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The Role of Nonlinear Pedagogy in Physical Education

Jia Yi Chow
Nanyang Technological University
Keith Davids
Queensland University of Technology
Chris Button
University of Otago
Rick Shuttleworth
Australian Institute of Sport
Ian Renshaw
Queensland University of Technology
Duarte Araújo
Technical University of Lisbon

In physical education, the Teaching Games for Understanding (TGfU) pedagogical strategy has attracted significant attention from theoreticians and educators for allowing the development of game education through a tactic-to-skill approach involving the use of modified games. However, some have proposed that as an educational framework, it lacks adequate theoretical grounding from a motor learning perspective to empirically augment its perceived effectiveness. The authors examine the literature base providing the theoretical underpinning for TGfU and explore the potential of a nonlinear pedagogical framework, based on dynamical systems theory, as a suitable explanation for TGfU's effectiveness in physical education. Nonlinear pedagogy involves manipulating key task constraints on learners to facilitate the emergence of functional movement patterns and decision-making behaviors. The authors explain how interpreting motor learning processes from a nonlinear pedagogical framework can underpin the educational principles of TGfU and provide a theoretical rationale for guiding the implementation of learning progressions in physical education.

Keywords: Teaching Games for Understanding (TGfU), nonlinear pedagogy, physical education, manipulation of constraints.

Educators are challenged to provide learning experiences for students that are realistic and present opportunities for potential performance solutions to be generated by learners themselves. Windschitl (2002) argued that learning, particularly with the implementation of constructivist approaches in learning contexts, would be optimized if students were engaged in complex and meaningful problem-based activities as well as applying knowledge in diverse and authentic performance contexts. These ideas have some relevance within the domain of physical education, because in recent years, teaching approaches attempting to improve students' involvement in meaningful and context relevant learning have emerged.

In curricular studies research, pedagogically oriented work on value orientations has provided the foundation for curricular development and analysis (Jewett, Bain, & Ennis, 1995). It has been noted that one of the most prominent value orientations in the domain of physical education is disciplinary or subject mastery, whereby practitioners attempt to teach perceptual-motor skills through verbal explanation, demonstration, practice drills, and simulated game play (Jewett et al., 1995). However, there are other significant value orientations in the study of education and curriculum, such as the learning process approach, which highlights the importance of how learning occurs, as well as the ecological integration of learners with specific learning contexts (see Jewett et al., 1995). This specific value orientation suggests that learners play a pivotal role in the acquisition of game skills and that the learning process needs to occur in representative performance contexts within physical education classes facilitated by teachers. The Teaching Games for Understanding (TGfU) approach for games teaching in physical education is one such increasingly popular[1] teaching approach that advocates a learner-centered orientation, with emphasis on exploratory learning within "gamelike" situations.

In this article, we review research that underpins the implementation of TGfU as a pedagogical approach for games teaching, and we discuss a theoretical framework within motor learning with the potential to provide an explanatory rationale for observed effects of this approach. This is because although TGfU has grown in popularity as a teaching approach, researchers and practitioners are still attempting to fully understand why learning within such a pedagogical approach may be successful. This lack of clarity has led researchers in the past decade to attempt to identify post hoc a theoretical foundation that may fit the TGfU approach. Therefore, specifically, we (a) provide a description of the TGfU approach, (b) review key empirical research in TGfU relating to its effectiveness, (c) provide a discussion of previously suggested theoretical underpinnings for the TGfU approach, (d) propose a theoretical explanation for TGfU based on recent advances in the motor learning literature, and (e) provide further suggestions for programs of work in TGfU to build on such a theoretical orientation.

Teaching Games for Understanding

The TGfU approach was originally developed because of dissatisfaction with how motor skills were taught in schools in the early 1980s. Bunker and Thorpe (1982), who first conceptualized TGfU, highlighted the limitations of traditional approaches to games education. Traditional approaches were viewed as being technique dominated, following a series of highly structured lessons in which a list of movement skills was sequentially taught to groups of learners (Werner, Thorpe, & Bunker, 1996). Such pedagogical approaches have tended to overemphasize (a) the isolation of movement skills from performance contexts during practice, (b) task decomposition during learning, and (c) the role of repetition in skill practices to allow learners to transfer acquired technical skills into game situations (Rink, 2005). The dominance of such a technique-oriented approach to games education led to calls for a greater emphasis on developing the cognitive and decision-making skills of students in physical education classes. Specifically, it has been proposed that (a) a large percentage of children have achieved little success as a result of emphasis on component skill performance, (b) the majority of students leave school understanding very little about games playing, (c) there has been a development of putatively technically sound players with poor decision-making capacity, (d) such practices emphasized the development of players who were teacher or coach dependent, and (e) there was a failure to develop "thinking" spectators and knowledgeable administrators at a time when games (and sports) are an important form of entertainment (Hopper, 2002; Thorpe, 1990).

The Rationale for TGfU

So how does TGfU purport to alleviate these concerns in games education? The focus of TGfU is to design learning experiences for individuals to acquire tactical skills of the major games through playing modified versions of target games considered suitable for their current physical, intellectual, and social states of development. Because TGfU emphasized tactical understanding being developed before movement techniques, it was seen as an approach for redressing the balance toward understanding the "why" of games playing performance before the "how" (Hopper, 2002; Werner et al., 1996). To exemplify the focus on tactical awareness, Thorpe (1990) pointed out that "the basic philosophy of TGfU is that a person can play games with limited techniques and, even with limited techniques be very competitive" (p. 90). Traditional approaches to teaching games skills are centered on acquiring relevant movement patterns in isolation of a game context, before using these skills in adult versions of a particular game (Turner & Martinek, 1995). On the other hand, TGfU is student centered, with the learning of both tactics and skills occurring in modified game contexts (Griffin, Butler, Lombardo & Nastasi, 2003; Hopper, 2002; Thorpe, 2001). Modified versions of the major games are practiced to enhance the understanding and awareness of learners when they transfer to full-game contexts. The modified games usually involve adapting equipment, playing areas, or rules to constrain or guide learners toward solving targeted tactical problems, such as how to maintain possession of a ball as a team or how to defend against dribbling opponents.

There are four game categories in the TGfU approach: (a) target, (b) net or wall, (c) striking or fielding, and (d) territory or invasion games (Werner & Almond, 1990). A TGfU lesson typically begins with games in one of these categories, modified to encourage students to think about a specific tactical problem targeted in the lesson (see Figure 1 for the TGfU model). The introductory game is followed up with questions and explanations by the teacher on the tactical implications of the tactical solutions being practiced. These questions emphasize the interactions between cognition, perception, and action during practice and performance.

Game appreciation is emphasized to enhance understanding of the rules and the strategic nature of the game to provide some structural shape to team performance. Tactical awareness is also encouraged to challenge learners to solve problems posed in the game by teammates and opponents and to gain relevant knowledge for performance. This initial emphasis is followed by developing decision making, which leads to knowing "what to do" and "how to do it" in relation to specific tactical situations (e.g., when defending or attacking). Skill execution and performance

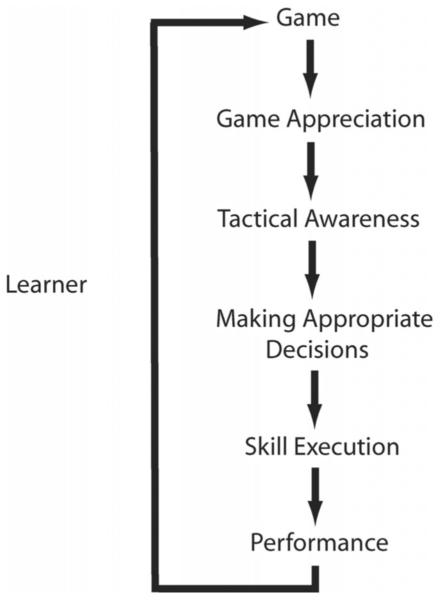


FIGURE 1. *Teaching Games for Understanding model. Adapted from Werner, Thorpe, and Bunker (1996).*

are then assessed by observing the outcomes of decisions as they are executed by learners during actual game play (Turner & Martinek, 1999; Werner et al., 1996). To summarize, the key features of TGfU are its student-centered approach and its flexibility in manipulating constraints in modified games to enhance interactions between learner cognition, perception, and actions to teach tactical knowledge and skills related to specific tactical concepts (Griffin et al., 2003; Hopper, 2002).

Empirical Support for TGfU?

Although the TGfU methodology was proposed by Bunker and Thorpe (1982) as an ideal alternative to traditional technique-based teaching approaches, empirical studies have revealed mixed conclusions about the validity and merits of the TGfU or a tactical approach. Much of the research on TGfU over the past decade has focused on comparing it with technique-oriented games-teaching approaches. Studies have tended to use quasi-experimental designs in which learners' knowledge has been assessed using knowledge tests and game play has been examined using protocols focusing on the control, decision-making, and skill execution components of performance. It is also important to note that participants' skill levels have often been measured by component skill tests (Turner & Martinek, 1995). In this section, we review the key empirical findings of research on TGfU to determine its efficacy over more technical approaches.

Rink, French, and Tjeerdsma (1996) noted that TGfU students performed better on tests relating to tactical knowledge compared with those who were taught with a "technique"-based approach. In addition, from an affective perspective, TGfU was found to be more enjoyable, and learners were more motivated to participate in physical education classes (e.g., Griffin, Oslin, & Mitchell, 1995). It has also been reported that when the intervention period was long (i.e., 15 lessons), students from a middle school in a group taught with the TGfU model in field hockey made better decisions than students in a technique instruction group (e.g., Turner, 1996). Some studies have also sought to examine possible differences between tactical and technical approaches to knowledge acquisition pertaining to declarative (what to do) and procedural (how to do it) processes in decision making. Declarative knowledge was higher for students who experienced the TGfU approach for field hockey (Turner, 1996) and volleyball (Griffin et al., 1995).

However, some studies have found less support for the TGfU or a tactical approach compared with a technique approach. For example, Turner and Martinek (1999) found that students taught with a tactical approach did not show significant improvements in some performance outcome measures related to tackling, dribbling, and shooting in field hockey, although the same students displayed better control and passing. Turner (1996), in an earlier study, also did not find any differences in skill development between a tactical and a technical approach. In addition, Gabriele and Maxwell (1995) did not find any differences in execution abilities between a direct teaching approach (i.e., a technique-oriented method) and an indirect method (i.e., games centered) when squash was taught for 6 weeks, although it was reported that students exposed to indirect teaching were able to make better decisions in terms of shot selection. Other studies examining differences relating to skill performance in soccer for middle school students (Mitchell, Griffin, & Oslin, 1995), volleyball (Griffin et al., 1995), and badminton in a high school (French, Werner, Rink, Taylor, & Hussey, 1996) mainly failed to report significant differences between tactical and technical approaches. Interestingly, a follow-up study with a longer intervention period (6 weeks vs. 3 weeks) was conducted by French, Werner, Taylor, Hussey, and Jones (1996) to determine if differences could be observed between tactical and technique groups. They noted that the technique group performed as well as the tactical group in decision making and in skill performance, even with an extended intervention period. Although Mitchell et al. (1995) indicated that there were no differences between tactical and technical approaches, it was reported that students were more successful in "off-the-ball" movement for soccer when taught with a tactical approach, with no differences in skill-related knowledge, examined using an 18-item written test. No significant differences in declarative and procedural knowledge were also observed over time between tactical and technical approaches for badminton (Lawton, 1989) and field hockey (Turner & Martinek, 1992). In summary, there seems to be an absence of a clear affirmation of the superiority of a tactical over a technical approach for various performance outcome measures in different games, and analysis of the extant literature generally reveals little in the way of empirical evidence to support its apparent effectiveness (Strean & Bengoechea, 2003; Turner & Martinek, 1999).

Why has there been such ambiguity in the data on the effectiveness of such a popular pedagogical method in physical education? There are a number of potential reasons for these inconclusive results, including key variations in study design and problems with research methods. Studies have varied according to the game chosen for analysis, the age of participants, the length and nature of the intervention, the variables chosen for investigation, and how these variables were measured

(Rink, French, & Graham, 1996). For example, game performance for soccer in Mitchell et al.'s (1995) study was measured using the Games Performance Assessment Instrument (developed by Oslin, Mitchell, & Griffin, 1995), whereas in Turner's (1996) study of field hockey, game performance was measured using an observational tool (Turner & Martinek, 1992) designed to measure the quality of decisions and motor execution during game play. In addition, different measurement tools were also used to determine cognitive knowledge for different studies, even though the games were similar in nature (e.g., both soccer and hockey can be categorized as invasion or territorial games). Certain knowledge items could be generic, such as moving into space, supporting for possession, or closing down space, and these could be assessed across games with similar characteristics. However, Mitchell et al. (1995) used an 18-item written test, whereas Turner and Martinek (1999) used a hockey knowledge test encompassing 15 procedural and 15 declarative items pertaining to the hockey curriculum. Studies have also used different intervention lengths, and this approach casts further doubt on the validity of comparing across different studies (e.g., 3 weeks of a total of 12 lessons for French, Werner, Taylor, et al., 1996; 15 lessons for Turner, 1996; 6 weeks but no information on the number of lessons for Gabriele & Maxwell, 1995). This lack of consistency in testing, measurement, and the design of research has inadvertently added to the equivocal findings from past studies examining differences between tactical and technical approaches.

Hopper (2002) attempted to address some of the misinterpretations of the TGfU approach by stressing the inadequacy of a dichotomous approach in focusing on either skill execution or tactical development. This dichotomy was based on the perceived emphasis of TGfU on students' understanding of why a skill is needed before they are taught how to perform a skill. The difference between a technique and tactical approach is a sequencing of what comes first. The TGfU approach has a "tactic-to-skill" emphasis, in contrast to the skill-based approach, which has a "skill-to-tactic" emphasis. The argument proposed by Hopper was to emphasize a student-centered approach rather than a content-based approach that promoted the precedence of either technical or tactical development. According to Hopper, both the skill-to-tactic and tactic-to-skill approaches can be effective if the skills and tactics taught are delivered with proper progressions and within the relevant game context to be effectively understood and used by students. Hopper concluded by arguing that the comparison of skill-to-tactic and tactic-to-skill approaches represented an irrelevant direction for future TGfU research. Moreover, the debate has tended to center too much on performance outcomes, creating a false dichotomy between tactical and technical teaching approaches (Strean & Bengoechea, 2003). Instead, it has been argued that the focus of research should be on the teaching and learning processes underlying the different approaches (N. L. Holt, Strean, & Bengoechea, 2002; Rink, 2001).

A Search for a TGfU Theoretical Framework

Although research on TGfU has been actively pursued over the past two decades, a number of questions still exist over its relative efficacy as a pedagogical method: (a) Is the perceived need to differentiate skill development from tactical development valid in assessing the effectiveness of TGfU compared with traditional technique-based approaches? (b) Is there a theoretical framework of adequate power for providing explanatory concepts and testable hypotheses to disambiguate expectations and predictions in empirical research related to TGfU? and (c) Is TGfU suitable for individuals at all stages of learning?

Clearly, the key observation is that TGfU currently lacks a sound theoretical base for examining its relative efficacy as a pedagogical approach. Griffin, Brooker, and Patton (2005) commented in their review of TGfU that its efficacy could be grounded in three possible theoretical frameworks: (a) achievement goal theory, (b) information processing, and (c) situated learning.

Achievement Goal Theory

In relation to achievement goal theory, it has been suggested that a classroom goal structure, usually referred to as motivational climate, affects a student's adoption of achievement goals (Xiang, McBride, & Solmon, 2003). It has been purported that when the goal is to develop an individual's ability through learning a task (task mastery), TGfU provides the relevant opportunities to increase students' motivation. Such an observation is based on the report that games help increase situational interest because they have structure and outcomes that are meaningful to performance (Griffin et al., 2005). From a psychological and affective perspective, achievement goal theory seems to provide a relevant theoretical grounding to support the efficacy of TGfU. However, achievement goal theory provides only a limited picture to augment our understanding of the underlying theoretical processes of TGfU. Other theoretical perspectives also focusing on explaining what decisions to make and the acquisition of the appropriate movement skills during games teaching are required.

Information Processing Approaches

In particular, many physical education researchers have proposed that the TGfU approach is generally aligned to the theoretical orientations of cognitivism and constructivism to which the information processing approach is linked (e.g., French & McPherson, 2004; Turner & Martinek, 1995). Specifically, the cognitive framework focuses on investigating domain-specific knowledge and how such knowledge about movements can be stored as well as built on through "knowledge structures or programs" with learning (Anderson, 1976). From a constructivist perspective, learners are seen as the center of the teaching and learning process, and it is assumed that students "construct" knowledge about a game from person-environment interactions (Gréhaigne & Godbout, 1995). For example, Turner and Martinek (1995) attempted to provide a theoretical overview for developing tactical awareness by examining the role that declarative and procedural knowledge plays in TGfU. Specifically, they viewed the development of decision-making skill in TGfU from an information processing perspective, in which learners use different knowledge bases to underpin the function of cognitive processes such as perception, attention, and memory during the motor learning. The acquisition of procedural knowledge, facilitated by TGfU, has been found to underpin successful movement performance because it engages less conscious modes of attention and movement planning.

French and McPherson (2004) attempted to provide "best-guess approaches" to sports-related games learning (e.g., TGfU) on the basis of an information processing approach. It was proposed that situational games in which opportunities for making decisions, on the basis of desired concepts to be taught, should first be provided. Thereafter, questions need to be presented to elicit insights and information on the knowledge to be processed. Their approach emphasized how knowledge is "constructed" and built on past knowledge stored in memory structures. The acquisition of higher order cognitive skills through the understanding of tactics and problem-solving activities present in TGfU suggests that it may be suitably grounded in such cognitive-based theories for understanding its perceived effectiveness as a teaching methodology. Certainly, the constructivist perspective has helped shaped many previous empirical works on TGfU, examining how knowledge is acquired through the TGfU teaching approach and comparing that to a technical approach (e.g., French, Werner, Rink, et al., 1996; Mitchell et al., 1995; Turner, 1996; Turner & Martinek, 1999).

However, investigations at a micro-level, although seemingly attractive and comprehensive, may not have provided an accurate picture of how development of decision making occurs in TGfU. What is required is a perspective that takes into account the dynamic interaction that occurs in learning environments, one that is not centered only on the construction of knowledge by a learner, emphasizing the examination of learning at a micro-level. In this respect, the ideas emanating from information processing theory have received increasing criticism, with a view that understanding learning through information processing theory is too simplistic and narrow, failing to account for the dynamic and extensive environmental interactions that occur in most learning situations (e.g., Kelso, 1995; Thelen, 1995; Van Gelder & Port, 1995).

Situated Learning Perspectives

A theoretical model that allows TGfU to be examined at a macro-level could provide a multidisciplinary framework to capture the multitude of physical, social, cognitive, and environmental factors that interact to influence a learner's ability to develop goal-directed behavior. In this vein, a situated learning perspective has been proposed as a possible explanation of the processes underlying the TGfU approach. Specifically, a situated perspective assumes that learning incorporates the active engagement of learners with their environment (Kirk & MacPhail, 2002; Rovegno & Kirk, 1995). Sociological aspects emphasizing the role of the environment and how learning is constructed within a "situated" setting argue that the relationships among the various physical, social, and cultural parameters in the learning context play a crucial role in TGfU (Lave & Wenger, 1991). Light and Fawns (2003) highlighted the need to adopt an embodied approach to understand the interdependence of cognition, perception, and movement skill execution within the TGfU learning context. By this they meant that the acquisition of tactical knowledge can be achieved only by actually moving within a game context, which TGfU provides. For them, the separation of knowledge and movement, devoid of the influence of specific learning contexts, is unrealistic in explaining how learning occurs in the TGfU approach. Certainly, a situated learning perspective provides a valuable starting point in understanding the need to investigate learning in TGfU as context dependent, in which the interactive components within the learning situation all play an important role. Rovegno, Nevett, and Babiarz (2001) adopted a "situated perspective," emphasizing individual and environmental interactions and focusing on participation rather than representation of knowledge in memory stores to examine the learning and teaching of invasion game tactics in fourth grade. Adopting qualitative analytical approaches such as interviews, meetings, and discussions, data on decision-making behavior and skills used in game settings were examined. It was confirmed how decision making and the execution of skills were relational and did not specifically depend on either the passer or receiver in invasion games (Rovegno, Nevett, Brock, & Babiarz, 2001). More recently, situated learning perspectives have been used by researchers (e.g., McNeill et al., 2004; Wright, McNeill, Fry, & Wang, 2005) to examine behaviors and perceptions of teaching abilities for student teachers in teacher education programs for games teaching.

However, although a situated learning perspective provides a viable description of how learning occurs by taking into account learner-environment interactions, inadequate information is provided with regard to how learning or goal-directed behavior could actually emerge under such interactions. Specifically, what are the mechanisms that allow interactions between learners, their environment, and, more important, their tasks, to constrain learners' behaviors? Can these interactions be adequately informed by a theory that can explain how these processes shape behavior? How is it that the manipulation of rules, instructions, and equipment can adversely influence certain behaviors of learners, especially in situational games present within the TGfU approach?

The provision of an empirically supported theoretical model of learning in physical education is required to provide a testable framework for investigating the relationship between pedagogical principles of TGfU and motor learning processes, with the aim of validating methodological decision making by pedagogists. McMorris (1998) noted that there have been few attempts to examine the relationship between research on TGfU and prominent theories of perceptual-motor learning. Thus, despite its popularity, few extensive theoretical rationales for TGfU have been forthcoming in the literature that emphasizes how goal-directed movement behavior emerges in a TGfU setting. It seems that pedagogists have tended to focus on how TGfU can be operationalized in specific pedagogical contexts from a problem-centered approach, with few attempts to critically evaluate and adequately develop the theoretical basis of TGfU.

One contemporary theoretical framework of motor learning with the potential for explaining the efficacy of the TGfU approach is the constraints-led framework, with its basis in dynamical systems theory (Araújo, Davids, Bennett, Button & Chapman, 2004; Davids, Button & Bennett, 2007; Handford, Davids, Bennett, & Button, 1997; Rossi, 2003; Williams, Davids, & Williams, 1999). The essence of a constraints-led approach to skill acquisition, which provides the scaffold for a nonlinear perspective to pedagogy in physical education, implies that educators need to understand the nature of the interacting constraints on each individual learner and how to manipulate key task constraints to facilitate the emergence of functional movement repertoires. Evidence shows that the manipulation of constraints by educators can lead to the production of successful motor patterns, decision-making behavior, and intentions that guide the achievement of task goals (Chow et al., 2006). Interestingly, it was briefly discussed by French, Werner, Taylor, et al. (1996) that the manipulation of tasks and establishing "environmentally designed tasks" (see Rink, 1993; Siedentop, Herkowitz, & Rink, 1984) to influence movement patterns can be associated with dynamical systems theory

(Kugler, Kelso, & Turvey, 1982). In a later article on levels of information processing, Rink (2001) also briefly drew attention to how learners could make suitable movement responses without the need for conscious processing and how the variables in a learning environment could constrain learners to “select” an appropriate response. Although Rovegno, Nevett, and Babiarz (2001) came closest to describing a theoretical perspective on the basis of situated learning, slanting toward a constraints-led perspective, the discussion of the theoretical perspective could have been further developed to espouse its role in TGfU. However, there has since been little further examination of the specific processes that dynamical systems theory could offer to provide a greater theoretical underpinning for the TGfU approach. Perhaps researchers in pedagogy may not have adequate access to the concepts of dynamical systems theory from a motor learning perspective, or perhaps advancement in understanding the pedagogical applications of a dynamical systems theory was still at an infant stage to limit its discussion at that point in time.

To remediate this possibility, in the remainder of this article, we show how key concepts from dynamical systems theory, pertaining to the interaction of constraints and the emergence of goal-directed behavior, can provide a theoretical basis for evaluating the merits of the TGfU approach. We discuss how the application of a nonlinear pedagogical framework can provide rich theoretical insights for training educators, leading to better understanding of how tasks constraints can be introduced and manipulated to enhance game awareness and movement skills in learners using the TGfU approach.

Specifically, in the remaining sections of this article, we (a) appraise key features of TGfU from a dynamical systems perspective and (b) examine how a nonlinear pedagogical framework, emanating from concepts in dynamical systems theory, may provide the basis for a model to determine how TGfU can be implemented by educators, leading to effective motor learning.

Nonlinear Pedagogy: A Constraints-Led Approach as a Theoretical Model for TGfU

The Influence of Dynamical Systems Theory

In the past decades, dynamical systems theory has provided a theoretical stimulus for understanding movement behavior, as well as the role of decision-making behavior, intentions, and cognitions on motor performance (Carson & Kelso, 2004; Davids, Williams, Button, & Court, 2001; Jirsa & Kelso, 2004). Prominent ideas from dynamical systems theory have been allied to concepts of ecological psychology (Gibson, 1979) to understand how movements are coordinated and controlled with respect to dynamic environments such as sports. Research has adopted a systems perspective and sought to characterize neurobiological systems as complex, dynamical entities, revealing how the many interacting parts of the body are coordinated and controlled during goal-directed movements (Bernstein, 1967). It is well established that patterns emerge between parts of dynamical movement systems through processes of self-organization ubiquitous to physical and biological systems in nature (Davids, Shuttleworth, Araújo, & Renshaw, 2003). Dynamical systems are able to exploit surrounding constraints to allow functional, self-sustaining patterns of behavior to emerge in specific contexts. Interest has focused on the transitions between different stable patterns as a consequence of the interaction between different components or constraints in a system. And the type of order that emerges is dependent on initial conditions (existing environmental conditions) and the constraints that shape a system's behavior. For example, investigations can focus on understanding how learners acquire one movement pattern rather than another movement pattern on the basis of the interaction of skill level with the equipment, instructions, and feedback provided. With respect to the study of dynamical movement systems, it has been argued that the number of possible movement solutions offered by the human body that need to be regulated by the central nervous system can vary in magnitude because of the temporary assembly of muscle complexes called coordinative structures. Coordinative structures are task-specific coordination patterns assembled for the functional purpose of achieving specific movement goals (e.g., catching or hitting a ball or running toward a target in space; see Williams et al., 1999).

The great flexibility with which the central nervous system organizes motor system degrees of freedom (i.e., possible movement solutions offered by parts of the body) into functional coordination patterns that emerge under constraints is an important feature of the constraints-led approach, suggesting how TGfU may work (Chow et al., 2006). Particularly relevant to TGfU, the interaction of task, performer, and environment provides the "boundaries" for an individualized goal-directed behavior to emerge, and this dynamic interaction between the constraints in the learning context is inherent in situational games in a TGfU lesson. This emergent characteristic of movement coordination suggests that the existence of a common optimal motor pattern for performing a skill is a fallacy attributable to the variability often observed in human motor performance (see Brisson & Alain, 1996). Individuals can use the great abundance of movement possibilities offered by the human musculoskeletal apparatus to vary the ways in which they solve movement problems, and an optimal movement pattern for one individual may not be optimal for another in relation to a specific task goal. This idea contradicts many traditional approaches to teaching motor skills predicated on the notion of an idealized, common optimal motor pattern toward which all learners may aspire (often presented by demonstrations from an expert model). Rather, the concept of emergence under constraints emphasizes the individualized nature of movement solutions as learners attempt to satisfy the unique constraints on them (Davids et al., 2001; Davids et al., 2007). Although similar movement patterns can be adapted and subsequently refined for motor performance, detailed analysis of movement kinematics are revealing that the specific movement patterns used by different individuals to achieve similar outcomes are not the same (Davids et al., 2003).

Movement pattern variability has traditionally been viewed as dysfunctional and a reflection of "noise" in the central nervous system. A constraints-led approach, however, suggests that movement variability is an intrinsic feature of skilled movement behavior because it provides the flexibility required to adapt to dynamic physical education environments (Williams et al., 1999). In fact, individuals find it extremely challenging to repeat a movement pattern identically across practice trials (Davids et al., 2003). Variability in movement patterns encourages exploratory behavior in learning contexts, a feature of relevance when engaging in TGfU. The paradox between stability and variability explains why skilled individuals are capable of both persistence and change in motor output during physical education (Davids et al., 2003). This feature of human movement

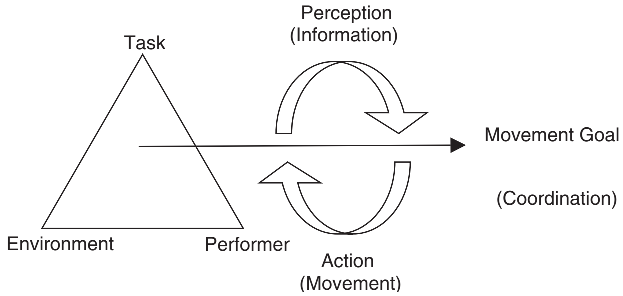


FIGURE 2. *Emergence of movement behavior from the interaction of key performer, environmental, and task constraints on the learner, as modeled by Newell (1986, 1996).*

systems actually provides performers with the capacity to invent novel ways to solve typical motor problems and to adapt to the changing task constraints of modified games. This radically different theoretical conceptualization of movement variability fits well with pedagogical claims of the efficacy of the TGfU perspective. For example, den Duyn (1996) observed that

> one of the interesting aspects of the game sense approach [the name given to the TGfU approach in Australia] is that incorrect technique is not necessarily seen as a "bad thing" that must be immediately changed. Many athletes use unorthodox techniques that still achieve the right result (and often bamboozle their opponent). (p. 7)

However, this is not to say that coaches and physical educators allow "free play" and hope that learners complete set tasks or game situations in whatever way the learners deem appropriate. Teachers must consider the constraints within the learning environment so that appropriate responses can be used by learners to achieve the desired learning outcomes planned for the sessions.

Constraints Framework for TGfU

From a motor control perspective, Kugler et al. (1982) and Newell (1996) emphasized the role of constraints in channeling motor behavior because the stability of functional coordination patterns can be altered by constraints imposed on performers. The concept of constraints is important to the nonlinear pedagogical framework espoused for TGfU. Constraints have been defined as boundaries or features that shape the emergence of behavior by a learner seeking a stable state of organization (Newell, 1986). Newell (1986) classified constraints into three distinct categories to provide a coherent framework for understanding how movement patterns emerge during task performance (see Figure 2). The three categories of constraints are performer, environment, and task.

Performer Constraints

Performer constraints are existing structural and functional characteristics of an individual, including height, weight, and body composition (physical attributes) and the connective strength of synapses in the brain, motivations, emotions, intentions, and cognitions (functional characteristics). An important performer constraint is the neuroanatomical design of the muscles and joints of the human body. Learners of different ages may present intrinsic differences in development of the neuroanatomical features specific to the stage of development of their bodies. These differences will have implications for how pedagogists structure learning tasks and plan modified games in TGfU. As noted earlier, the skill levels of learners are a crucial performer constraint that will have an impact on how relevant the TGfU approach is for the development of tactical awareness for specific learners. This observation is supported by data from French, Spurgeon, and Nevett (1995), who examined performance differences in youth baseball related to skills, expertise, and age. They noted that younger players were unable to use advanced tactics because they were constrained by the inability to appropriately execute the necessary movement skills. It seemed that skills and tactics constrain each other, developing in tandem. These findings are harmonious with the theoretical tenets of a constraints-led perspective, as we outline later, and it is notable that some proponents of TGfU have proposed modified games to introduce tactics so that all learners can learn without being handicapped by a lack of skill (Hopper, 2002).

Environmental Constraints

Environmental constraints are often physical in nature and could include such features as ambient light, temperature, or altitude. In any movement task, gravity is a key environmental constraint that influences how movement coordination may be adjusted. Other environmental constraints are social, including factors such as peer groups, social norms, and cultural expectations. Such factors are of particular relevance for young learners, for whom motor performance is often strongly influenced by the presence of critical group members such as teachers or classmates.

Task Constraints

Task constraints are more specific to particular performance contexts than environmental constraints. Task constraints are particularly important for the TGfU approach because they include the rules of games, the equipment used, boundary playing areas and markings, nets and goals, the number of players involved, and the information sources present in specific performance contexts. Clearly, pedagogists need a mastery of the task constraints of specific sports and games, because their manipulation could lead to the channelling of certain coordination patterns and decision-making behaviors (Araújo et al., 2004; Davids et al., 2007). Modified games in the TGfU approach typically involve the modification of task constraints to allow for appropriate progressions for tactical development. For example, instead of playing a full-sided game in soccer, manipulation of the rules to allow a three-against-one situation may be presented to encourage ball possession for the team of three players. The use of modified equipment is also widely promoted in TGfU. Shorter rackets, bigger playing balls, and lighter projectiles are all possible manipulation of task constraints to make modified games easier for learners to play. The manipulation of task constraints and making modified games "playable" for all learners certainly meets Bunker and Thorpe's (1982) proposals of developing a games appreciation outcome for TGfU.

An important task constraint relates to the available information in specific performance contexts that learners can use to coordinate actions. It has been argued that biological organisms, including humans, are surrounded by huge arrays of energy flows that can act as information sources (e.g., optical, acoustic, proprioceptive) to support movement behavior, including decision making, planning, and organization, during goal-directed activity. The role of information in regulating movement was particularly emphasized by Gibson (1979), who suggested that movement generates information that in turn supports further movement in a cyclical process. Understanding the need to keep key information sources and movements coupled together could inform how TGfU proponents design educational environments to facilitate perceptual-motor learning and the acquisition of decision-making skills in games. As a pedagogical principle, information-movement coupling certainly mitigates against traditional approaches such as task decomposition and the isolation of movement skills from game contexts for practice execution (Davids et al., 2007).

Implications of the Constraints-Led Perspective for TGfU

Following this brief synopsis of the constraints-led perspective, it is pertinent to assess how this particular theoretical framework can improve our understanding of the TGfU approach. In this section, we attend to these issues of pertinence, demonstrating how a constraints-led perspective can provide theoretical insights into issues of mechanism and function, while emphasizing person-environment interactions during teaching and learning.

A major implication of a constraints-led perspective in motor learning suggests that a key aim of games teaching in physical education is for learners to become attuned to the relevant informational properties in specific environments. Because information flow patterns are specific to particular environmental properties, they can act as invariant information sources to be acquired by individual performers to constrain their actions (Davids & Araújo, 2005). The use of task constraints, specifically informational constraints, in TGfU will allow games players to become better at detecting key information variables that specify movements from a myriad of noncritical variables in practice environments. Learners can attune their movements to essential information sources available through practice, thus establishing information-movement couplings that can regulate behavior (Jacobs & Michaels, 2002). For example, in a striking and batting game such as baseball, for which the tactical problem in a TGfU lesson could be "preventing scoring," outfielders need to successfully perceive positional and timing information from ball flight and to couple these sources with appropriate movement patterns to successfully intercept the ball. A good example of this idea was provided by Thorpe (2001), who illustrated how someone who is falling can still pass a basketball in a temporally constrained situation, thus demonstrating the interconnectedness of perception and movement in such dynamic sporting contexts.

It is also important to note that the interacting nature of key constraints shapes the emergence of motor behavior in the form of actions, intentions, and decisions. The presence of task constraints does not influence the emergence of a decision to act per se but determines how the specific intentions of a performer and information-movement couplings interact to allow a functional movement pattern to emerge in a modified game context (see Davids et al., 2007). It seems that a rich mix of structural, task, and intentional constraints interact to shape the emergence of stable, coordination modes, a finding that has strong implications for learners needing to use equipment in performance (e.g., rackets, oars, balls and bats).

How will a constraints-led perspective inform future research on TGfU? Certainly, the measurement of discrete variables to explain students' learning is incomplete and could provide a slanted perception of emergent behavior. The need to take into account how different constraints interact to produce a goal-directed behavior provides valuable information on the learning processes that are present within the TGfU approach. Although it is easy to acknowledge the need to examine interactions among the different performer, task, and environmental constraints in the learning context, it is more challenging to interpret the interactions of the different constraints and explain the emerging behaviors from a constraints-led perspective.

To establish ideas for future research programs on TGfU from a constraints-led perspective, our research group has undertaken a series of investigations on how emerging behavior can occur on the basis of the presence of specific task constraints in a learning environment. For example, one study examined how coordination changes as a function of practice for a soccer kicking task with specific task constraints. For the task, novice adult male participants were required to kick a soccer ball to a "live" receiver over a height barrier (bar) with different height constraints (1.5 to 1.7 m) and to various distances (10 to 14 m). All participants practiced over a period of 12 weeks with three sessions of 40 kicking trials per session. No explicit instructions were provided to the participants, and only a short video showing the ball's approach to the live receiver was provided to highlight ball flight characteristics upon ball reception by the receiver. Performance scores using a 7-point, Likert-type scoring scale were used to determine the appropriateness of the kicks in relation to the accuracy and weight of the passes. It was found that early in learning, participants were generally "driving" the ball, with little success in clearing the height barrier. Subsequently, later in practice, participants achieved success in clearing the height barrier and acquired higher performance scores. It was also found that the kicking patterns of the participants changed from a driving to a "lifting" or "scooping" action, which facilitated the attainment of the task goal. Interviews with participants after every practice session provided valuable information on their thought processes as they attempted to improve performance. It was particularly fascinating to note how participants were trying different techniques to first clear the height barrier before attempting to improve on accuracy. Interestingly, the change in coordination and improvement in performance was achieved without the presence of explicit instructions on technique, and goal-directed behavior emerged as a consequence of the presence of the specific task constraints in the learning task.

The findings from that study highlighted how the presence of the appropriate task constraints can help direct learners to search for functional behaviors to achieve task goals in the absence of direct instructions on technique. Moreover, in the study, both outcome (performance scores) and process (kinematic data analysis that provided information on coordination and interviews that provided qualitative information on cognitive processes during learning) measurements were useful in constructing a reflection of the learning process that encompassed the interaction of key performer, task, and environmental constraints. This study has implications for framing future research in TGfU, highlighting the situated learning and constraints-led approach that could be adopted to better understand the learning processes of students in a TGfU setting. Particularly, a multitude of variables focusing on both processes and outcomes of teachers' teaching behavior (e.g., task manipulation, questioning technique, delivery of skill learning opportunities) and students' behavior (e.g., decision-making behavior, movement skills demonstrated in simulated situational games) should be measured and analyzed to provide a clearer interpretation of the processes underlying the TGfU approach in a constraints-led perspective in future research. For example, we can compare how goal-directed behavior can be present in small situational games when the "appropriate" task constraints are manipulated, in relation to a learning context in which those task constraints are absent. Dependent variables pertaining to observable students' behaviors can be categorized using existing tools (e.g., the Games Performance Assessment Instrument developed by Oslin et al., 1995; the Team Sport Assessment Procedure developed by Gréhaigne, Godbout, & Bouthier, 1997; or any other self-developed validated behavior coding tool) if relevant. Further quantitative measures on skill and performance can be determined to investigate specific technical skills acquired through TGfU lessons. Questionnaires or interviews with both teachers and students could also be undertaken to elicit qualitative information on perceptions or even thought processes driving the movement and decision-making behaviors.

In relation to understanding the development of skilled games players from a practitioner's perspective, the constraints-led framework, based on the tenets of nonlinear pedagogy, could provide further insights into how sports expertise is acquired. Possession of superior knowledge, organization of task-specific knowledge, superior recognition of patterns of play, and effective perception of kinematic information are all reportedly characteristics of sports expertise (e.g., Abernethy, 1994). It is plausible that skilled games players are able to form effective information-movement couplings through effective practices that present various task constraints that interact with performer and environmental constraints. Task-specific actions that satisfy goal-directed behavior could generally be seen as qualities of effective decision making, which could help in improving understanding of game tactics in TGfU.

Below, we elucidate key practical implications of a constraints-led perspective for teaching decision-making behavior from the TGfU approach, using the volleyball attack subphase as an exemplar.

Constraints on Decision Making in TGfU

The ideas of Newell (1986) on performer, environmental, and task constraints provide a sound framework for examining the central principle in the approach of TGfU (i.e., to develop appropriate tactical behavior in games through the manipulation of key constraints). Teachers' manipulation of constraints can lead learners to attempt to satisfy them in a lesson context, thereby guiding them toward a range of suitable action solutions to tactical problems. In this view, intentions in humans are "embodied," that is, based in real-world settings and constrained by a number of factors, including mind, body, social, and biological contexts (Davids et al., 2007). It is important to understand that the intention of a performer is emergent; that is, the decision making takes into account initial conditions that allow the attainment of a final condition along a goal path governed by the existing environmental context. Along the goal path from initial conditions to final outcome, more and more information becomes available as a learner advances toward a specific movement goal (e.g., moving to intercept a ball). Given that information

LESSON PLAN (UNIT: Net-Volleyball)

Level: 8th Grade Lesson No.: 3 Class Time/ Duration: 30 mins

Date: _______ Venue: Indoor Courts

Equipment needed: 3 sets of badminton posts and nets

16 volleyballs, markers and cones

Tactical Problem: Setting up to attack

Lesson Focus: Set up volley pass for attack hit

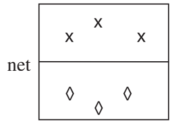
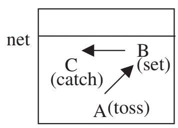
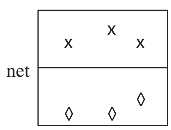
Situational Game 1: **Goals:** 1) Score points to win rally 2) 10 points to win set **Conditions:** 1. Bounce between passes allowed 2. No consecutive hits by the same player 3. Ball has to be hit above head when played over to opponents 4. Toss to serve 5. Maximum 3 hits per side	**Organization:** 3 v 3 in half a badminton court  	**Observation/ Evaluation:** Ball to be set high near the net	**Time:** 8mins
Question & Answer: 1) Where is it easiest to attack from? Ans: Near the net 2) How would you score a point? Ans: Execute an attack hit above the head 3) What must your team do to prepare for an attack hit? Ans: Set up to attack			**Time:** 2mins
Practice Task: Volley pass from setter to spiker **Goals:** 1) Successful pass to spiker 2) 3 good passes before rotation **Condition:** 1) Toss, set, catch 2) A to toss, B to set and C to catch the ball above head	**Organization:**  	**Teaching Points:** 1) For setting, get under the ball 2) Bend knees 3) Contact ball with finger pads, flick wrist, elbows bent and wide 4) Set the ball high 5) Face direction of pass	**Time:** 8mins
Situational Game 2:	**Organization:**	**Evaluation:**	**Time:**
Goal: To execute setting up to attack effectively (as a team) **Condition:** 1. As per Situational Game 1 2. Point won only with set pass prior to attack hit	 		10mins

FIGURE 3. *Representative Teaching Games for Understanding lesson plan for net-barrier (volleyball) game.*

emerges to carry out the intended action, the available action paths become clearer, and eventually, at the penultimate moment of achieving the goal, a final path can be uniquely defined from a number of action choices (Kugler, Shaw, Vincente, & Kinsella-Shaw, 1990). From a constraints-led approach, physical educators' manipulation of key task constraints can guide learners toward a range of highly suitable action paths, narrowing down the time needed for exploratory behavior of the learners.

In a typical TGfU lesson, constraints that need to be satisfied by each learner and that may be manipulated by a physical educator are outlined in Figure 3. Figure 3 depicts a lesson in which a physical educator can provide a tactical problem to learners with an emphasis on "setting up to attack" in a volleyball game (i.e., net-barrier game). Learners can be challenged to "decide" when, where, and how to set up an attack in the game of volleyball. In Figure 3, it can be seen that an introductory game presents an appropriate context for learners to explore how best to make an attacking hit into the opponents' court (assuming that learners have previously learned how to "dig" a ball in previous TGfU lessons). Suitable task constraints can be manipulated to provide the necessary boundaries to encourage learners to execute an attack. For example, equipment constraints can be manipulated so that only badminton nets, which are much lower in height than actual volleyball nets, are used. In addition, specific instructional constraints can emphasize "playing the ball toward an opponent by contacting the ball above your head," encouraging learners to "set" the ball up for an attack above the head. Other constraints that allow for a bounce between hits within the same team and tossing for service provide opportunities for greater success in the situational game. The task constraints in this lesson guide the learners to search for appropriate goal-directed movements to attempt to outplay their opponents. With the appropriate task constraints in place, learners will soon realize that for an attack hit to be played across to the opponents' court, the pass prior to the attack hit will have to be high and elevated. In turn, the learners will possibly attempt to set the ball high, either by digging the ball or trying a "volley" set. In this sense, goal-directed behavior emerges without the need to provide explicit and prescriptive instructions for executing an overhead set pass for a smash. Subsequently, skill development occurs after the question-and-answer session (which confirms the demonstration of the desired movement behavior and decision for setting up an attack). Task constraints can be manipulated further to provide "tighter" boundaries for learners to set up an attack with the modified instructions "to execute set pass prior to attack hit." Through attempting to satisfy constraints manipulated by the physical educator, learners will gradually acquire the appropriate decision-making skills to set up an attack and therefore solve the tactical problem for this particular TGfU lesson.

In the TGfU approach to teaching tactics and decision making, the example on volleyball setting and smashing indicates the value of allowing decision making to emerge under interacting constraints, on the basis of the satisfaction of task constraints that interact with environmental and performer constraints. The skill levels and physical makeup of the learners, together with intentionality to perform the task, may also interact with the task and environmental constraints to influence the development of decision making in TGfU. The provision of relevant information through suitable questions presented by educators, coupled with setting up appropriate task constraints, may encourage the emergence of effective tactical awareness on the part of the learners. Wright et al. (2005) summarized it neatly in their study examining games teaching in teacher education: Game players need to execute the necessary movements required in the game by understanding why certain moves are appropriate. The questioning process in TGfU reinforces the “knowing” of strategy, but the goal is to embody that knowing in the actions carried out during the learning process (Wright et al., 2005). And from a constraints-led perspective, the knowing comes about from learners’ satisfying the various interacting constraints in the TGfU lesson, in which appropriate goal-directed movements and decisions to move emerge through the teacher’s careful manipulation of key task constraints.

Constraints and Skill Learning in TGfU

Earlier, we suggested that links with a model of motor learning were required for the successful understanding and implementation of the TGfU approach in pedagogical practice. A useful model for this purpose is Newell’s (1985) model of motor learning, which can be used to address the question of TGfU’s relevance for performers of different skill levels. Newell (1985) proposed that early in learning, an individual is in the coordination stage, seeking to harness available movement possibilities offered by the neuromuscular system to provide stable solutions to specific motor tasks. The successful search for a functional coordination pattern allows performance of the task to a basic level, as the learner assembles component relations between relevant parts of the body. Stability and refinement of a coordination pattern is achieved as a result of the learner’s exploring the coupling between varying informational constraints and different performance contexts. Performers are in the control stage of learning when they can flexibly adapt stable coordination patterns to imprecisely fit changing performance environments. Subsequently, expert performers reach the skill stage when they can vary coordination patterns in an energy-efficient manner to fit changing circumstances in dynamic environments (Davids et al., 2007).

The constraints-led approach, incorporating Newell’s (1985) model of motor learning, illustrates how a suitable progression in lessons within a TGfU curriculum could be structured to allow optimum learning opportunities for learners. One suggestion is to begin with less complex games, such as target games with simple tactical concepts, in the TGfU curriculum as categorized under the classification system for games (see Griffin, Mitchell, & Oslin, 1997) before proceeding to more complex games such as invasion games (Werner et al., 1996). The use of modified games and questioning techniques within the TGfU approach serves to encourage learners to actively seek and explore a variety of solutions to tactical problems rather than receiving information passively. The delivery of exploratory or discovery learning promotes functional variability in practice and the exploration of movement dynamics, which enhances the search process by increasing learners’ exposure to varieties of task solutions (Newell & McDonald, 1991). In relation to Newell’s model of motor learning, such exploratory practice is valuable in both the coordination and control stages of learning for different reasons (see also Davids et al., 2007).

In the coordination stage, exploratory learning is useful for learners to assemble functional and unique coordination structures to achieve a specific task goal, such as kicking a ball. At this stage of learning, simple tactical problems could be presented, and the emphasis may be on acquiring some basic movement pattern of performing a skill before decision making could be taught. This is to allow learners to find success in both skill execution and decision making at this stage of learning. Specifically, learners who are in the coordination stage of learning may require modified games that have task constraints ensuring experiences of success, because learners at that stage may not have the necessary skills required to play a modified game that is more similar to the adult version of the game. For example, smaller activity groups or bigger targets or projectiles could be made available so that learners could achieve success in the modified games while attempting to solve simple tactical problems without worrying too much about the lack of necessary "skills" to perform the required movement in situational games. For example, in the previous example on volleyball, bigger and softer balls can be used so that the learners have a greater likelihood to execute a volleyball set or dig pass successfully so that an attacking hit can occur in the situational game. Thus, the use of modified balls allows learners to acquire basic movement patterns to execute volleyball set or dig passes, which will be useful for learners in the coordination stage of learning. Certainly, the appropriate manipulation of task constraints supports the stand put forth by proponents of TGfU that all learners can play a game if suitable modifications to the game are made to generate meaningful play (see Mitchell, Oslin, & Griffin, 2005). Subsequently, physical educators could proceed to present specific skill practices that place emphasis on the acquisition of relevant movement patterns that use age- and skill-appropriate equipment for learners. While later in learning, exploratory practice allows players to refine and adapt existing coordination patterns to enhance flexibility in coordinating actions to the events of dynamic environments.

Practice structure, particularly when individuals proceed beyond the coordination stage into the control stage, should emphasize keeping information and movements together so that learners can start to associate movements with key information sources (e.g., hand movements with a moving ball or movement of a learner in relation to teammates in the situational game). Traditional methods of decomposing tasks to manage information loads on learners inadvertently prevent such information-movement couplings from forming. An example of task decomposition is when learners practice the ball-toss phase of a serving action in racket sports separately from the hitting component. Task simplification refers to the process whereby scaled-down versions of tasks are created in practice and performed by learners to simplify the process of information pickup and coupling to movement patterns (Davids et al., 2003). The use of modified games with a preservation of the intended tactical concepts at the beginning of a TGfU lesson can be seen as another example of task simplification. For example, when learning to maintain possession in soccer, instead of passing with the feet in an introductory game, learners can be introduced to the tactical concept by participation in a passing game with the hands. This manipulation of task constraints could allow more opportunities to develop an awareness of tactical requirements in a modified version of soccer, with specific task constraints maintained (e.g., goals, line markings, other players). In this sense, learners in the control stage can focus more on the tactical aspect of the game in terms of movement off the ball or concurrent movement by teammates in the surrounding environment. Subsequently, learners can engage in additional skill practices on passing with the feet, acquiring the specific skills and information-movement couplings in the game of soccer to facilitate ball control as well as ball possession.

Moreover, the use of hands in the introductory game for maintaining possession in soccer could provide teachers with an opportunity to highlight the generality of tactical concepts used in different types of invasion games. The provision of a variety of experiences accentuates the similarities and differences among games, which is the purpose of game sampling in a TGfU setting (Griffin & Sheehy, 2004). For example, positive transfer of game performance and cognitive knowledge has been observed from badminton to pickle ball (Mitchell & Oslin, 1999). However, this assumption of "skill substitution" in TGfU, whereby one skill is substituted for by another to reduce the technical demands of the game, requires further investigation because this may lead to negative transfer when the real game is introduced (J. E. Holt, Ward, & Wallhead, 2006).

Whereas past research on TGfU has presented mainly dichotomous views on skill learning from either a tactic-to-skill or skill-to-tactic approach (e.g., Alison & Thorpe, 1997; Rink, 1996; Rink, French, & Tjeerdsma, 1996), from a constraints-led perspective, this distinction may be a false dichotomy warranting further investigation. On the basis of Newell's (1985) model, the key issue of delivering either skills or tactics will be resolved by adopting a student-centered approach (see also Hopper, 2002). This decision is a matter of differences in the proportion of emphasis on both approaches, which is dependent on students' stages of learning. The implication here is not to focus solely on skill development for beginners in the coordination stage of learning but to place greater emphasis on presenting games that challenge learners to develop fundamental skills required for the specific game. The development of simple decision awareness could also be taught in the coordination learning stage for beginners to allow them to acquire basic yet essential understanding of game play to enable them to achieve success. In the control stage, greater emphasis could be placed on providing variations in task constraints in modified games to optimize learners' acquisition of movement skills and game awareness through increasing interactions with the environment. Such a process in motor learning occurs by adapting basic coordination pattern to achieve more challenging and varied task goals.

In summary, Newell's (1985) motor learning model presents pedagogists with a content framework to vary emphasis of TGfU games to suit the needs of each individual learner, regardless of the stage of learning. This model of motor learning shows how a constraints-led approach can be harmonious with the student-centered perspective advocated by TGfU (e.g., Hopper, 2002). A key issue for pedagogists interested in TGfU is not whether skills teaching should precede tactics but how an appropriate model of motor learning can be used by teachers to adjust TGfU lessons through manipulating appropriate constraints in an individualized, student-centered approach.

Constraints and Feedback in TGfU

An important aspect of pedagogical practice concerns the provision of feedback to learners. For many years, motor learning theorists have been concerned with the verbal and visual delivery of augmented feedback to learners (Newell, Broderick, Deutsch & Slifkin, 2003). Recently, Davids et al. (2007) viewed the role of augmented information as directing learners' (continually evolving) search for solutions that satisfy the constraints imposed on them. From a constraints-led perspective, current research has supported the idea of allowing discovery of learning through focusing on an image of achievement (focus on the movement effects to be achieved in a practice setting) rather than an image of the act (focus on movement dynamics or specific topological form of a movement to be acquired) (see also Vereijken & Whiting, 1990). It was argued that an emphasis on achieving effective movement outcomes in sport would allow functional coordination patterns to emerge from the interactions of the various task, performer, and environmental constraints. These ideas on augmented feedback have received some support from work by Wulf and Shea (2002), who observed that an external focus that directed performers' attention toward the movement effects, rather than to other external sources of information, yielded better learning and performance of a tennis forehand drive. They proposed that an "external focus of attention" did not distract learners from the movements required but instead allowed the implicit regulation of task performance and learning.

These ideas on the use of augmented feedback from a constraints-led approach have important implications for TGfU, in which the teacher is seen as a facilitator and questioning is an important aspect of the educational process for the development of tactics in learners (Griffin et al., 2003). The provision of augmented feedback through questioning after the introduction of modified games helps direct learners' attention to the specific tactical knowledge required rather than to the skills needed. The infrequent presentation of augmented knowledge coupled with an external focus of attention in the skill acquisition process of TGfU can allow learners to use discovery learning to full effect and exploit self-organization processes in the motor system during practice. In addition, the use of a less prescriptive and a self-regulated feedback mechanism, which complements discovery learning, could encourage learners to more effectively explore constraints provided in TGfU for decision making.

Conclusions: Nonlinear Pedagogy in TGfU—Implications for Physical Education

TGfU has been actively adopted across the globe as an effective approach to teach games skills to learners in physical education. In reviewing previous research, we have argued that the constraints-led framework within a nonlinear pedagogical perspective has the necessary theoretical underpinnings to explain how and why TGfU is effective in creating appropriate learning outcomes for learners. There is a clear need for future research to continue to provide empirical data to validate a constraints-led framework as a sound basis for implementing TGfU. The analysis of empirical data could present important implications for structuring practices and the delivery of instruction as well as the provision of feedback in physical education more generally.

The use of appropriate models of motor learning, such as that of Newell (1985), will assist researchers on TGfU in understanding how it can be used with learners at different skill levels. Specifically, the valid categorization of learners at different stages could help researchers understand differences in expected performance outcomes for different learners within the TGfU approach more successfully. Progressions for TGfU lessons and activities in physical education may be more effectively planned, taking into account the needs of learners at different stages of learning in a student-centered approach. Greater emphasis on tactics or skills can be presented in introductory games through the manipulation of task, performer, and environmental constraints without compromising the core objective of developing game awareness for learners through TGfU. For example, a teacher could present more complex games by progressively manipulating specific task, performer, and environmental constraints to guide learners to explore relevant tactical solutions. The challenge for teachers is not just to understand how to manipulate constraints but to identify the key individual constraints that can be presented to students to encourage learning. From a pedagogical perspective, the TGfU approach empowers learners to become active learners (Kidman, 2001), and the manipulation of constraints within TGfU lessons encourages learners to engage in self-discovery in attempting to satisfy individually specific constraints, which could lead to greater enjoyment and motivation. The debate about the need to differentiate skill development from tactical development in assessing the effectiveness of TGfU over traditional technique-based approaches may be somewhat secondary because the primary goal is to determine and comprehend how constraints can be presented to meet individual learning objectives.

In this article, we have reviewed a number of alternative explanations for the efficacy of TGfU, focusing initially on cognitive, constructivist theories based on situated learning. Later, we emphasized how a constraints-led framework from a dynamical systems perspective could provide a relevant framework for the implementation of TGfU, which needs to be empirically examined through an evidence-based practice approach in physical education. It was indicated how TGfU could gain input from the motor learning and control literature to provide a much-needed explanatory theoretical framework for understanding and implementing TGfU (see criticisms of McMorris, 1998). We also showcased some empirical work on how emergent behaviors can occur under specific task constraints. It was suggested how such empirical work could frame future research programs on investigating the interaction between intentionality of learners and emergent behaviors as a consequence of manipulating performer, task, and environmental constraints in TGfU. We proposed how the exploration of using key conceptual components from a dynamical systems perspective could also lay the foundations for the development of a conceptual model for nonlinear pedagogy, providing a theoretical framework to further examine motor learning issues in pedagogy and physical education. Although the potential for theory development in this area is significant, there is now clearly a need for established programs of empirical research to investigate how manipulating performer, environmental, and task constraints can strengthen the interaction between the intentionality of learners and the emergent movement behavior. This body of research will clarify specific practical recommendations for structuring effective learning progressions during the process of skill acquisition through TGfU and also shed valuable knowledge on structuring appropriate pedagogical interventions in our schools.

Note

[1]A Teaching Games for Understanding (TGfU) task force consisting of academic researchers from different parts of the world has been set up to undertake continued research in TGfU. A series of conferences have also been organized since its inception to advance the delivery and presentation of TGfU lessons for learners (see http://www.tgfu.org).

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Authors

JIA YI CHOW is a lecturer in the Physical Education and Sports Science Section of the National Institute of Education, Nanyang Technological University, 1 Nanyang Walk, Singapore 637616, Singapore; email: *jiayi.chow@nie.edu.sg*. He was awarded an Overseas Graduate Scholarship from the National Institute of Education to undertake doctoral study with University of Otago, New Zealand, in 2004. His area of specialization is in motor control and learning, with specific research interests in examining the coordination of discrete multiarticular movement, physical education pedagogy from a nonlinear approach, and the functional role of movement pattern variability.

KEITH DAVIDS is currently head of the School of Human Movement Studies at Queensland University of Technology, Kelvin Grove, Queensland 4059, Australia; email: *k.davids@qut.edu.au*. He was a first-class honors graduate in education and physical education at the University of London and gained a PhD at the University of Leeds in 1986. His main research interests concern how theoretical ideas from ecological psychology and nonlinear dynamics can be integrated into a nonlinear pedagogical framework for designing strategies for organizing learning and teaching opportunities in physical education.

CHRIS BUTTON is a senior lecturer in motor learning in the Division of Sciences, School of Physical Education, University of Otago, Dunedin, New Zealand; email: *chris.button@otago.ac.nz*. His research interests include the control of interceptive actions, coordination variability, and decision making. A summary of much of his research can be gained from the textbook *Dynamics of Skill Acquisition* (Human Kinetics, 2007).

RICK SHUTTLEWORTH is a skill acquisition specialist in the Australian Institute of Sport. He joined the Australian Institute of Sport in 2007, coming from a university and also an applied coaching background. His research and applied interests are dynamical systems, coordination dynamics at the individual and team levels, decision making in sports, constraints-led coaching, and rugby union.

IAN RENSHAW is a senior lecturer in the School of Human Movement Studies at Queensland University of Technology, Kelvin Grove, Queensland 4059, Australia; email: *i.renshaw@qut.edu.au*. His research interests include visual regulation of locomotion, perceptual training and the development of a nonlinear pedagogy for the teaching and coaching of sport.

DUARTE ARAÚJO is an assistant professor on the Faculty of Human Kinetics at the Technical University of Lisbon, Lisbon, Portugal; email: *daraujo@fmh.utl.pt*. His research involves the study of expert decision making in sports, which led to his receiving the Young Researcher Award at the European College of Sport Science in 2001 and at Association des Chercheurs en Activités Physiques et Sportives in 2002.