

Nonlinear pedagogy and its application in a volleyball didactic unit: a practical approach La pedagogía no lineal y su aplicación en una unidad didáctica de voleibol: un enfoque práctico

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Abstract. Introduction: The current holistic demands of the curriculum for the students' Secondary education require further methodologies that do not only focus on the simple acquisition of physical and motor skills. The implementation of contemporary models such as the non-linear pedagogy understand the teaching-learning process as a complex and nonlinear system, in which students, group-classroom, environment and teachers interact between each other, therefore negotiating the barriers of the acquisition of motor skills. Objective: The aim of this study was to design, implement and observe the motor response to a volleyball Didactic Unit based on non-linear pedagogy principles, such as the modification of the rules, size of the game area or material used. Methods: 66 students participated in this experience (age= 14.8 ± 0.3 years old). All of them performed a self-assessment of this practice and we also collected some observations. We encouraged the students' participation through the variability, the use of uncertainty activities, learning exploration, creativity and decision-making. Results: We observed the expected students' motor response to the modification of constraints without giving specific instructions addressed to what they should perform. There was a high significant correlation between the knowledge of the game and the self-perception competence of the pass ($r=0.366$, $p=0.004$), the reception ($r=0.266$, $p=0.040$), serve ($r=0.376$, $p=0.003$), colocation of the body ($r=0.413$, $p=0.001$), and attack and block ($r=0.267$, $p=0.038$). Conclusions: Through the implementation of non-linear pedagogy, we observed that the students improved their autonomy and decision making. We also observed multiple interactions among the students in order to optimize their response to the constrictions applied.

Keywords: Physical Education, Non-linear pedagogy, Complexity, Constraints, volleyball.

Resumen. Introducción: La demanda actual desde una perspectiva holística del curriculum hacia el alumnado de Secundaria, requiere de la implementación de metodologías que no sólo tengan en cuenta la simple adquisición de habilidades motrices. La implementación de modelos contemporáneos tales como la pedagogía no-lineal entienden el proceso de enseñanza-aprendizaje como un Sistema complejo y no lineal, en el que alumnado, el grupo-clase, el entorno y profesorado interactúa entre sí, negociando las barreras de la adquisición de habilidades motrices. Objetivo: El objeto de este estudio fue diseñar, implementar y observar la respuesta motriz del alumnado de Secundaria a una Unidad Didáctica de voleibol impartida a través de la pedagogía no lineal, empleando la modificación de las normas, el tamaño del área de juego, o el material empleado. Metodología: 66 estudiantes participaron en esta experiencia (edad= 14.8 ± 0.3 años). Todo este alumnado llevó a cabo una auto-evaluación de su práctica, al mismo tiempo que el profesorado tomamos notas de las observaciones. Fomentamos la participación del alumnado a través de la variabilidad, la introducción de tareas dirigidas hacia la incertidumbre, la exploración del aprendizaje, creatividad y toma de decisiones. Resultados: Observamos las esperadas respuestas motrices por parte del alumnado, en respuesta a la modificación de las constrictiones, aún sin haber instrucciones específicas dirigidas hacia lo que debían ejecutar. Encontramos una alta correlación significativa entre el conocimiento del juego y la auto-percepción de la competencia del pase ($r=0.366$, $p=0.004$), la recepción ($r=0.266$, $p=0.040$), el saque ($r=0.376$, $p=0.003$), la colocación del cuerpo ($r=0.413$, $p=0.001$), y el remate y bloqueo ($r=0.267$, $p=0.038$). Conclusiones: A través de la implementación de la pedagogía no lineal, observamos que el alumnado aumentó su autonomía y toma de decisiones. También observamos interacciones múltiples entre el alumnado, con el objeto de optimizar su respuesta a las constrictiones aplicadas.

Palabras clave: Educación Física, Pedagogía no-lineal; Complejidad, Constrictiones, Voleibol.

Introduction

The learning acquisition of motor skills is a complex task that should be analysed from a holistic perspective to find the strategies that better suit the development of the students as a whole. According to Decree 87/2015, of June 5, which establishes the curriculum of Compulsory Secondary Education and Baccalaureate of the Valencian Community, the Physical Education (PE) should not only contribute to the development of motor skills, but also to the acquisition of behaviours that improve the physical, social, emotional and psychological wellbeing.

The educational context is a complex system in which numerous elements interact and self-organise. Some researchers (Atencio, Tan & Lee, 2014; Chow, Davids, Button, Shuttleworth, Renshaw, & Araújo, 2007), have stated that the pedagogical strategies that emerge from complex and non-linear structures such as the educational process, can

fulfil these demands of the curriculum. According to Biesta (2010), these perspectives conceive the students' behaviour as emergent and through learning processes in a unique and unpredictable way, rather than in a predictable linear progression. This non-deterministic view is opposed to traditional models that relate teaching to the transmission and linear acquisition of knowledge and skills. Instead, it focuses on the creation of behaviours that reflect unique individual beings.

As suggested by Light (2008), behaviourism -as a traditional perspective-, has been the predominant pedagogical approach during the 20th century. Despite it has been largely replaced by constructivism, it still has a great influence on the current PE. However, behaviourism has a dualistic conception that in PE is reflected in the separation of the body and the mind or thought and action. According to Munafó (2016), the Descartes' statement that affirms «I think therefore I exist» separates the mind from the body and it also elevates it above it. Conceptions such as this, have lead to the existence of a hierarchy of knowledge in schools in which the practical knowledge that PE develops is

underestimated. It also encourages the subject of PE to focus on the physical part and leave aside the intellectual one. Davis, Sumara & Luce-Kapler (2000) affirm that PE practices based on this perspective assume that learning is a linear, quantifiable and explicit process of internalization of knowledge.

Traditionally, knowledge has been conceived as something pre-existing on the outside of the students' body and learning as a process of internal representation. Torrents, Araújo, Gordillo & Vives (2011) stated that the teaching-learning process is focused on the self-organisation of all the elements that interact: the students, the class environment and the teachers. Therefore, the behaviourism conceives the fact that students are fulfilled through instructional procedures. For instance, by providing some guidelines and the students would repeat the gesture individually, in pairs, in a round, etc. However, in the last decade of the twentieth century, there was a growth in the interest in constructivist theories of learning in PE (Kirk & Macdonald, 1998). This approach adopts a more holistic view of learning that challenges the dualism posed by behavioural theory. Unlike in behaviourism, in the constructivist current there is no predetermined external reality, but a world inseparable from us and that we only know as we experience it.

According to this theory, cognition does not only occur in the mind, but is also incorporated into the body and the acquisition is seen as a process of modification and adaptation to a world that is constantly evolving. In this way, the understanding arises from the student's commitment to the world through perception, motor action and bodily senses. The body ceases to be seen as a simple structure through which we learn. Constructivism appreciates learning as an active process in which students are not seen as a passive recipient, but as involved in learning through experience, making mistakes and solving problems. It also rejects that cognition is individual, affirms that it is formed in and out of social interaction and collective knowledge. The students are guided by the teachers to create their own knowledge and understand the subject by themselves. This can encourage students to construct their own personal meanings by understanding their experiences in PE in relation to their lives, backgrounds and values (Munafó, 2016). Thus, this can also drive this process to a Higher Order Thinking process (Newman, 1990).

According to Torrents et al. (2011), constructivism is the theory that best approaches the proposals of complexity and non-linearity since it gives a more protagonist and autonomous role to students and appreciates them as responsible and constructor of their learning. For instance, through a guided discovery, students would experience the possibilities of making a specific movement and decide the best way to do it. According to Light (2008), the development of the Teaching Games for Understanding (TGfU) carried out by Bunker & Thorpe (1982) is associated with the constructivist perspective in Physical Education. Chow, Davids, Button, Shuttleworth, Renshaw & Araújo (2007) add to this that the goal of the TGfU is to design learning experiences for students to acquire tactical skills of the main games through modified games which are appropriate to their physical, intellectual and social abilities.

The TGfU prioritize the tactical understanding of technical skills. Thorpe (1990) points out that the philosophy of TGfU is that a person can play games with technical limitations and can, therefore, be very competitive. The modified versions help the understanding and awareness of the main game. The modified games suppose the adaptation of the material, the zones of game or the rules to guide the students to solve a tactical problem. Almond (1986) established a division into four categories of the TGfU: 1- White and target (golf, billiards, bowling ...), 2-net or wall (volleyball, table tennis, squash ...), 3-f bat and field (baseball, cricket, softball ...) and 4-invasion (water polo, ultimate, handball ...). According to Renshaw, Araújo, Button, Chow, Davids & Moy (2016) the TGfU and the non-linear pedagogy share similarities such as the holistic vision of the student, the role of the teacher or the design of the learning tasks.

In this line, the theory of complexity is understood by Morin (2000) as a fabric of events, actions, interactions, feedback and determinations that constitute our phenomenal world. According to Torrents et al. (2011), the theory of complexity, from the motor skills point of view, has its origin in the dynamics system theory of dynamic systems and ecological psychology. The dynamics system theory proposes the emergence of behaviours from the interaction with the environment and the existence of certain conditioning factors that modify such as the behaviour.

Moreover, the ecological psychology proposes a perception-action cycle in which both are interconnected and interdependent. It also proposes that the organism cannot be studied independently from its surroundings. The properties of the context that the practitioner is able to perceive are understood according to ecological psychology as opportunities for action. According to Torrents et al. (2011), non-linear pedagogy is the closest application of complexity to PE. The non-linear pedagogy is based on the student's understanding, the classroom environment, the teacher and the process itself as a non-linear and complex system. The non-linear perspective and complexity implies a more holistic education, which goes beyond the acquisition of physical skills and seeks to educate students with a broader understanding of learning, development and identity (Kirk & McPphail, 2002).

According to the principles of complexity theory, the student behaviour depends on the conditions that influence each moment. These conditions are called constraints and set pressure on the system to produce a response towards a specific direction (Torrents et al., 2011). According to Newell (1986), constraints are limitations or characteristics that seek for the student behaviour and stability of self-organization and, therefore, can be classified into three different categories: the students themselves, environmental, and the task. Some examples of constraints of students are the individual characteristics such as weight, height, physical composition, skill level, motivation, emotions, fatigue, etc. The constraints of the environment are those related to the climate, ambient light or terrain characteristics, oxygen level, but also social factors such as peer group, social rules or cultural expectations. According to Torrents et al. (2011), when designing sessions with a non-linear character, these two types of constraints are difficult to modify to achieve the

desired objectives. Instead, the teacher is responsible for modifying those constraints pertaining to the task. Passos, Araújo, Davids & Shuttleworth (2008) propose that the task constraints that can be manipulated are: the variation of the rules of the game respecting its internal logic, the modification of the dimensions of the field game, the change of role of practitioners, alteration of the number of participants of each task and modification of the time to carry out the task.

According to Chow & Atencio (2012) non-linear pedagogy is carried out by manipulating constraints to look for the emergence of the desired behaviour and to encourage variability in tasks and to facilitate exploratory learning. In a context of learning based on non-linear pedagogy, students will have many opportunities for movement and, through the modification of constraints, they will discover individualized solutions for the purpose of the task. In this sense, it is important to highlight the importance of sciences literacy, which will increase the connexions among the formal curriculum and the informal experience (Estrada & Carlos, 2011). According to Atencio et al. (2014) teachers acquire a role of guide and facilitator of learning and students themselves can also take responsibility for modifying the constraints of the task to encourage learning. Decision-making is a very important aspect to be addressed in collaborative-opposition sports, since they have uncertainty as a game characteristic (Passos et al., 2008). They understand as uncertainty the result of the interaction between teammates and opponents and claim that players can never know at a 100% confidence what their opponents are going to do. According to these authors, the decision-making skills of the participants of a team can be improved by modifying the constraints of the task. The variability of the tasks will allow them to handle the uncertainty of specific game situations. Therefore, they propose that teachers must be constantly manipulating the constraints of the task. The traditional methods that tend to practice the skills without opposition and repeat or isolate the technical gesture of the context in which they occur, do not have enough variability in the activities so they do not encourage decision making in the same way.

There is a clear difference between the constraints that take place in nonlinear pedagogy and the prescriptions of more traditional models. Constraints are the conditions under which and through which the desired behaviour will arise. Instead, prescriptions are instructions that are given so that the desired behaviour arises. Kugler, Kelso & Turvey (1980) propose that the coordination patterns that take place in childhood are due to the change of the constraints imposed in the action, rather than the prescriptions that are given. Taking into account these concepts, if intended to teach a pass with the inside side of the foot in soccer from a non-linear perspective, the teacher will seek to create contexts in which the performance of this type of pass will emerge, without giving any premise of how it should be technically executed (Torrents et al., 2011). According to these authors, a good way to emerge this type of pass is to perform an activity in which a 2 against 2 game is played with 2 wild cards in which the goal is to score goals in opposing goals. The goals will be small since this type of pass is the most accurate and so using another surface of the foot would be

inconvenient. The team that reaches 6 passes in a row will also be rewarded to avoid that the defenders are always defending the goals and promoting the pass.

According to Atencio et al. (2014), despite the fact that the acceptance of complex and non-linear pedagogical perspectives in PE is increasing, there are few practical examples that reflect these perspectives. Different authors have proposed the application of non-linear pedagogy in activities such as athletics or tennis (Atencio et al., 2014), soccer (Torrents et al., 2011; Martín-Barrero & Lazarraga, 2020), youth footballers (Práxedes, Del Villar, Moreno, Gil-Arias, & Davids, 2019), street football (Machado et al., 2019), in cricket (Renshaw & Chappell, 2010), basketball (Jess, Atencio, & Carse, 2012), rugby (Passos et al., 2008) or volleyball (Caldeira, Paulo, Infante, & Araújo, 2019).

Therefore, the aim of this study was to design, implement and assess a Didactic Unit (DU) of volleyball in Secondary teaching level by using a non-linear pedagogy methodology. We also aimed to design a rubric that would allow us to assess the acquisition of technical-tactical and understanding of the game of the students from a non-linear perspective. Moreover, we intent to observe the relationships established among the members of the groups that were organized heterogeneously.

Methods

Design and Participants

The volleyball DU taught through nonlinear pedagogy was carried out in a Secondary Education High School (IES) of the locality of Valencia (Spain). A total of 66 students participated in this experience (age=14.8 ± 0.3 years old). This DU lasted two weeks, which corresponded to four sessions of PE lessons of one hour duration each. The teaching styles used were very participative, such as problem solving or guided discovery, where the teacher acted as a guide. The teaching conducted the activity into heterogeneous groups, therefore not showing any segregation by motor skills or sex.

The activities were based on what performed by previous studies (Torrent et al., 2011; Atencio et al., 2014; Arias, Arroyo, Rabaz, Domínguez, & Álvarez, 2016; Serra-Olivares & Garcia-Rubio, 2017) in sports such as tennis, soccer and volleyball. In the activities of this innovation, we modified the tasks constraints (Newell, 1986): the rules, number of players, size of the playing field and materials used. We established some other rules such as the performance of at least three passes before sending the ball to the other side of the field so that more students and attention were paid to the activity. We encouraged the opportunities to play by increasing the dimensions of the field, varying the materials and providing the students the chance to adapt the rules to their motor skills. Therefore, we asked several questions during the games, in which they had to think of the optimal strategies that better suited each situation, as the ones suggested by Gil, Araújo, García-González, Moreno, & del Villar (2014).

Variables and Evaluation

All students were encouraged to fill the rubric shown in

Table 1 as a self-evaluation. This rubric was not addressed towards the technical excellence but referred to a more self-competence acquisition of the basic dynamics of the volleyball game and the capability to reproduce these parameters in real onsets, as stated by the official curriculum for Secondary teaching.

among the knowledge or acquisition of the variables, considering as significant when $p < 0.05$.

Results

We observed the evolution of many positive social relationships among the students, where they showed high respect and consideration of all the members of the group. We also highlighted that there was a high interest in solving the objectives of the tasks. The students were grateful with the teacher, due to the flexibility proportioned towards the adaptation of rules to the game, size of the field and motor skill levels.

We observed that each student provided the optimal output to the task constraints through the free exploration. They were able to choose the best technical-tactical decisions, based on the requirements of each game situations. Also, they solved successfully the problems arised from the tasks successfully.

The self-assessment qualifications are shown in Figure 1 (a, b, c, d and f).

We found a significant correlation among the knowledge of the rules of the games and all the parameters assessed (reception, serve, colocation of the body, and attack and block (table 2).

Data collection and analysis

The data from the rubric (Jonsson & Svingby, 2007) were collected at the end of the fourth and final session. Then, we performed the analysis of descriptive variables (frequencies, means and standard deviations) (Excel, Microsoft Office 10 for Windows). We also performed a summary from the annotations written in the teacher's diary, such as reflections, observations and interpretations of the events that had taken place during the sessions. We performed Spearman correlations (0.1-0.3: weak; 0.4-0.6: moderate; 0.7-0.9: strong; 1: perfect) (Dancey & Reidy, 2007) to analyse the relationship

Table 2. Correlations among the pass, reception, serve, colocation of the body and attack and block.

	(2)	(3)	(4)	(5)	(6)
(1) Pass	0.475***	0.555***	0.358**	0.445***	0.366**
(2) Reception	-	0.272*	0.571***	0.493***	0.266*
(3) Serve	-	-	0.292*	NS	0.376**
(4) Colocation of the body	-	-	-	0.354**	0.413***
(5) Attack and block	-	-	-	-	0.268*
(6) Knowledge of the rules	-	-	-	-	-

NS: Non Significant; *: $p = 0.05$; **: $p = 0.010$; ***: $p = 0.001$.

Discussion

This study aimed to design, implement and evaluate the practice of a DU of volleyball in Secondary teaching through the non-linear pedagogy. For this purpose, we developed a 4-session DU in which we observed the students flow and adaptation of the rules of the games to their learning acquisition, motor competence and interrelations established from heterogeneous groups. In this regard, Kuguer et al. (1980), stated that movement patterns arise as a response to the implementation of imposed constraints in the action, rather than as a response to the given prescriptions.

From the results of the rubrics, we observed that the understanding of the game was quite positive by the students. Indeed, there was a significant correlation among the knowledge of the game and the pass ($r=0.366, p=0.004$), the reception ($r=0.266, p=0.040$), serve ($r=0.376, p=0.003$), colocation of the body ($r=0.413, p=0.001$), and attack and block ($r=0.267, p=0.038$), which is in the line of what stated by Atencio et al. (2014) in the regard that all the performed activities were based on the tactical representation of the game.

Table 1.

	Fair	Good	Very good	Excellent
Pass	I am not able to make passes to my teammates.	I am able to make passes although sometimes the way of passing does not adapt to the way in which the ball comes.	I am able to make passes, varying the way to do it depending on how the ball comes, although sometimes the pass is not entirely accurate.	I am able to adapt the way of passing the ball depending on how it comes and also my passes are comfortable for teammates.
Reception	I am not able to receive the ball properly or do not do it when necessary.	I get the ball properly at times and I provide a ball for my team to play.	I almost always receive the ball properly and with that I provide for the team with enough balls to build a play.	I receive the ball properly and that makes it easier for my team to make an attack play.
Serve	I cannot hit the ball properly or send it to the opposite field.	I get to hit the ball properly, although sometimes it does not fit within the limits of the opposite field.	I am able to draw properly and send the ball within the limits of the opposite field.	I am able to perform a strong serve towards the opposite field that makes the game difficult for the other team.
Collocation, position in the field and displacements	I do not occupy the spaces properly, I am static and I do not adopt the required position.	Sometimes I distribute properly in the field, I move though space and sometimes I adopt the right posture.	Quite often I occupy the spaces properly, I adopt a good body position and I move through the field logically.	I always occupy properly the space, I place properly my body and I move through the field correctly and logically.
Attack and block	I do not attend to finish or block.	I attend to finish and block sometimes but I do not do it properly.	I assist many times to finish and block and sometimes I do it properly.	I make auctions and blocks when the game situation allows it and in an adequate way.
Knowledge of the rules	I am not able to apply the rules of volleyball.	On many occasions, I do not know the rules.	On most occasions, I recognize which team knits, which one, when it is broken, in what sense ...	I always apply the rules and I know what equipment is knitted, what is taken out, when it is broken, in what sense ...

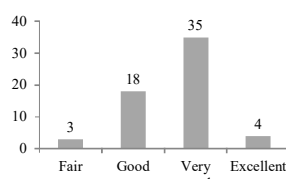


Figure 1.a. Frequency obtained from the Pass parameter



Figure 1.b. Frequency obtained from the Reception parameter.

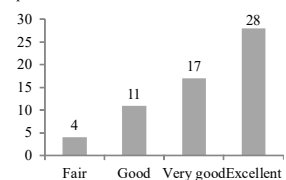


Figure 1.c. Frequency obtained from the Serve parameter.

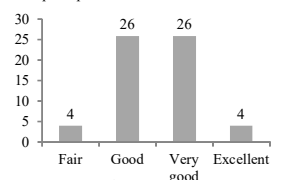


Figure 1.d. Frequency obtained from the Distribution in the field, body position and movements.

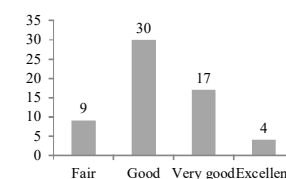


Figure 1.e. Frequency obtained from the Attack and Blocking parameter.

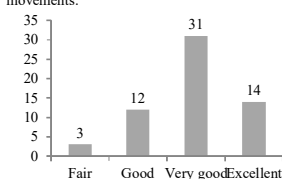


Figure 1.f. Frequency obtained from the Knowledge of the rules parameter.

During this DU, students looked for different movement patterns through the exploration. Indeed, on many occasions, they were able to seek for strategies that best provided solutions to the situations of the games. In the line of Chow & Atencio (2012), the modification of constraints allowed the variability in the task designs and, therefore, facilitated the exploration. Specifically, the exploration of the best possibilities of movement derived by the tasks is linked to the development of very important transversal contents such as the autonomy or creativity, which are highlighted in the educational curriculum.

As we mentioned above, it was very important that students were able to find the best solutions to the existing movement possibilities, which means that they were able to make the right decisions according to the situations. Decision-making is a very important aspect to be addressed in collaborative and opposition sports, due to the uncertainty generated by the players' actions (Passos, 2008). In fact, the variability arises from the constraints, which differ from the traditional methods in the way that they used to be practiced repeatedly or through isolated technical gestures of the context in which they occur.

In the present innovation, the teacher was in charge of forming the groups and, as a result, heterogeneous groups were created and students of all characteristics coexisted. Even showing different levels of motor skills or self-perceived motor competence, all students had to agree on the rules or the size of the playing area.

The results obtained in this DU accomplished the principles established by the educational curriculum. Specifically, in the block of contents of games and sports, it specifies that «it should contribute to the improvement of attitudes of collaboration, dialogue and teamwork for the achievement of common goals and the formation of individuals who are members of a welfare society».

Everything discussed so far shows that the implementation of this kind of DU are far way from traditional models, but we take a step towards a different way of understanding the PE. Moreover, the methodology applied is in line to what suggested by Kirk & McPhail (2002), as teachers must take into consideration the learners and the games that best suit according to their capabilities. As stated by the educational curriculum, we fostered the social, psychological and physical development of students.

Conclusions

We can conclude from our data that the implementation of nonlinear pedagogy in Secondary PE lessons contributed to discover and perform the best responses to the game situations created by the given constraints. The self-assessment by the students for the skills acquisition consciousness was quite positive. We encourage PE teachers to be aware of the importance of this subject to achieve the students' skills development from a holistic perspective and to enhance some aspects such as decision-making or autonomy. Future research can be addressed to develop more practical examples of how to apply this perspective in different games and sports.

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