled soccer players were
able to effectively vary foot speed at ball contact to chip a ball towards different target positions. A higher foot speed at ball contact was used when the target was located further away. However, novices were not able to vary foot speed at ball contact functionally when target positions were altered during kicking trials. A plausible explanation could be that skilled players were able to use reactive forces in the different limb segments during the kicking action to allow an effective kicking pattern to emerge compared to learners at the Coordination stage where the aim is to acquire a basic movement pattern. This view suggests that, at the Control stage, it is important to organise more complex games involving fielding (e.g., softball or cricket) or invasion games (e.g., basketball or netball) where learners are required to execute multi-articular movements involving many limb segments and are faced with increased amounts of information to manage the numerous movement possibilities.

At the Skill stage of learning, more complex manipulations of task constraints can be incorporated to raise the difficulty of game play to help learners refine and demonstrate already well-established skills in varied game situations. For example, the size of play areas could be reduced to increase the time-space demands in small-sided games, challenging skilled performers to raise their perceptual-action attunement for successful task completion.Certainly, invasion games could provide ample opportunities to effectively engage learners at the Skill stage of learning.

Increasing task complexity can be achieved by manipulating task constraints within the same game category or the same sport. Different learners may progress at different rates in acquiring game tactical knowledge/technical skills. Physical educators need to adjust the complexity of the learning task appropriately to adequately challenge learners to achieve success. At the Skill stage of learning, learners can vary a movement pattern in an energy-efficient manner to fit changing circumstances in dynamic environments (Davids, Button, and Bennett 2008). Physical educators teaching a class of skilled learners need to provide situated games with higher levels of complexity in terms of concepts and technical skills to suitably challenge these learners. Advance tactical decisions and knowledge have to be presented in constrained games to provide opportunities for skilled learners to explore movement solutions in those contexts. Useful constraints to be added to these small-sided games include changes to space, target areas, equipment, player numbers involved and introduction of artificial rules. For example, the teacher could limit the number of ball touches per player or time spent in an attacking zone.

**Representation**

Representation involves developing modified, mini-games that contain the same tactical structure of the adult game (Thorpe and Bunker 1989; Thorpe, Bunker and Almond 1984). The premise of its effectiveness is that games are developed and modified to the extent where the tactical intricacies of the adult game are retained but simplified and adapted to suit the learners’ (e.g., children or novices) size, age, and ability for successful participation (Thorpe and Bunker 1989; Thorpe, Bunker, and Almond 1984). The aim of representation is for learners to experience opportunities for developing tactical awareness, making appropriate decisions, and practicing skills in manageable practice environments.

In a nonlinear pedagogy, the relevant use of rules and equipment can provide a learning situation that is appropriate for different stages of learning (Handford et al. 1997). For example, in net games such as volleyball, an adult 6 v 6 version of the game may not be as valuable a learning experience for many less skilled learners. They typically do not have the positional awareness or skills to benefit from this representation of the full game.
However, a mini, simplified 3 v 3 game, perhaps initially allowing an additional bounce between volley passes by the same team, is better suited to the lower skill levels of the beginning learners, while maintaining the tactical structure of the adult form of the game.

The key point about the pedagogical principle of representation is to keep the information-movement coupling of the structured game or practice relevant such that it is still representative of the actual game. This goal can be achieved through the process of task simplification and physical educators should avoid the error of task decomposition in seeking to enhance representation (Davids, Button, and Bennett 2008).

Undoubtedly, teachers or coaches should modify games that provide learners with access to the perceptual information available in the performance context which can be closely coupled with relevant actions. If the relationship between information and movement is weak after a task modification, it becomes challenging for teachers and students to find associations between the modified game and the full game form represented in the TGfU approach. For example, if the use of a modified racket distorts the movement information so that the learner adopts a highly unique stance or movement pattern for a tennis forehand drive, then the modification is not representative and risks becoming less relevant for the learner when transferred to an actual tennis game (where other variations of the drive is required). In essence, representation needs to be built on a close relationship between the dynamics of a modified task and the task dynamics involved in a full game. If this close fit is not maintained, the dynamics of the practice task and required performance task may compete, rather than cooperate during learning. Nevertheless, more empirical research in relation to transfer across representative game contexts needs to be undertaken to properly determine its relevance for learning.

Additionally, the dynamics of a game are fluid and variable in actual game contexts. As such, practice task constraints should aim to mimic the actual performance environments as much as possible. Traditionally, the focus of many coaches is to provide repetitive drills during practice tasks to ‘train’ athletes/ players to be as consistent as possible, repeating a movement continually but devoid of how the skill might be functionally adapted for performance in dynamic game settings. Such drills tend to be too static and generally lack representation of how real game situations could be actualised. In a nonlinear pedagogy, the infusion of variability requires learners to experience different movement parameters during the learning process all the time. This principle forces the learner to explore a larger performance ‘solution space’ which will actually be more relevant and effective when required to satisfy the ecological constraints of a real game context. As mentioned earlier, the role of variability in modified games is to enhance learners’ flexibility and adaptability, which are critical in satisfying performance constraints of real games.

Exaggeration

Closely related to the pedagogical principle of representation, Thorpe and Bunker (1989) and Thorpe, Bunker, and Almond (1984) highlighted that mini-games developed should also pose tactical problems that can be ‘solved’ by children. For this process to occur, games should maintain the primary rules of the full game, although elements of the games can be modified to exaggerate a tactical idea to be explored. In this respect, exaggeration involves frequent manipulation of task constraints, a key strategic aim in a nonlinear pedagogy, to provide relevant learning environments. This TGfU principle involves changing the rules of the game to overstate or emphasise a specific tactical problem by making the ‘to-be-taught’ concept obvious to the learners (albeit implicitly), thus constraining them towards learning about a particular pattern of play. A well-established example of
exaggeration in net games is the use of a long and narrow court in practice; here, the shape of the court makes it obvious for learners to direct their shots to the front and back of the court. The perceived information from the task constraints (long narrow court), together with the intentions of the performer, will accentuate the role of high clears and drop shots in play. Exaggeration through task manipulation can also come in the form of game rules. For example, in a modified game of football where more points are awarded for consecutive passes than actually scoring a goal, the team in possession would be encouraged to maintain control of the ball. Here, behavioural pattern of keeping possession is precipitated through simple adjustment to game rules.

In a nonlinear pedagogy, a functional behaviour to be acquired (e.g., hitting long or short, or maintaining ball possession) emerges based on the task constraints designed in the modified game setting. The focus of this perspective highlights the role of manipulating task constraints in learning design to exaggerate a specific tactical play to encourage and shape learners’ behaviours without explicit instructions being involved. This process avoids the over-use of verbal information which encourages explicit learning in favour of the subtle manipulation of task constraints to encourage implicit learning. Conceptually, the theoretical rationale in nonlinear pedagogy for this process involves the construction of appropriate boundaries through the manipulation of task constraints. This pedagogical activity facilitates learners to search within a narrower area in the perceptual motor workspace where functional movement solutions for task problems can be found and established. This constrained approach also contrasts with the idea of ‘free play’ where, a lack of exaggeration will warrant a ‘blind’ search for movement solutions by the learners, resulting in more time needed and enhanced health and safety risks.

Moreover, exaggeration in situational games can direct learners to the relevant information-movement relationships that are critical for successful game performance. This point was exemplified by Chow, Davids, Button, and Koh (2008) who found that learners can explore and discover individualised kicking patterns when challenged to kick a ball over a height barrier in the absence of explicit instructions on kicking technique. The height of the bar, distance of the target in the kicking task and the video presentation of the expected outcome (i.e., learners were shown the accurate landing of the ball in an appropriately weighted manner only) all exaggerated the relevant information-movement relationship to assist learners in their search for functional kicking solutions. Without exaggeration, learners become less attuned to the key environmental parameters that are pertinent for the generation of functional movement solutions. This aspect of learning design is especially critical at the Control stage of learning (see Newell 1985) where learners need to be exposed to more exploratory search in learning to find associations between their movement patterns and the performance context.

Learners’ exploration of functional movement solutions could occur where high levels of movement variability are encouraged. Functional movement variability, as mentioned previously, is a positive opportunity for learners to determine and differentiate between successful and less successful movement solutions in these game contexts. With the principle of exaggeration, more opportunities are provided for learners to search for functional movement solutions within a ‘controlled’ practice scenario where the tactical concepts to be taught are clearly exaggerated.

Conclusion: future research and implications for practitioners
In this paper we have proposed how a nonlinear pedagogy can offer new conceptual insights and could provide a theoretical rationale for explaining the operational principles
of TGfU in learning design of games teaching. To achieve this aim, we examined the viability of the key pedagogical principles of the TGfU model. We highlighted how the theoretical and practical implications of nonlinear pedagogy, considered with some empirical evidence from the recent motor learning literature, to provide an understanding of how TGfU might function. Our analysis originally stemmed from the need to provide an insight to Thorpe and Bunker’s (1986) question: ‘Does TGfU work?’ Following that, the discussion on ‘how does TGfU work?’ provided analysis of the pedagogical principles that underpin TGfU, with an emphasis on how they might be supported by a nonlinear pedagogical perspective.

From a research standpoint, it is clear that there is a need for further empirical studies to validate the proposal of a nonlinear pedagogy framework as a suitable theoretical grounding to support learning design in TGfU. Considerations for future research include empirical studies focusing on the role of small-sided games, looking at different categories of games, conducting school-based learning studies, examining performance outcomes as well as affective parameters, examining the learning design of TGfU beyond the four pedagogical principles, and also examining individual changes (that is, intra-individual analysis coupled with group analysis).

Additionally, some specific questions that might guide future research in TGfU from a nonlinear pedagogical perspective include: What is the relative effectiveness of teacher guidance that focuses on the achievement of performance outcomes rather than on the production of a specific movement pattern? What are the affective (e.g., motivation) and physical (e.g., activity level) consequences of this approach to teaching game skills? Is a nonlinear pedagogy relevant for promoting enjoyment and learning games skills in groups of low-skilled individuals? Does movement pattern variability emerge prior to the acquisition of new preferred movement patterns, rather like fluctuations prior to a phase transition in a complex system?

The ideas raised in this paper could also inform practitioners to more effectively engage students using the TGfU approach. Application of a nonlinear pedagogical perspective to further our understanding of the possible processes underpinning the key pedagogical principles (sampling, tactical complexity, representation and exaggeration) of TGfU in games teaching has several key practical implications for physical educators. First, physical educators can lead learners to harness existing system intrinsic dynamics to facilitate learning and performance by exposing students to tasks with similar tactical characteristics (e.g., running into space or providing options for a pass to keep possession) within different games in the same category (e.g., invasion games such as field hockey and football). By sampling key common features within specific categories, based on the games classification systems, positive transfer of learning can occur from one game to another. Second, physical educators need to plan for developmentally appropriate tasks by adjusting the complexity of the task to adequately challenge learners to achieve success. This can be done by manipulating task constraints (e.g., changes to space, target areas, equipment, and number of players involved) according to the learning stages of learners, as exemplified by Newell’s (1985) model of motor learning. Third, physical educators should maintain the functional information-movement couplings of the structured game or practice task such that it is still representative of the actual performance environment (for example, a simplified 1v1 tennis game, using a lighter, shorter racket, a sponge ball, and a low net instead of an adult 1v1 game). Practice task constraints should aim to mimic the actual performance environment as much as possible by having learners experience ‘variability’ (that is, different movement parameters) during the learning process all the time. Finally, physical educators could develop mini-games that are not only representative of the actual
performance environment, but should also pose tactical problems that appropriately challenge learners to explore functional solutions. Again, this aim can be achieved by subtle manipulation of task constraints (e.g., by changing the rules of the game) to make the ‘to-be-taught’ concept obvious to the learners so as to encourage implicit learning about a particular pattern of play (e.g., using a long narrow court for net games to accentuate hitting long or short). In conclusion, attempting to understand the learning design of TGfU from a nonlinear pedagogy approach might provide some valuable insights into the underlying processes of the TGfU pedagogical principles. This research task might allow researchers and physical educators to more effectively engage students and provide developmentally appropriate teaching materials and resources for curriculum development.

References


