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Nonlinear Pedagogy: Implications for Teaching Games for Understanding (TGfU)

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Abstract

Nonlinear Dynamics, provides a framework for understanding how teaching and learning processes function in Teaching Games for Understanding (TGfU). In Nonlinear Pedagogy, emergent movement behaviors in learners arise as a consequence of intrinsic self-adjusted processes shaped by interacting constraints in the learning environment. In a TGfU setting, representative, conditioned games provide ideal opportunities for pedagogists to manipulate key constraints so that self-adjusted processes by players lead to emergent behaviors as they explore functional movement solutions. The implication is that, during skill learning, functional movement variability is necessary as players explore different motor patterns for effective skill execution in the context of the game. Learning progressions in TGfU take into account learners' development through learning stages and have important implications for organisation of practices, instructions and feedback. A practical application of Nonlinear Pedagogy in a national sports institute is shared to exemplify its relevance for TGfU practitioners.

Nonlinear Pedagogy: Implications for Teaching Games for Understanding (TGfU)

Introduction

TGfU provides a viable approach to teach games skills and tactical concepts to learners (e.g., Butler, Griffin, Lombardo & Nastasi, 2001; Griffin & Butler, 2005; Rink, 2001, Turner 1996), and has been adopted by many practitioners to exploit learning opportunities in small-sided games. This chapter proposes a theoretical framework to account for how TGfU activities might support the learning of game skills and games sense. Emanating from the motor learning literature, it is argued that a valid conceptual foundation for the function of TGfU is the constraints-led approach which underpins Nonlinear Pedagogy (see Chow et al., 2007 for a discussion on different theoretical frameworks for TGfU). Nonlinear Pedagogy highlights the interactive role that key constraints (i.e., performer, task and environmental) play in learning contexts to shape emergent movement behaviors which arise during practice (see Chow et al., 2006; 2007, Davids, Chow & Shutleworth, 2005; Davids, Button & Bennett, 2008).

How our work in Nonlinear Pedagogy aligns itself with TGfU principles is exemplified here in a case study involving the 2008 Australian women's water polo team in preparation for the 2008 Beijing Olympics. In this intervention, it was agreed after reviewing match videotapes and observing introductory practices with coaching staff that the aims of the skill intervention program would be to develop adaptive movement behavior of these elite athletes. Small-sided games and practices were to be used to improve both the players' shooting ability and their decision making in attack. The shooting intervention included three phases. In phase one the intention was to encourage all players in the squad to explore and discover new individualized movement solutions and variations of pre-existing ones. The aim of phase two was to enable players to continue learning to control and adapt their shots to a range of dynamic practice situations. Phase three focused on increasing the level of movement adaptation to sudden and unexpected perturbations from team-mates and opponents during shooting. We introduced various task constraints to generate high levels of variability within the movement context, focusing on movement effects and movement outcomes. Task constraints such as equipment (e.g., pool noodles, hoops and swiss balls) served as a perturbation forcing shooters to explore alternative coordination patterns that would achieve the same desirable effect on the ball (i.e., ball flight trajectory). In addition, balls differing in weight (1.5kg, 800g & standard), size (size 3, 4 & 5), and type (tennis, golf, & rubber ball) were used in shooting and passing games to elicit random variability in a 'differential learning' process (see Schöllhorn, Michelbrink, Trockel, Sechelmann, Westers & Davids, 2006).

This case study of an intervention using practices based on Nonlinear Pedagogy provides a practical platform for readers to understand the concepts of this theoretical framework which we overview in the next section. In the concluding sections of this chapter we provide an analysis of the relationship between Nonlinear Pedagogy and a TGfU approach. Specifically, we: a) elucidate key concepts in Nonlinear Pedagogy, illustrating how they might embrace TGfU; b) provide implications for instructions, feedback and practices within a TGfU framework; c) share ideas on progression and transfer of learning in games using concepts in Nonlinear Pedagogy; and d), provide another case study on the use of Nonlinear Pedagogy for game skill acquisition in a practical setting at the Australian Institute of Sport (AIS).

Key Concepts of Nonlinear Pedagogy and their association with TGfU

Nonlinear Pedagogy is predicated on concepts from dynamical systems theory and views each learner as a complex system (see also Sumara & Davis, 2008). It describes, explains and predicts how changes over time occur in the organisational state of each individual considered as a *learning system* (Chow et al., 2007). From this viewpoint, humans are considered complex neurobiological systems in which different components (e.g., muscular, neural, skeletal) need to be coordinated and organized in a functional manner to support the execution of goal-directed movements (Bernstein, 1967). Successful actions require the individual to effectively regulate system components involved in a movement to function as a controllable unit to meet the objective of each movement task. From a systems-based perspective, different components in a neurobiological system play a role in effecting the eventual outcome of action. The interaction between system components and the constraints of each specific performance situation provides the platform for functional movement behaviors to emerge, and no single component is seen as the over-riding factor in prescribing how movements should be performed.

Consequently, there is no one common optimal movement pattern towards which each individual learner should aspire during practice (Chow et al., 2007). Instead inherent self-adjustment processes allow learners to harness interactions between system components as each individual explores unique coordination solutions during learning (see Davids et al., 2008). A situated-learning perspective (see Kirk & MacPhail, 2002) has also been proposed as a viable description of learning processes in TGfU which focuses on learner-environment interactions. However, from that viewpoint, it remains unclear how learning or goal-directed behavior could actually emerge under such interacting constraints.

In Nonlinear Pedagogy, increasing attention has been directed to investigate transitions between stable patterns of behavior as a consequence of interactions between different system components during learning (e.g., Caillou, Nourrit, Deschamps, Lauriot & Delignieres, 2002; Chow, Davids, Button & Rein, 2008; Liu, Mayer-Kress & Newell, 2006). Phase transitions during learning exemplify learners progressing to novel patterns of behavior. In neurobiology, it has been observed for some time that changes in movement behavior can occur (i.e., a switch in behavioral patterns) when key constraints in the performance context are manipulated (see, Kelso, 1995; Kugler et al., 1982). An important observation has been that changes in movement behavior do not necessary follow a linear progression and sudden and abrupt changes in system organisation might arise as a result of the dynamic interactions that occur in a learning context (Newell, Mayer-Kress & Liu, 2006). Kugler et al. (1982) and Newell (1996) emphasized the role of *constraints* in channeling movement behavior, arguing that the stability of functional coordination patterns can be altered by constraints imposed on performers. Therefore, manipulating constraints underpins the acquisition of skills which is more than just developing novel motor patterns. The emphasis is on developing *functional* actions in the context of games, incorporating tactical awareness and technical proficiency through satisfying appropriate constraints in the learning environment. Functional movement patterns in games can differ between individuals as players learn to solve movement problems in a variety of unique ways, rather than learning to execute a single movement pattern in a technically specific manner. Movement variability in team games is important as players adapt their actions in order to satisfy the personal and task constraints imposed on them during practice and performance.

Constraints have been defined as boundaries or features that shape the behavior by a learner seeking stable movement patterns to achieve a specific task goal such as to catch or hit a ball (see Newell, 1986). Small changes to rules, practice organization or equipment dimensions in game learning contexts (i.e., games that simulate tactical and technical expectancies in the real game situation) can lead to dramatic changes in movement patterns while in other instances, no change of movement patterns may occur (see Liu et al., 2006). Within a TGfU approach, individual constraints like learners' experience levels (personal constraints), changes to rules, boundaries and equipment (task constraints) and performance surfaces (environmental constraints), for example, can result in emergence of different self-adjusted, goal-directed behaviors during learning.

It is clear that the nonlinear dynamics perspective on understanding how change might occur in movement behavior is complementary to the operational activities involved in TGfU. Modified games are useful vehicles to support the manipulation of appropriate task constraints during learning and can channel learners' exploratory movement behaviors, aligning them to the objectives of intended game concepts/skills to be taught. For example, playing with three attackers against one defender to support ball possession among the attackers would certainly create greater opportunities for learning how to keep possession since there is an overloading of attackers to defender as compared to having equal numbers of each. These practice task constraints can be manipulated by changing numbers of attackers and defenders depending on which sorts of movement behaviors are required to emerge from learners. In the following sections, we exemplify more specifically how conceptualisation in Nonlinear Pedagogy can support the organisation of practices and the provision of instructions and feedback within a TGfU approach.

Nonlinear Pedagogy and TGfU: Implications for Practices, Instructions, and Feedback

Practice Organisation

Quantity and quality of practice are crucial to the development of expertise (e.g., Davids, 2000; Deakin & Cobley, 2003; Ericsson, 2003; Starkes, 2003) and teachers and coaches carefully consider the micro-structure of practical sessions to maximise learning opportunities. Recent evidence suggests that children in physical education classes on average spend only 25% of the time actually engaged in physical activity (Tinning, 2006). Decomposing practice sessions into sub-sections such as warm-ups, drills, games and cool downs (Kirk & McPhail, 2002) may limit learning opportunities even more, since only undertaking practice activities that are ***representative*** of performance demands will lead to ***transfer*** of skills between practice and performance environments (for a discussion of the concept of representative task design see Renshaw, Davids, Shuttleworth & Chow, in press).

An established tenet of ecological psychology, associated with a Nonlinear Pedagogy, is that behaviors of individuals cannot be understood without reference to their specific environments (Gibson, 1986). Actions are supported by perceptual information from the environment and, in turn, perception of high quality information is acquired by acting. This assumption has implications for games teachers and highlights the need to ensure congruence of practice environments with dynamic performance environments (Davids et al., 2007). The provision of representative practice tasks is important because during performance and learning the perception and action systems of individuals become tightly coupled (Savelsbergh, Davids, Van Der Kamp & Bennett, 2003). Changing perceptual information available to performers (e.g., by learning to catch or hit a ball via use of ball machine feeders in fast ball sports or by undertaking static, unopposed drills in invasion games) can result in learner attunement to information sources that are not useful in producing functional movements and decisions appropriate to the performance environment (see Renshaw, Oldham, Davids & Gould, 2007). By faithfully representing performance environments during practice, learners can engage in exploratory behavior and become attuned to key perceptual information sources (e.g., their position on the playing area or the relative position of team-mates or opponents) available in specific performance environments (Beek, Jacobs, Daffertshoffer & Huys, 2003). One of the strengths of the TGfU approach, highlighted in Nonlinear Pedagogy, is that it enables learners to practice in a managed environment with all key information sources present, so that perceptual and action processes in learners can become tightly coupled during practice.

In TGfU, as in Nonlinear Pedagogy, there are no universal rights or wrongs in terms of techniques used or decisions made. That is, there is no undue emphasis on learners' acquisition of perceived 'optimal movement patterns' for success in team games. The functionality of a particular decision or action is determined by how well it satisfies the constraints of the game. Individuals who engage in constrained discovery learning can become skilled at satisfying the extant interacting individual, environmental and task constraints during practice to find their own optimal solutions. Providing performers with multiple opportunities to explore and work out problems for themselves is in line with Bernstein's (1967) definition of practice as 'repetition without repetition', a key feature in Nonlinear Pedagogy. Creating variability in practice is essential to learners' exploratory activities during game play and produces flexible and adaptive individuals who can create novel solutions to solve typical motor problems.

Skill Interjections: The Role of Instructions and Feedback

Although most discussions on the validity of TGfU have focussed on the development of 'game awareness' and 'tactical understanding', it is often under-reported that Bunker and Thorpe (e.g., 1996) did not neglect technical development in their model. They specified that "when students see the need for a particular kind of skill and are ready for these skills within the context of a game, technical instruction is given (Werner, Thorpe & Bunker, 1996, p. 38)." Kidman (2005) clarified what Thorpe meant by technical instruction in a later article, signifying that that this was not to be construed as reference to pure 'technical' instruction in the form of drills due to limitations in transfer back to the game environment. Ideas from Nonlinear Pedagogy are in line with Thorpe's views on technical development (see Kidman, 2005), as illustrated when we consider below the use of instructions and feedback in skill interjections. An example to illustrate this point concerns work on improving a cricket batter's front foot drives by requiring him/her to face varied deliveries bowled by a bowler (not a bowling machine- see Renshaw, Oldham, Davids & Gould, 2007) to hit the ball through gaps between 'fielders' (real fielders, manikins or cones) to score 'runs'. In this skill interjection, the performer can develop perceptual skill (e.g., recognising the right ball to drive (versus defend), decision-making skill (e.g., choosing when to hit with a full follow-through versus using a checked swing) *and* technical skills (e.g., adapting body positions to work the ball into scoring zones between the fielders) in unison. Ideas from Nonlinear Pedagogy are also in line with Thorpe's views on skill interjections as we exemplify below concerning the use of instructions and feedback in skill interjections

High levels of explicit verbal instruction and augmented feedback are the norm in traditional coaching (Williams & Hodges, 2005), since beginners in sport are believed to be reliant on conscious control processes in movement (Masters & Maxwell, 2004). However, Bernstein's (1967) insights on the control of action suggest that most movement behaviors are typically regulated by subconscious processes (for a review see Davids et al., 2008). Explicit instructions force learners to switch to higher (i.e. more explicitly-regulated) levels of action control and can lead to performance disruption and de-automisation (Beek, 2000). In Nonlinear Pedagogy, verbal information is seen as a temporarily imposed informational constraint provided by teachers that can have positive or negative effects on performance. Using explicit instruction directed at conscious control processes in a 'skill interjection' (such as developing an overhead hitting action in badminton) might have a negative effect on learning since it is unlikely to direct learners to the regulatory information flows available during games performance. Conversely, more positive instructions might be those that do not specifically prescribe a movement solution but guide exploration and use of implicit learning strategies (see Jackson & Farrow 2005; Masters & Maxwell, 2004) to allow intrinsic self organisation processes to be harnessed during learning.

The way that teachers and coaches implement feedback schedules for learners could be based on similar principles as for instructions. Forcing learners to attend to inappropriate information sources should be avoided and good practice could constrain individuals to search for the most useful information to underpin their actions and decisions. A useful strategy could be to constrain learners to focus their attention externally on outcomes of movements rather than on internal control processes (Passos et al., 2008; Wulf et al., 2000). The use of questioning to guide this search process has been considered an important strategy for developing autonomous, intelligent performers who understand their own performance and can comment verbally on their intentions. In games, learners need to express intentions through actions and providing feedback that is inherent within learning tasks might avoid an over-reliance on augmented verbal feedback. The use of spatial task constraints may be helpful in this regard, where 'inherent anchoring' (Carson, Goodman, Kelso & Elliott, 1995) can be used to shape behavior. For example, constraining a batter to move the backfoot to land on an appropriately placed mat can be used in learning to play a back foot defensive shot in cricket batting, rather than requiring learners to verbally express this intention. In invasion games, the use of spatial markers to create channels through which play must flow can constrain players to create width in attacking play.

Attending to the delivery of instructions and feedback during the skill practice phase in a TGfU lesson is pertinent in learners acquiring the necessary technical skills to support functional performance in small-sided games. Below, we discuss how learning progressions and transfer of learning could be situated within an understanding of performer constraints as a function of learning stages in TGfU.

Progression and Transfer of Learning

Two interesting issues related to the effectiveness of TGfU concern: a) how practice activities should be progressed for learners of different skill levels, and b) the extent to which skill transfer is encouraged within TGfU. In order to address these issues, it is important to acknowledge a key performer constraint, which is the relative progression of the learning process for each individual. For this purpose, Newell's (1985) model is helpful in categorising the learning process into three general stages: the Coordination, Control, and Skill stages.

The earliest stages of learning, i.e., Coordination and Control, play complementary roles in regulation of human movement and both constructs can be viewed as interdependent (see Newell, 1996). 'Coordination' is the stage in which available motor system components (muscles, joints, limbs) are constrained into a functional movement pattern to achieve a specific task goal. The 'Control' stage refers to the 'parameterizing' of the coordination pattern. It is the process by which values are assigned in the coordination function to link movement effectively with environmental variables and key movement parameters such as speed, duration and tempo can be adapted to specific performance conditions. The boundaries between these different stages of learning in the model are not clear cut, but instead functionally overlap and are dynamic, to provide opportunities for learners to adopt and discard movement solutions as required (Chow et al., 2008). Finally, in Newell's (1985, 1996) conceptualization, the 'Skill' stage occurs when optimal values are assigned to the variables in the coordination function. Only after a significant period of 'quality' practice (e.g., practice under representative task constraints) can learners attain the Skill stage where their movement patterns have been fine-tuned to become highly adaptable, efficient, and effective at achieving task goals.

Learning Progressions

A key skill for pedagogists is identifying the most important performance aspect that an individual or a team needs to work on as they progress through the stages of learning. In our view, different teaching strategies such as ‘tactic to skill’ and ‘skill to tactic’ approaches can each be delivered effectively by adopting a student-centered approach (Hopper, 2002). Whilst these approaches have sometimes been proposed as contrasting strategies, in Nonlinear Pedagogy either may be viable as long as the learner is implicitly challenged within practice to understand the “what to do” and “how to do it” in relation to particular motor skills. For example, in football, learning to dribble a ball around a set of cones does little to help learners adapt their movement patterns to an active, moving opponent or the actions of their team-mates. Instead skill execution should occur within more dynamic scenarios which represent task ‘simplifications’ of actual game skills (i.e., dribbling around initially passive defenders (who become increasingly more active as learning increases) and passing to team-mates when opportunities arise). An important point is that the ‘skills first’ approach need not necessarily imply endless skill repetition within drills that have no tactical context. Skills practice must occur within a tactical conceptual setting in representative, constrained small games in a TGfU approach e.g., in a game-like context and not simply through repetition of a movement pattern.

During the coordination and control stages of learning, the emphasis in Nonlinear Pedagogy is for learners to be provided with plenty of opportunities to explore and discover important information sources available in the environment to support skill performance and tactical decision making. This search process is important to promote awareness and enhance functional movement variability. Importantly, individual differences amongst learners are embraced by a student-centred approach as opposed to the traditional ‘one-way-fits-all’ philosophy. As learners advance to the control stage they become increasingly able to demonstrate flexible, adaptive behaviors in different performance scenarios. At this time more emphasis may be placed on skill acquisition to satisfy more specific task constraints during performance. Due to subtle changes in feedback and modifications to coordination patterns that are required, the learner now requires opportunities to explore a narrower bandwidth of movement solutions and, in this context, repetition of achieving specific movement outcomes becomes more valuable. The term ‘repetition' is used here in the Bernsteinian sense, i.e. learners should not be required to repeat an identical movement pattern from situation to situation, but instead should be encouraged to repeatedly construct subtly differing, but successful,solutions to movement problems during learning. In practice, a more pertinent focus is on exploring successful movement solutions with flexibility and variation in the process to achieve a desired outcome.

For advanced learners at the Skill stage, the emphasis in practice on tactics or skills production depends on the needs of the particular learner or group. For example, if a team is making too many mistakes in exploiting scoring opportunities such as rushing shooting opportunities, not moving into space to support the ball carrier or not exploiting width in attack, an important exercise could be to practice small-sided attacking scenarios. Simplified task constraints could provide opportunities for attackers to practice and improve scoring skills involved in shooting the ball. At the same time tactical issues can be addressed in modified games that are representative of the actual sport (i.e. deciding when to initiate an attacking phase). In a soccer example, one such game would involving playing 5 attackers vs 3 defenders with all players restricted to the middle third of the practice pitch until an offensive passing option presents itself on either flank to open the game up into the attacking third of the pitch, allowing attacking runs, spreading of play from one end of the field to the other or even pulling the defence away from goal area. In the Skill stage, it is important that practice provides opportunities for learners to stabilise effective movement solutions in high intensity, game-like situations.

Transfer of Learning

Transfer refers to the influence of previous practice or performance of a skill on the acquisition of a new skill. The essence of transfer is being able to adapt an existing movement pattern (e.g., practice performance) to satisfy a different set of task constraints (e.g., game situation). To maximise skill transfer, practice activities should be representative of competition demands. That is, the task constraints of practice should closely match the task constraints of the performance environment for successful learning outcomes. One of the original stimuli for the development of the TGfU approach was the perceived lack of transfer between outcomes of traditional teaching methods of skills repetition to game performance environments. One of the main strengths of the TGfU approach lies in its potential to enhance transfer within skills learning and skills performance in games. TGfU ensures that learners are exposed to a rich variety of movement skills which many have argued can also be transferred across games (Griffin & Sheehy, 2004; Mitchell & Oslin, 1999). In Nonlinear Pedagogy, constrained (modified) games have a beneficial role to play in learning at all levels of ability due to the congruence between the task constraints of the small-sided games and the targeted sport, as well as the emphasis on exploratory activity in the former.

In summary, designing representative task constraints that guide learners to understand key principles of games playing are key features of TGfU, which are emphasised in Nonlinear Pedagogy. Bunker and Thorpe (1982) suggested that this principle could be implemented by using ‘modification through representation’ or by ‘modification through exaggeration’. In Nonlinear Pedagogy it is proposed that task modifications could be based on an understanding of the key constraints acting on learners in specific games. Early learners benefit particularly from TGfU as they are encouraged to explore and discover individually appropriate movement solutions. As learners progress, increasingly more practice time could be devoted to skill optimisation in modified games because they help learners to couple movement patterns with the information sources present in a performance environment (e.g., passing the ball in response to team mate's movements with a greater level of accuracy). As the learner's skill level improves, more challenging tactical concepts present in, for example, invasion games, can be introduced. For example, in the 5 vs 3 football game described earlier, rolling substitutions or an offside rule can be incorporated into the practice to further develop the decision-making skills of skilled players.

Certainly, infusing appropriate game situations and skill practice is imperative within a TGfU setting for learners at different stages of learning for successful performance. While Nonlinear Pedagogy is a relatively new conceptualization for teaching and learning movement skills, some applications have been already been undertaken on skilled athletes, as we identified in the introductory case study from the AIS. In the following section, we further elaborate on how concepts in Nonlinear Pedagogy have been applied in a practice setting for elite athletes at the Australian Institute of Sport (AIS). It is important to note that these ideas can be applied with equal success to novice and intermediate learners in physical education programmes.

Use of Nonlinear Pedagogy at the Australian Institute of Sport

The role of skill acquisition and pedagogist specialists at the AIS is to provide expertise and support to coaches and athletes by developing evidence based practice strategies to optimise learning and transfer. These specialists recognise that an individual athlete's learning and performance trajectory is nonlinear and transits at different rates (Liu, Newell & Mayer-Kress, 2004).

Developing on the initial example of the Australian Olympic water polo team in the introduction section, coaches encouraged greater shot adaptation with individual constraints which forced the shooter to co-adapt their movements by using their limbs and joints in a compensatory manner to achieving the task goal. Defenders would attempt to restrain and de-stabilise parts of the shooters' body during movement execution in addition to pulling abruptly on rubber tubing that was tied around each shooter's waist. Other strategies used to perturb shooters' movement systems included the temporary occlusion of the view of the goal and forcing them to adapt their shot using minimal pre-shot information and vary the time available to execute their movement.

To encourage shot deception and disguise we designed a shooting task with three conditions. The first condition involved a game where the shooter notified the goalkeeper where she intended to shoot, a goal scored like this was worth 3 points and anywhere else was worth 1 point. Points were accumulated over six shots and a running tally was kept. To score maximum points shooter were forced to attempt to deceive the goalkeeper into taking the less preferred option on occasions. In the second condition the goalkeeper was instructed to initiate the first move in goal in a direction signaled by the coach situated behind the shooter. The shooter had to perceive the goalkeeper's early movements and exploit these within the time available to score the goal. The third condition required the shooter to initiate a shot on goal. However, the coach, who was situated behind goal and goalkeeper, indicated which direction the shooter needed to shoot at during the latest possible moment in shot execution. This condition produced a high number of goals being scored, we can only speculate at this point but we assume that due to the late signal given by the coach to indicate to the shooter when to shoot resulted in the shooter remaining unaware of the shot direction until relatively late on in the movement therefore providing the goalie with a minimal amount of relevant kinematic information from which to make her decision. In addition, the shot had to be made relatively quickly due to the shooter's inability to maintain a high position out of the water, this also provided disguise in the shot due to the faster than usual arm rotation to produce the shot.

Players' reponses were generally positive in relation to the interventions. They found practice tasks challenging, exciting, competitive and, at times, mentally and physically intensive. This type of practice contrasted with their structured sport-specific training and provided a valuable addition to the players' existing shooting and decision-making repertoire. Some players believed that, when they had to spontaneously self-organise during small-sided games to satisfy new task constraints, certain players had problems adapting to others around them if there was no prescribed move or play *a priori*. Players who adapted well during moments of high variability and/or uncertainty were generally those who were more aware of the effects of their own actions on their opponents. These players were more able to adapt at the right moment to exploit any instabilities created. Particularly, these players were instrumental in the success of the decision making process at critical periods within the games. Ongoing performance measures are being undertaken in all future events including 2008 Olympic Games where the squad took the bronze medal. The Performance Analysis Unit and data miners at the AIS conduct analysis using performance measures such as each player's shooting tendencies in specific situations and against certain opponents in addition to critical events and decisions made leading up to successful and non-successful outcomes. It is envisaged that any performance or learning improvements that may have taken place in addition to performance outcomes will be detected over time post-Olympics.

Conclusion

In this chapter we have proposed that Nonlinear Pedagogy provides a viable platform to understand how learning and teaching processes can underpin operations of a TGfU approach. We briefly overviewed key theoretical principles of Nonlinear Pedagogy and elucidated the specific reasons for its relevance to support learning processes in TGfU. Implications for the organisation of practice, delivery of instructions and feedback, emphasising exploratory student-centred learning were discussed. Ideas on transfer of learning and learning progressions within a TGfU approach were also described from a Nonlinear Pedagogy perspective. In all sections, brief examples illustrating applications of Nonlinear Pedagogy in the acquisition of game skills were presented to emphasise its application in learning environments.

There is clearly a need for continued applied pedagogical research as principles of Nonlinear Pedagogy will be further refined and developed in the coming years, with growing empirical support from the motor learning literature and beyond. The challenge for researchers is to extend understanding of how practitioners can explore application of Nonlinear Pedagogy theoretical concepts in TGfU and game skill learning in physical education, focusing on individual player's performance as well as the understanding of game play as a team.

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