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The Constraints-led Approach Framework in Training and Coaching.

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ABSTRACT

Movement "constraint" is defined as a variable that defines the way a movement can be organized and controlled. The "constraint model" emphasises the important interactions of individual constraints, environmental constraints, and those of skill - in a balanced perspective - and suggests that constraints can shape the manifestation of movement patterns, cognitive processes, and decision-making processes. According to the Constraints Model, any learning / teaching environment should be arranged in such a manner as to provide any learner with capability or protentional into movement. Therefore, in this way, each youngster will feel that they have accomplishing something, improving their perception of their abilities and, thus, their self-confidence. The application of the Constraint Model within PE can help to 'shape' young people who will progress in life with fluency and skill, will be creative and confident, and have acquired a deep understanding and knowledge of how they interact within a dynamic and ever constantly changing environment.

Key words: constraints, representative learning design, physical education

Introduction

In a school / (an academic) curriculum, Physical Education (PE) is the subject that aims to contribute to the holistic development of students - at a physical abilities level, cognitive and emotional. The content of PE lessons aims to help pupils to develop knowledge and skills, to grow their ability and confidence and therefore to perform fundamental and progressively specialised movements, which will result in them adopting a more physical active way of life for the rest of their life. An essential component of physical education programmes is developing independent, innovative, and self-sufficient 'learners' (Roberts, Newcombe, & Davids, 2018).

The theoretical model 'constraints-led approach' is a contemporary pedagogical approach that can be applied in the school environment and serve the afore-mentioned purposes of PE. In this paper, the term 'Constraints Model' will be used for the 'constraints-led approach'.

The development of the "Constraints Model" has been based on the Dynamical Systems Theory and on ideas related to Ecological Psychology. It is an ecological model that focuses on the relationship that arises between the interaction of the individual with an environment of efficiency. According to

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the constraints model, the most skilful execution/performance of a movement occurs through self-organization in the presence of constraints as individuals become perceptually attuned to important sources of information that can regulate individuals' actions in specific performance environments (Renshaw, Araujo, Button, Chow, Davids, & Moy, 2015).

In this paper, we refer to the constraint model and the categories in which constrains are classified. It is explained how the Constraints Model contributes to the formulation of appropriate PE contents, with the aim of learning and developing of motor skills, and the management of the information provided it results from the "performer-environment" interaction. It also discusses how the management of constraints is related to cognitive skills and self-organization ability. The final part of the paper (**Appendix**) describes examples of PE lessons using the traditional teaching method and the constraint model approach.

Ecological Dynamics and Constraints Model

Ecological dynamics is a theoretical model that has evolved combining the theories of Dynamical Systems and Ecological Psychology. The Ecological Dynamics model emphasizes the importance of the relationship between "performer and environment" for the design of learning contents and for the process of developing skills. Adopting such an approach leads coaches / trainers to view learners as complex, adaptable dynamic systems, that adapt to events, objects, significant others, in a constantly changing performance environment.

The Constraint Model pedagogical approach supports the development of intelligent, internally motivated pupils, who are engaged in PE lessons (Moy, Renshaw, & Davids, 2016). The Constraint Model is an expression/manifestation of the Ecological Dynamics theory and is based on ideas and concepts such as: the combination of information-movement, representative learning plan, modification of constraints, acceptance of variability / diversity, external focus of attention, alignment to opportunities for movement (Renshaw et al., 2015). The constraint model focuses on the performer-environment' relationship and proposes that functional motor solutions are an inherent characteristic of humans, who are considered as self-organised, non-linear motor systems. It is argued that behaviours - actions/movements, perception, knowledge - arise from the ongoing interaction of each performer's unique individual constraints with the constraints of abilities and performance (Renshaw, Chow, Davids, & Hammond, 2010).

The constraint model provides a framework for understanding how individuals learn, each person's constraints, the skill / ability and the environment that shape the learning process. Valid categorization of constraints for each practitioner helps to understand how differences lead to different, appropriate performance outcomes. Constraint model approaches help develop a model for the trainee and for the learning process that will further improve practice. This logic supports the creation of novel kinetic solutions by designing learning contents that provide controlled "frontiers" of exploration within dynamic environments by providing skill-relevant constraints. According to the constraint model, motor skill learning depends on self-organization in relation to the constraints of the individual, the skill / ability, and the environment, as well as the effective combination of perception and movement (Brymer & Renshaw, 2010).

Classification of the Constraints

Constraints are defined as "boundaries" or characteristics that shape the manifestation of a behaviour. The interaction of various constraints 'forces' the performer to adopt stable and efficient motor patterns when performing physical activities and dynamic target interception movements (Brymer & Renshaw, 2010; Renshaw et al., 2010).

According to constraints-led theory, a movement constraint is defined as a variable that defines the way in which a movement can be organized and controlled. The 'constraints model' proposes that constraints drive the dynamics of the evolution of movement. They can shape the manifestation of motor patterns, cognitive processes, and decision-making processes (Chow, Davids, Button, Shuttleworth, Renshaw, & Araujo, 2007; Renshaw et al., 2015).

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Due to the interdependence of the various processes in the motor system, a small change in one part of the system can bring about large changes in the motor-sensor outcome (Renshaw et al., 2010). According to Newell (1986), the constraints are classified into three categories: individual or organismic constraints, environmental constraints, and task constraints (Brymer & Renshaw, 2010; Renshaw et al., 2010).

The **individual constraints** refer to the unique structural and functional characteristics of each individual and relate to biological, physical, and psychological - cognitive parameters. These parameters influence/shape how individuals approach a motor skill. Personal - individual factors provide affordances for actions and play an important role in determining how a motor behaviour is performed/executed. These different individual constraints demonstrate various possible strategies/techniques that can be used to manage specific skill / abilities characteristics, as well as lead to individual adaptations (Brymer & Renshaw, 2010; Renshaw et al., 2010). Obviously, the ways of approaching or managing a kinetic energy (ability to move) will vary, as each performer will try to "meet" their individual limitations and "manage" specific situations through their own adaptations. For example, when adjusting the straddle before crossing over a puddle, individuals with different lower limb lengths will use different ways of performing the skill (task solutions) based on their own (individual) physical characteristics. Unique individual constraints can influence behaviour and provide specific 'individual pathways' to achieve similar performance outcomes.

The term 'affordance' is also used in the literature to describe a possibility for action/movement that combines the objective nature of the environment with the subjective nature of the performer (Brymer & Renshaw, 2010; Renshaw et al., 2010). This means that a specific environment will have certain properties/characteristics and an individual perceives possibilities for movement/energy within it from their own unique perspective. For example, two performers performing the same exercise with a canoe, in the same environment, but with different physical characteristics (body height and length of body parts) will come to different conclusions and different ways of performing the task- solution. In the same environment, performers with different individual characteristics will perceive the same motor demand differently and will result in a different - individual - motor outcome (Brymer & Renshaw, 2010). In dynamic performance environments, the influence of environmental constraints is very important. **Environmental constraints** relate to physical and socio-cultural factors. Physical factors refer to the immediate environment in which a motor skill is performed, and the information provided within it (dimensions and characteristics of the skill performance area, weather conditions, lighting level, gravity, altitude). Socio-cultural factors relate to the role of social structures/contents and cultural - intellectual expectations (group expectations, the relationship with significant others such as the teacher and peers in the school environment).

Skill constraints are all about the objectives of the skill / ability, regulations, spatial boundaries, and requirements related to the performance of the skill, applications or equipment used in the learning process. Unlike other constraints, skill constraints are easier to modify (e.g., modifying the equipment available to the trainees or the dimensions of the practice area, identifying specific motor objectives). Small modifications to the skill constraints result in big changes in the performer's behaviour.

Skill constraints play an important role in influencing performer's intentions and can be modified in a learning/practice environment to encourage specific behaviours or motor solutions. An effective modification of a skill's constraints should direct performers towards 'discovery' of functional coordination patterns and into decision-making behaviours (Chow et al., 2007; Renshaw et al., 2010). However, decisions to modify the constraints of an ability should be related to the performer's cognitive level and their level of motor development (Chow et al., 2007; Gagen & Getchell, 2006; Rudd, O'Callaghan, & Williams, 2019). Such modifications to the content/learning environment can lead to large changes in motor patterns during the learning process. Newell's (1986) constraint model empha-

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sises the important interactions of individual constraints, environmental constraints, and skill constraints - in a balanced perspective. Understanding the unique - for each performer - skill constraints will assist in designing effective learning content (Renshaw et al., 2010).

Teaching contents design based on the Constraints Model

Physical education (PE) subjects should take place in learning environments that have a specific learning objective, are 'playful' and information rich. According to the Constraints Model, each learning environment should be designed in such a way that it provides possibilities for movement for each student. Therefore, in this way, every youngster will feel that they have accomplishing something, his abilities' perception and self-esteem will improve. The rules of the game or activity, the dimensions of the practice area, the number of children in each group, the amount and size of the equipment should be modified to create appropriate learning content, which - in an implicit way - will provide possibilities for movement aligned with the intended goal. In such a learning content, learners are 'silently directed' towards the desired motor solutions. They discover, self-act, gain knowledge, understanding and learn (Roberts et al., 2018). According to Constraints Model to design the appropriate learning context / boundaries in PE the below principles need to be applied (Roberts et al., 2018):

1) Teachers should design appropriate learning environments, considering the cognitive level of the trainees and their level of motor development (Chow et al., 2007; Gagen & Getchell, 2006; Rudd, et al., 2019), which "provide" the desired possibilities for movement. Teachers should identify the most important sources of information - which performers can use to coordinate movements/actions - and confirm that this information is available in specific practice environments. It is important that the learning environment facilitates problem solving when regulating motor actions. Observing children engaged in the decision-making process is a sign that they are building knowledge from different domains. Deciding when and how to act should be motivated by information in relation to the possibilities for movement in the environment.

2) The learning environment should encourage the trainee / performer to discover possibilities for movement relevant to the objectives pursued. Decisions for actions should come from the trainee's choice to align with the information related to the possibilities for movement in the environment (information-movement combination). A well-structured learning content should implicitly lead the trainees to knowledge and understanding of movement - tailored to their own individual characteristics.

3) Management of constraints. Modifying the constraints of the skill / ability is considered a common way to direct performers towards functional information-movement combinations that will facilitate the creation of functional motor patterns and enable them to achieve the goals of the skill / ability.

4) Collaboration and co-adaptation. The performer's interaction with teammates and opponents in a learning environment will have the greatest impact on the discovery of innate self-organizing tendencies. Skill constraints should be modified in such a way as to provide performers with the opportunity to cooperate and co-adapt, understanding how their interaction with others can affect both their own development and that of others. Having students work in pairs or small groups on the various games emphasizes collaboration and is also a useful method of differentiation.

5) Management of unstable conditions. When teachers design practice contents, it is important to manage the "performer-environment" system so that it is balanced at a critical point - on the edge of chaos - i.e., in a performance area that is neither too stable, where the resulting behaviours will be static, nor in a continuously unstable area that is unmanageable. When the "performer-environment" system is in equilibrium in an area, where many motor-related performance solutions are available, non- stable conditions are created for performers, who are forced to discover different options and create problem-solving behaviours.

6) Skill and adaptability. The need for flexibility in skill development is emphasised to encourage performers to seek different solutions to the same or similar problems. Creating learning environments that have some volatility in the learning contents, which provide many possibilities for problem solving, allow performers to discover effective adaptive motor (skill) solutions. The modification of skill constraints in a practice environment should provide characteristics of repetition and variability, so that performers can move deftly while also interacting with the performance environment. Coaches / trainers should incorporate a variety of appropriate constraints to help performers effectively seek successful motor (skill) solutions in a practice environment. The search process should create conditions for adaptability so that performers can find unique solutions compared to their individual and skill constraints and of the environment. The development of this functional variability in motor models facilitates a 'discovery approach' during the learning process (PE lesson/training) allowing practitioners to create effective coordination models that meet skill constraints (Brymer & Renshaw, 2010; Renshaw et al., 2010). While variability features have traditionally been classified as non-functional, the constraint model proposes that variability in motor models is viewed as an intrinsic feature of adaptive motor behaviour that is necessary to consistently achieve a motor goal in a dynamic learning and performance environment (Brymer & Renshaw, 2010; Renshaw et al., 2010).

The application of the Constraint Model in the context of physical education can help 'shape' young people who will move with fluency and dexterity, be creative and confident, and have gained a deep understanding and knowledge of how they interact with a dynamic and ever-changing environment (Roberts et al., 2018).

Management of the information provided through the Constraints Model

The constraint model could facilitate the learning process through the approach of "managing the information provided to performers/ trainees".

Teaching motor skills by 'decomposing' the skill into 'manageable' components (task decomposition) is a teaching method commonly used to manage the amount of information provided to performers (Thomas, 2007). However, 'decomposing' complex coordination models can cause the information-movement combination to 'break down', making it difficult for performers to perform the skill / ability. The constraint model encourages a method of "task simplification" of motor skill. This is a teaching method that allows different components of complex motor coordination models to be learned together, thus preserving the information-movement combination. According to this approach, skill development - learning should take place in the real environment, but where needed the learning content (e.g., environmental characteristics, target of the performed motor skill) can be simplified to explore effective movements. It is also argued that additional modifications of the skill constraints can facilitate the learning outcomes of this method (Renshaw et al., 2010).

For example, using larger and softer balls or smaller handles on rackets could allow performers to successfully complete the overhead service movement without affecting the important time-position relationship in the movement. To make such modifications to the learning environment, it is essential that the coach / trainer has full knowledge of the skill and environmental constraints and the ability to observe and interpret individual constraints (Brymer & Renshaw, 2010; Renshaw et al., 2010).

Effects of constraints management and cognitive abilities

Physical activity, in addition to improving motor skills, is being explored as a method of enriching cognitive skills. Cognitive skills are linked to the development of the self-organisation required for a child to be able to coordinate movements with a specific goal. During motor skill learning, cognitive skills - inhibitory control, working memory, cognitive flexibility - work cooperatively and independently through the processes of decision-making, planning, problem solving, attention, perception, and coordination actions (Rudd, et al., 2019). The design of learning contents, through the Constraint Model approach, could support performers

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in the process of searching for and developing functional and adaptable motor solutions. The process of searching for alternative movement solutions requires the suspension of previously used solutions and the continuous updating of information retained in working memory. Children will need to use the same information but will come up with different solutions, possibly generating unusual and/or novel solutions, thus developing their cognitive flexibility (Rudd, et al, 2019). Closely related to this is the enhancement of competence and sense of autonomy, as the child who has successfully discovered their own motor patterns experiences a sense of accomplishment and satisfaction that comes from their own self and does not rely solely on feedback or praise from the teacher, as in linear pedagogy (Moy et al, 2016). Using non-linear pedagogy, students are asked to find multiple solutions to a motor problem, demonstrating not only their ability but also their creativity. This will result in enhanced decision making and a strong sense of self-organisation.

Conclusions

In the process of learning a motor skill, performers need simplified, realistic performance environments where they can be attuned to information that enables them to make intelligent and appropriately informed decisions based on a comprehensive understanding of their own abilities/possibilities in any environment (Brymer & Renshaw, 2010). The constraint model perspective can generate novel -movement- solutions by designing learning contents that provide controlled exploration 'frontiers' in dynamic environments - through the provision of skill-relevant constraints (Brymer & Renshaw, 2010; Renshaw et al, 2010). The constraint model (Newell, 1986) provides useful ideas on how to practice / train as it adequately 'captures' the rich range of different constraints that act on performers during motor skill learning. The constraint model emphasises the importance of a balanced interaction between the constraints of the individual, the environment, and the ability (task). According to this perspective, those involved in promoting effective motor skill learning should expect variability in motor-related solutions. It is, therefore, suggested that the academics seeking to design effective learning experiences need to understand the unique limitations of the ability / skill, environment and individual that provide references for creating a learning pattern in a specific way for each performer (individual-level adaptation) (Brymer & Renshaw, 2010; Renshaw et al., 2010).

The effectiveness of the constraint model approach for designing representative learning/practice contents has been evaluated in some complex motor skills such as long jump (Panteli, Smirniotou, & Theodorou, 2016) and springboard diving (Barris, Davids, & Farrow, 2013, 2014), and in physical activities such as canoeing and kayaking (Thomas, 2007) and rock climbing (Seifert, Wattebled, L'Hermette, Bideault, Herault, & Davids, 2013), with application in a training environment. However, the practical application of this model is not yet well developed in the school environment. Future research could examine the practical application of the constraints model - with intervention programmes - in a wider range of sport activities included in the proposed PE curriculum (gymnastics, classical sports, group games) and in different educational / academic settings (different levels of education).

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Appendix

Traditional learning approach courses examples vs constraints-led approach

Traditional approach	**Constraint-led approach**
Goal: Teaching – learning skill ability: «hitting / swinging the ball with a bat»	Goal: Teaching – learning skill ability: «Hitting the ball with tools»
The trainer / coach is preparing to teach the ability «hitting / swinging the ball with a bat». This skill is associated to group sports such are baseball, softball, cricket (game-related skill). He explains and presents the skill to the students and asks those in the class to perform this skill, trying to imitate the same movement as originally presented to them. They all have the same equipment – a bat and a ball – and they must be used in the same way.	To teach motor skills in a developmentally appropriate way, more than just the characteristics of the skill should be considered - such as the characteristics of everyone performing a dynamic skill (with specific goals, rules, equipment) in a such environment (physical and social). The teaching of the skill "hitting the ball with a bat" will be transformed into a lesson aimed at developing the skill "hitting the ball with tools". The learning content will include: • hitting with tools (small paddles, rackets, bats) of different sizes and weights, • using balls of appropriate size and colour (even balloons), • available at different locations within the practice area, and • each child will be able to choose the hitting tool they feel comfortable hitting with, and the object they wish to swing.
	(Gagen & Getcchell, 2006)

Traditional approach	**Constraint-led approach**
Goal: Teaching – "hurdling" / "obstacle race" motor ability	
The traditional teaching method is characterised by: • Descriptive analysis and demonstration of a skill - isolated from the competitive performance environment. • The repeated attempts by students to reproduce the movement as presented by the coach / trainer. • The provision of verbal, correct feedback by the coach / trainer. • A final game or performance of the motor skill in its entirety, where students attempt to apply the movements learned. ⇒ In obstacle lesson, the trainer/coach «decomposes» the obstacle technique and demonstrates isolated areas/ items of the movement for the 1st and 2nd leg, respectively. ⇒ students practice, through multiple repetitions, performing/reproducing these «ideal» movement patterns individually in a progressive sequence of specific exercises (e.g., 2nd leg movement from the side of the obstacle by walking, jogging, skipping). ⇒ The teacher regularly provides verbal feedback in relation to observed errors while performing the movement. ⇒ Having practiced individually, students try to apply the overall movement model in race conditions: 50m race with 3 obstacles of specific height, placed at specific distances (for girls: obstacle height 76cm and intermediate distance 8m, for boys: obstacle height 84cm and intermediate distance 8.5m).	According to the Constraints Model, the curriculum plan, and the instructions / or feedback are designed based on the nonlinear pedagogy approach. ✓ The learning/exercise environment consists of 8 routes with 4 obstacles on each route, placed at different distances and different heights per route. ✓ The skill constraints - obstacle height and intermediate distance - are progressively increased from the 1st to the 8th route. E.g.: Route 1: obstacle height 60cm and intermediate distance 5m. Route 4: obstacle height 68cm and intermediate distance 6.5m. Route 8: obstacle height 84cm and intermediate distance 7m. ✓ Students are given the opportunity to choose which course they wish to start their training on. ✓ In relation to feedback, the trainer provides "general" phrases that act as constraints on the students' search for appropriate movements/actions. These phrases mainly relate to the outcome of the movement, reinforcing an external focus of attention, e.g., "try to make 3 jumps between the obstacles». ✓ Students are given time to discover the practice environment and seek their own ideal functional motor solutions, with self-generated feedback. ✓ When the performers feel able to achieve these results, they are encouraged by the coach / trainer to practice the next difficult route. ✓ The last skill has a racing character (simulates real-life conditions) - 50m race with 3 obstacles - with the students choosing their «opponent» and the preferred racing route.
	(Moy, Renshaw, & Davids, 2016)

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REFERENCES

1. Barris, S., Davids, K., & Farrow, D. (2013). Representative learning design in springboard diving: is dry-land training representative of a pool dive? *European Journal of sport Science, 31*, 305-313.
2. Barris, S., Farrow, D., & Davids, K. (2014). Increasing functional variability in the preparatory phase of the takeoff improves elite springboard diving performance. *Research Quarterly for Exercise and Sport, 85*, 97-106.
3. Brymer, E., & Renshaw, I. (2010). An introduction to the constraints-led approach to learning in outdoor education. *Australian Journal of Outdoor Education, 14*(2), 33-41.
4. Chow, J., Davids, K., Button, C., Shuttleworth, R., Renshaw, I., & Araujo, D. (2007). The role of nonlinear pedagogy in physical education. *Review of Educational Research, 77*(3), 251-278.
5. Gagen, L., & Getchell, N. (2006). Using 'constraints' to design developmentally appropriate movement activities for early childhood education. *Early Childhood Education Journal*, doi: 10.1007/510643-006-0135-6
6. Moy, B., Renshaw, I., & Davids, K. (2016). The impact of nonlinear pedagogy on physical education teacher education students' intrinsic motivation. *Physical Education and Sport Pedagogy, 21*(5), 517-538.
7. Panteli, F., Smirniotou, A., & Theodorou, A. (2016). Performance environment and nested task constraints influence long jump approach run: a preliminary study. *Journal of Sports Sciences, 34*(12), 1116-1123.
8. Renshaw, I., Araujo, D., Button, C., Chow, J., Davids, K., & Moy, B, (2015). Why the constraints-led approach is not teaching games for understanding: a clarification. *Physical Education and Sport Pedagogy, 21*(5), 459-480.
9. Renshaw, I., Chow, J., Davids, K., & Hammond, J. (2010). A constraints-led perspective to understanding skill acquisition and game play: a basis for integration of motor learning theory and physical education praxis? *Physical Education and Sport Pedagogy,15*(2), 117-137.
10. Roberts, W., Newcombe, D., & Davids, K. (2018). Application of a constraints-led approach to pedagogy in schools: embarking on a journey to nurture physical literacy in primary physical education. *Physical Education and Sport Pedagogy, 24*(2), 162-175.
11. Rudd, J., O'Callaghan, L., & Williams, J. (2019). Physical education pedagogies built upon theories of movement learning: how can environmental constraints be manipulated to improve children's executive function skills and self-regulation skills? *International Journal of Environmental Research and Public Health, 16*, 1630, doi: 10.3390/ijerph16091630
12. Seifert, L., Wattebled, L., L'Hermette, B., Bideault, G., Herault, R., & Davids, K. (2013). Skill transfer, affordances, and dexterity in different climbing environments. *Human Movement Science, 32*, 1339-1352.
13. Thomas, G. (2007). Skill instruction in outdoor leadership: a comparison of a direct instruction model and a discovery-learning model. *Australian Journal of Outdoor Education, 11*(2), 10-18.

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