Developing Players' Tactical Knowledge Using Combined Constraints-Led and Step-Game Approaches—A Longitudinal Action-Research Study

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Abstract

Purpose*:** Using an action-research design, this study examined the impact of combining concepts from two contemporary pedagogical approaches, the Constraints-led Approach (CLA) and Step-Game Approach (SGA), on the development of youth volleyballers' tactical knowledge, as expressed in performance, throughout a full competitive season. ***Method: Fifteen players and one coach participated in this study, which involved three action-research cycles, each including the processes of planning, acting and monitoring, reflecting, and fact-finding. The first author, who had the role of coach-researcher, collected data using a reflexive diary and field notes between September 2017 and June 2018, as well as eight semi-structured focus-group interviews. Data were analyzed using thematic analysis, in which inductive procedures deepened understanding of the development of the participants' tactical knowledge. ***Results:*** Findings suggested that combining CLA with SGA improved tactical knowledge in specific ways. Players progressed from a starting point where they were only able to describe game scenarios, and act without tactical criteria or considering contextual game constraints, to a point where their intentions during tactical actions were shaped by their ability to think strategically and guide their attention to recognize and interpret different constraints. ***Conclusions:*** Results suggested that the development of players' tactical knowledge benefited from a mutual integration of different, yet complementary, pedagogical approaches. By integrating SGA and CLA it was possible to enhance players' adaptable thinking using learning tasks involving the manipulation of meaningful constraints that afforded variable repetition and the resolution of tactical problems.

Keywords: player development; sports pedagogy; qualitative analysis; volleyball

In recent decades, research has suggested that team sports can be conceived as a dynamical system (e.g., Davids, Araújo, & Shuttleworth, 2005) comprised of a set of interdependent elements (i.e. cooperating and competing players) that self-organize and self-regulate to satisfy competitive performance constraints over time. From this perspective, the players can be viewed as being informationally-coupled to the dynamic performance environment. As such, the outcomes of competing and cooperating players' coupled actions cannot be completely predicted in advance because they are dependent on dynamic environmental conditions which, in turns, continuously emerge and change as a consequence of players' actions at each game moment. This perspective is aligned with insights of researchers who have highlighted the importance of developing tactical knowledge (TK) for game-problem resolution (McPherson, 2008). Specifically, TK refers to the decision-making process and choices made related to the organization of functional tactical behaviors when performers interact with specific dynamically-changing circumstances of unpredictable performance contexts (McPherson & Thomas, 1989). Indeed, the relationship between tactical needs and movement (re)organization is such that *knowing* (tactical skill) facilitates *perceiving* and *doing* (movement (re)organization and adaptations to changing performance conditions) and vice versa.

The constraints-led approach to coaching and teaching emphasizes how, through task constraint manipulations, athletes can gain a profound, adaptive relationship(i.e., development of a specialized comprehension underpinning tactical configurations of play under the effects of different, interacting environmental constraints (Davids & Araújo, 2010)). This type of 'knowledge of' a performance environment facilitates a deeply entwined and integrated relationship between knowledge, perception, and action to support learning and performance in sport (Araújo, Hristovski, Seifert, Carvalho, & Davids, 2019). In ecological

psychology, a performer's contact with a performance environment is based on *knowledge of* the environment, which is deeply integrated with processes of perception and action that support decision-making. Gibson (1966) advocated a functionalist approach by arguing that *knowledge about* the environment involves perception - mediated by language, symbols, pictures, and instructions - that can all help analogical reasoning, problem solving, decision-making, and cognitive processes to verbally describe what an information source means. In contrast, *knowledge of* the environment involves perceiving the layout of the performance environment as it relates to an individual's body and action capabilities (Turvey & Shaw, 1999). According to Gibson (1966), *knowledge of* the environment leads to knowing how to (re)organize actions because it involves the perception of information used to regulate actions needed to utilize affordances. *Knowledge of* the environment involves acquiring perceptual information to directly constrain functional behaviors, such as perceiving the flight of a ball in space and the movements of an opponent in preparing an action. The development of players' knowledge of the environment can be achieved by practice under meaningful and representative learning designs.

Through exploratory behaviors, during practice and performance, the perceptual systems of a performer become progressively more "attuned" to the invariant information in the performance environment through direct experience in specific contexts (Silva, Garganta, Araújo, Davids, & Aguiar, 2013). Information picked up by a performer becomes more subtle, elaborate, and precise with task-specific experience and when it is coupled successfully to actions. The key point is that, although performers can learn *knowledge about* a performance environment, which can allow them to describe the decisions and actions they may undertake, coaches need to ensure that during representative tasks learners are using *knowledge of* the environment to (self)regulate using tactical behaviors and decisions and to

support the perception of information to continuously (re)organize actions (Araújo, Davids, & McGivern, 2018).

Furthermore, previous research on TK has consistently supported the idea that players with a higher quality of TK are more able to perceive relevant surrounding information for action, reducing the time needed to interact with a performance environment (Kolman, Kramer, Elferink-Gemser, Huijgen, & Visscher, 2019). Indeed, they are better able to act during performance to perceive information to regulate further actions. Because the game rules in volleyball forbid players to carry (hold) the ball, fast play is encouraged (Mesquita & César, 2007). Therefore, the speed with which players interpret and respond to the dynamically-changing informational constraints of the performance environment is vital.

Despite these important insights, few investigations have focused on development of TK in volleyballers, with much of that assessing the impact of different pedagogical approaches. In recent years, several emerging, second-generation pedagogical models (e.g. Teaching Games for Understanding, among others) (Ennis, 2014) have gained support. Conceived as player-centred practices, these contemporary models provide an applied basis for the development of skillful and tactically astute players who are engaged in actively building their own learning programs. The idea to place players at the centre of the learning process emerged simultaneously from constructivist and ecological learning principles. Such principles state that players develop their own performance understanding through the connection between their prior experience and knowledge that mediates their perception-action coupling in representative learning contexts (Mahoney, 2002; Mckay & O'Connor, 2018). The acquisition of TK from constructivist and ecological perspectives implies that performers enhance their deep tactical understanding (e.g., acquiring specific game-related 'knowledge of' a performance environment, in Gibsonian terms, to support perception and action) by engaging in practice designs shaped by the specific task constraints of each sport.

From a constructivist viewpoint, the Step-Game Approach (SGA) was didactically conceived according to the specificities of non-invasion team sports (Mesquita, Graça, Gomes, & Cruz, 2005). Based on the didactical assumptions from the Teaching Games for Understanding (Bunker & Thorpe, 1992) and the Skill Development Approach (Rink, 1993), this player-centred approach advocates the specific development of performance abilities in volleyball, in which players are presented with step-by-step game tactical problems during practice designs which allow them to develop a functional coupling between tactical behaviors and movement skills (see Table 1 for further details). Here, the question arises whether these practice designs are an important tool that s guide the players towards self-reflection, self-regulation and adaptation, and problem solving through posing open-ended questions in practice (Metzler, 2011). The SGA approach has typically been applied in physical education contexts, indirectly assessing children's TK using GPAI measures (e.g., Araújo, Mesquita, Hastie, & Pereira, 2016).

Without disregarding the constructivist assumptions, but particularly highlighting the importance of ecological learning designs, a Constraints-led Approach (CLA) emphasises a performer-environment centred approach focused on the mutual interaction between players and the task constraints of a specific performance environment (Chow, Davids, Button, Shuttleworth, & Araújo, 2007). This approach advocates the building of meaningful and representative learning contexts, through the manipulation of different constraints, that provide opportunities for players to act (i.e., affordances) (Gibson, 1979). Despite the importance of each approach, to date there have been no investigations about TK development using CLA and SGA pedagogical principles. Furthermore, there few studies have explored the teaching-learning process when there has been a combination of context representativeness (CLA) and the provision of sport-specific, didactical (SGA) augmented informational constraints.

Therefore, research suggests that improvements in performance dimensions, including higher quality TK (based on 'knowledge of' a performance environment), is important for the development of experienced and skilled sport performers (Araújo et al., 2016). Despite the undeniable scientific contribution, the investigations have typically relied on quantitative assessments of the effects of learning interventions. In contrast, a qualitative analysis using an Action-Research (AR) design could offer a deep, contextualized, and continuous analysis and assessment of the teaching-learning process. Moreover, an AR-intervention could also promote an expansion of the comprehension about how the design of representative learning contexts (through manipulation of environmental and task constraints), might influence the development of players' TK. Moreover, an AR design facilitates reflective monitoring and systematic manipulations of the task constraints in practice designs. There is an important emphasis in AR on the rich insights and experiences of athletes and practitioners during the practice process (Cooke & Wolfram Cox, 2005). Recently, an AR approach to assessing the work of practitioners has been applied in educational contexts such as physical education lessons (e.g. Farias, Hastie, & Mesquita, 2018), although the implementation of AR in sports training contexts remains scarce.

Purpose of the study

In the present paper we sought to explore whether a combination of constructivist (SGA) and ecological (CLA) approaches might serve as a useful framework for understanding how to improve the development of players' TK. Indeed, practice programs based on a manipulation of meaningful constraints that affords variable repetition and stimulates the ability to resolve tactical game-problems may help learners to enhance the adaptability of their thinking and tactical skills.

Accordingly, using an AR design, this study examined the impact of combining CLA and SGA on the development of youth volleyballers' tactical knowledge (knowledge of a performance environment) throughout a competitive season. Through this interventive design we sought novel insights about the *processes* underlying TK development, rather than merely adopting an *end-product* perspective, that is, merely gaining information on differences between levels of TK in learners at the beginning of the season, compared to the end.

Method

Context and Participants

The study took place in a volleyball club located in the North of Portugal, which is one of the most prestigious in the male and female Portuguese National Premier Volleyball Leagues. The club philosophy follows a long-term vision of developing young players for integration into senior teams. Purposive and convenience sampling criteria (Sarstedt, Bengart, Shaltoni, & Lehmann, 2018) were applied to select the fifteen female volleyballers who took part in the study. Players, aged between 14 and 15 years old, had experience of at least one year of specialized volleyball training and performance. Participants were chosen for the study because they were considered 'information-rich' because: (i) they were at the beginning of their development pathway, and (ii) of their ability and willingness to participate in the study. The first author assumed the dual role of coach-researcher. As a researcher, she completed a Masters course in Sports Training Sciences and a Masters degree in High Performance Sport. As a coach, she holds the highest level of coaching certification in Portugal (level III) and has accrued 6 years of competitive coaching experience with teams winning two national championships and one cup competition.

The study was conducted across the full length of a competitive season, which lasted from September 2017 to June 2018 and included two separate competitions: The Regional

(September-January) and National championships (February-May). Both competitions are divided into two phases: the qualifying stage and the finals. A total of 143 training sessions and 32 official matches (18 and 14 matches from Regional and National championships, respectively) were completed during the research period. On average, each week, the players undertook four x two-hrs training sessions and participated in one official competitive match.

The study followed the guidelines stated in the Declaration of Helsinki and was approved by the Institutional Research Ethics Committee of the first author's institution. In addition, players and their parents were informed about the research scope, as well as the possibility to withdraw from the investigation at any time. After this, informed consent forms were signed by parents and players. Guarantees of confidentiality and anonymity were also explained, hence all names mentioned in the study are pseudonyms.

Study Design

The study followed an AR design where the coach systematically and critically reflected about her own practice, and then changed it according to her own reflections (Bodner & MacIsaac, 1995). Specifically, an insider action-research paradigm was used, offering a privileged standpoint from inside the coaching process in competitive sport (Coghlan, 2007). Due to its reflexive, collaborative, and interventionist nature (Cooke & Wolfram Cox, 2005), the AR format offers the ability to monitor, control, assess, and adapt the coaching intervention designed to developed players' TK, whilst endorsing its reconstruction and transformation over a sustained and longitudinal competitive performance period.

A total of three AR-cycles were completed as Figure 1 depicts. Each cycle included the processes of planning, acting and monitoring, and reflection. As suggested by Gilbourne (1999), the first AR cycle addressed context exploration by players. Additional diagnostic

analyses were undertaken by the coach in order to identify the main tactical problems of the players and team, that needed to be resolved. Aligned with the study's purpose, the remaining two AR cycles focused on combining the key principles of CLA and SGA to support development of the participants' TK. At the end of each AR-cycle, the reflections and identification of unresolved issues, in both training sessions and competitive performance, guided the re-framing of ongoing pedagogical practice. Considering the complexity of the coaching process and the inherent unpredictability of a competitive season, the ecological learning designs and coaching intervention were regularly adjusted depending on the daily challenges and problems faced by the coach.

****please insert Figure 1 around here****

Coaching Practice Protocol

Each training session used an ecological representative learning design according to the principles of CLA (Chow, Davids, Shuttleworth & Araújo, 2020). The learning tasks followed principles relevant to tactical, instructional, and didactical constraints relevant to the specific demands of volleyball (i.e., SGA). Table 1 provides a description of the main CLA and SGA instructional constraints manipulated.

**** please insert table 1 around here ****

Instructional and treatment validity

In order to ensure that an integration of CLA and SGA was achieved, the coaching protocol was validated by one researcher of the present study, and an externally-trained observer not associated with the study. The external observer had extensive research in pedagogical approaches and analyzed the documented training plans and video records of training sessions. The few disagreements were discussed and resolved among the research

team (first author and coauthors). A ten-item checklist was adapted from the studies of Práxedes, Álvarez, Moreno, Gil-Arias, and Davids (2019) and Pereira, Graça, Blomqvist, and Mesquita (2011) to test the behavioral fidelity of the coaching intervention. Accordingly, 18 training sessions - more than 10% of the total sample - were randomly examined by both, the external observer and one of the coauthors for the presence of items included in Table 2 (Tabachnick & Fidell, 2007). Items 1, 2, 4, 5 and 6 are characteristics of SGA, while items 3, 7, 8, 9, and 10 are related to CLA. The external researcher and one of the coauthors, both pedagogical experts, confirmed that all key aspects of CLA and SGA content were used in each observed training session. A 100% agreement between these observers confirmed the absence of doubt regarding to the integration of both pedagogical approaches.

*** *please insert table 2 around here* ***

Data Collection

The study used multiple sources of evidence to gain an in-depth understanding of the coaching process from all participants' perspectives. The coach's perceptions were recorded by a written Reflexive Diary (RD) and Field Notes (FN). Players' insights were recorded during Focus Group sessions (FG). A total of 39 coach reflections and 8 semi-structured focus group interviews were conducted.

Reflexive Diary

The RD was written by the coach (first author) and contained information from a critical and emotional perspective about the events, providing evidence of context comprehension, self-awareness, and professional judgment (Thomas, Morgan, & Mesquita, 2013). A total of 39 coach reflections were collected. The RD's purposes were: (i) to think critically about the influence of the coaching intervention applied on development of players' TK, (ii) to inform the training process, (iii) to generate useful questions that guide focus

group sessions, and (iv), to create new insights derived from data. The FN, collected during training sessions, guided the writing of the RD, and reflected the most critical observations, perceptions, personal experiences and events that occurred.

Focus-Group

A total of eight FG sessions were conducted. For each interview, the team was divided into two groups of seven and eight players respectively (Sparkes & Smith, 2014). Throughout the first and second AR-cycles, four FG sessions were conducted (two for each AR-cycle). The third AR-cycle included the remaining four sessions. The interviews took place throughout the training session, in a quiet location inside the volleyball club. Interviews lasted approximately 60 minutes. All FG sessions were audio recorded and transcribed verbatim by the first author. The purpose of FG interviews was to elicit players' perspectives about their TK development. Being semi-structured in nature, such interviews supported the players' reflections and evaluations about a specific framework (i.e., individual and team tactical behaviors during competitive environments, tactical purposes of the learning tasks conducted during the training sessions), offering the opportunity to gain deeper information about crucial issues. Accordingly, FG sessions enhanced data quality by encouraging interactions among participants which, in turn, allowed the researcher to differentiate consistent themes from extreme views (Patton, 2015).

Data Analysis

The data were analyzed throughout each AR-cycle (see figure 1). A thematic analysis was used to analyze the data from RD and FG. Thematic analysis was chosen because it enabled the researcher to identify, analyze, and report patterns (themes) within the data set (Braun & Clarke, 2012). Based on the proposals of Charmaz (2014), the first stage of this process comprised a repeated reading of the data from RD and FG interviews followed by an

inductive line-by-line open coding of the data to capture thoughts, ideas, and meaning as well as to search for patterns. The second stage of this processes involved analyzing the defined codes and testing possible combinations that guided the construction of themes and subthemes (focused coding). Such a process included an attempt to interpret potential relationships between codes and themes by adding a chronological perspective on the data. The next level of analysis included working back and forth between data and theory. Issues about coaching pedagogies, a tactical framework for players' tactical development in team sports (Mitchell, Oslin, & Griffin, 2013), and building ecological learning designs (Chow et al., 2007) were used to examine, clarify, and reflect sensitively about the data. Nevertheless, an explicit effort was made not to force data to fit the theory, but rather to search for patterns and comprehend how it might support or oppose current conceptualizations.

Trustworthiness

To enable a change to occur, an insider action-research design requires the researcher to strike a balance between closeness and distance (Coghlan, 2007). The first author tried to deal with the consequences of their presence by building trust and a caring environment, as well as showing impartiality during the process (McNiff, Lomax, & Whitehead, 2003). Three additional procedures were undertaken. First, data triangulation involved the cyclical and iterative collection of data from different sources (i.e., FN, RD and FG interviews). The frequent interpretations from the coaching intervention and team events were continuously validated through additional data generated throughout each AR-cycle (Denzin, 2012). Second, in order to verify the accuracy of the coach-researcher's interpretations, players were frequently asked about both the implicit meaning of their verbal reports and their tactical actions, not only about the implicit meanings of their actions, but also about their verbal interventions. Third, regular peer debriefings with the research team (first author and

coauthors, who are currently volleyball coaches and/or experts in sport pedagogy research) were held to minimize individual research bias in the interpretational analysis (Patton, 2015).

Results

Data analysis generated three main themes representative of players' TK development: "tactical awareness", "emerging understanding", and "playing tactically". The ability of players to adapt tactically to the game context reveals tactical awareness. Emerging understanding captures the players' ability to establish a connection between the purpose of a constrained game-form and the formal competitive game-form, in other words, understanding the relationships between the informational constraints of each environment (practice and performance). Finally, playing tactically relates to the use of tactics during competitive performance. This implies the recognition of an opposition's strengths and weaknesses, as well as teammates' strengths and weaknesses.

1st AR-cycle [September 2017 - December 2017] – What is the baseline of players' TK?

Tactical Awareness

At the beginning of the season, players were able to verbally describe their *knowledge about* their opponents' tactical behaviors, knowing what (declarative knowledge) and how (procedural knowledge) they could perform an action. However, they were not yet capable of verbally describing actual the tactical perceptions, decisions and actions undertaken (based on *knowledge of* opposition behaviors perceived and acted upon). The following excerpt supports this idea.

"At this point of game analysis, I think they can see what's going on, but cannot interpret it or build an appropriate strategy that is based on the opponents features, because when I asked where they thought that they should serve to, all the team agreed they should perform a diagonal service, but no one was able to explain to me why"

5th RD, 16th October

Moreover, players were capable of perceiving opposition placements (an environmental constraint), but were not able to identify critical information sources, and consequently anticipate opposition defensive moves, due to the inherent unpredictability of the competitive performance context. Accordingly, players frequently adopted an attempt-error strategy, revealing a preliminary ability to vary and adapt their offensive options.

"Rose: After some rallies we understood where we should have attacked.
Researcher (R): But did you change your attack trajectory for any reason?
Rose: Sometimes we have a purpose, others not… sometimes we just want to try new actions for instance, when we aren't able to score through a line-attack, we try the diagonal-attack.
1st FG, 23rd November

Emerging Understanding

Initially, players were not able to identify or comprehend how the manipulation of tasks constraints could create representative opportunities for them to act (i.e., affordances), or guide their perceptual awareness of the relevant information offered by the context (e.g., providing 'knowledge of' the location of the smaller blocker). To allow players to develop adaptable skills within a representative tactical task setting, the coach consequently constrained practice tasks with the purpose of providing opportunities for varied actions or 'repetition without repetition' (Bernstein, 1967). During practice, the coach guided the players' attention to the most relevant informational constraints to make the practice more meaningful and to stimulate the players' understanding. The next excerpt emphasizes this process:

"I clearly explained why we were doing each task. For instance, in a structured task I explained that we were training the line-attack because we needed to attack against the smaller blocker […] Indeed, I feel that players' performances improved when they understood the purpose of the task"
5th RD, 16th October

Playing Tactically

The players' use of tactics in competitive performance environments was found to be simplistic and mostly associated with a pre-planned strategy. Indeed, players could not

describe a focused and intended goal-oriented action. Moreover, the contextual constraints (e.g., emerging match status) seemed to inhibit variability in the setters' tactical choices, that is, the ability for the players to coordinate actions to take advantage of perceived opposition weaknesses. As the next excerpt depicts, at decisional set moments, the setters tended to set to their best attacker without considering contextual performance constraints such as who was in the opposition block, or which offensive combination could generate a greater advantage.

"R: In your opinion, which is the best zone to serve to? Why?
Elizabeth: Zone 1, because I serve with my right arm, so I have a larger area to serve
Kate: And the ball arises on the back of the opponent's setter
[…]
R: Kate, do you feel that your setting options changed since 20 points?
Kate: I cannot vary the game, I only set to the player who I know is going to score more."
1st FG, 23rd November

2nd AR-cycle [January 2018 – March 2018] – interpreting constraints to evolve TK

Tactical Awareness

The players perceived that increases in learning task complexity, via the introduction of different task constraints, stimulated their thinking and focus. In fact, practice in complex representative scenarios helped the players to become perceptually attuned to the emergence of important affordances. In turn, these perceptions led players to consider the purpose of their own tactical actions based on what they perceived to emerge during game play, and to not merely rely on the coach's recommendations. The next excerpt supports this observation:

"R: You said that you are currently better able to understand the game. Is there any connection with the increase in game complexity?
Katherine: Yes, because this forced us to think.
Kate: We are more focused now.
Katherine: Yes, once the game became more complex we needed to stay focused, think more and this ends up affecting us […] for instance, during the attack, now I can see the block but, in the past, I only did what the coach told to me, without think about it.
2nd FG, 20th January

Practice task designs also provided the players with opportunities to develop their ability to perceive critical information sources that constrained their technical and tactical

actions to adapt to the dynamic performance context. Accordingly, in the first evidence of strategic thinking, the players revealed how they were becoming more aware of opposition play features and future possible moves. The comments of Katherine and Mariah below clearly support this idea. Additionally, as stated by Emily, questions related to specific tactical actions helped players to reflect on their performance and explore various solutions constructively.

Mariah: […] For instance, if I saw the block is open, I would attack between the blockers
Katherine: yes, likewise, if we saw the defense moves up, we would attack the back of the court
[…]
R: Emily, you said that currently you understand the game better… in what actions?
Emily: Now, I know who I should set to.
R: […] what do you think that helped you improve?
Emily: the coach, for example, you [coach] *asked me why I set to someone that failed 5 consecutive service-receptions."*

2nd FG, 20th January

Emerging Understanding

At this stage, players started to establish a connection between the purpose of a constrained practice task and the tactical demands of competitive volleyball. Manipulation of task constraints in practice seemed to; (i) guide the players' attentional focus, (ii) stimulate their understanding of different game scenarios and increase the repertoire of performance solutions available to them in offensive and defensive game sub-phases, and (iii), facilitate their problem-solving in the competitive performance environment. In this sense, as Katherine later expressed, the training sessions started to gain more practical meaning.

"R: What did you think helped you develop your understanding of the game?
Ellen: The coach planning a lot of specific tasks and through them, we can develop our mind
Emily: And complex tasks […] conditional game-forms
Katherine: Where we have to be focused
[…]
R: Do you think that the training tasks have a connection to the formal game?
Penny: The best players usually attack to the same zones, and we practice this type of defense

Liz: Yes! And the block! There are also several block tasks based on the team features of our next opponent
R: Are these types of tasks important?
Lisa: Of course!
Loren: It is much more similar, it's identical [to the official game]
Liz: And it is much more specific, so then it's easier to solve problems during the game"
2nd FG, 20th January

"R: Do you think we play more game-forms?
Katherine: yes, and we do it at the end of the training session, meaning we can use what we had practiced before […] For instance, when we are training collective block organization, then during the game we can apply it. We train with a purpose"
3rd FG, 4th April

Use of convergent questioning, while supporting the players' awareness of team role responsibilities, also contributed to perception of opposition tactical features and weaknesses. This process helped inform players how to instigate a competitive strategy to exploit perceived opposition limitations.

"During a constrained game-form situation I stopped the game and asked one of the teams which are the opponents' spikers at that exact moment, and to who the setter will probably set…players started to talk between each other, defining block priorities…Then I said, this is the purpose of the task, Agatha, as a middle-blocker, you have the responsibility to lead the block organization, focus on it."
25th RD, 18th February

Throughout this process, where representative learning tasks were designed to promote players' intentionality and to stimulate inherent self-organizing tendencies within the team to satisfy the interacting performance constraints, the coach's learning support progressively decreased. Therefore, by developing tactical knowledge, players began to understand some reasons for their errors, and how to change their performance to resolve emerging issues. The players' reflections on their tactical options became essential to inducing their kill adaptation. Emily's example here supports this observation:

"When we were training final set moments, that is, a game phase that highlights tactical awareness, Emily failed three consecutive setting options, and I just screamed EMILY!!! She came to me and said that she knew that she should not have set the ball to Jennifer. I asked her why, and she responded that as she had good setting conditions and had Mariah and Kate in attack positions, she should set to one of them."
27th RD, 4th March

Playing Tactically

Because of the players' initial difficulties in identifying opposition weaknesses and tactical application during competitive performance, while considering the contextual performance constraints, the coach increased the use of divergent questioning during training. The main aim was to allow players to make sense and apply meaning to the information that they perceived, as well as induce links between new information, their previous knowledge and experiences. Players were also encouraged to explore different technical skills and to develop diverse tactical performance solutions. The next excerpt clarifies this process:

"Kate, why did you plan that move with the middle blocker? Why did you set to her? […] Or Mariah, who is blocking you? What do you think you can do to score? […] and it was enjoyable because they were answering me, executing different actions, and improving their game understanding"

28th RD, 11th of March)

Additionally, before each match, the coach started to discuss tactical configurations of play with players to simulate their strategic thinking. These principles emerging from these discussions were defined according to the shared understanding of the coach and players, as well as specific opposition features. Subsequent training tasks were constrained by these tactical principles, meaning that players had the opportunity to stabilize perceptual-action couplings aligned with the key events of a competitive context. As a result, players started to act intentionally, understanding how exploit perceived opposition weaknesses.

"R: What do you think about when we build a game plan?
Rose: In almost all matches this help us, because during the game we know exactly what the weaknesses of the opponent are and where we should attack
Katherine: Now, we did not feel so lost on the court because we had an idea of what they can do
Kate: And we know what we need to do to score
Lilian: For instance, we attack according to the opponents' defensive organization, if they defend using another form, we certainly execute different type of attacks
Kate: and sometimes we cannot remember what the coach told us to do, and so we see the videos again and figure out what we are supposed to do"

3rd FG, 4th April

3rd AR-cycle [April 2018 – June 2018] – achieving a sustainable and adaptable TK

Tactical Awareness

By now, players had developed a reasonable technical ability and were able to perceive critical information sources to regulate their actions during performance. Given the crucial role of setters during the game, the coach decided to move a step forward in terms of tactical setting issues. Consequently, a strategic plan specific to setters was discussed between the coach and setters. Setters were invited to identify and interpret the contextual constraints of opposition defenses, as well as to develop a plan to counter such features. Through this process they enhanced their strategic thinking. The next excerpt clarifies this process:

"I made setters come early to training sessions as I wanted to discuss a setting plan with them, for the first time […] I explained everything, in which cases we should play with overlap or reversal, when we would play with middle-blockers […] during the formal conditioned game the correct setter option was often achieved, with rallies being conducted with a setter's criteria"

33rd RD, 15th April

This training process led to a progressive increase in the intentionality underpinning the tactical awareness of setting actions at each moment during performance. Moreover, constraints introduced in thematic training games created a desirable instability (known as 'metastability' in dynamical systems theory: instability that promotes different options for a complex system). These practice designs encouraged problem-solving within unpredictable learning environments. Consequently, representative affordances emerged from practice task designs which, supported by the coaching intervention, was extremely helpful for the players' tactical development. This was noted by Emily.

"R: How do you think the game evolved across the season?
Kate: I think we started to understand the game moments better. For example, at 24/24 we will set to a player that is displaying higher consistency across the game.
Emily: Yes, at the beginning I only set to Mariah, now I vary the game, for example, if she fails, I know that I cannot set to her again, immediately […] I always look for the opponent blockers', for instance, if Liz is in zone 2, I play a stick with middle-blocker
R: And do you think that the conditional game-forms helped you?

Emily: Yes […] and… sometimes I set to the best attacker, but the coach told me she is attacking against the best blocker and let me think about it […] the coach also helped me […] and I started to understand. At the beginning I set without looking at the blockers"

4th FG, 2nd June

At the end of the season, some players also started to reveal their capacity to anticipate emergent, competitive game scenarios. In this sense, players began to act according to the predictions of their own action outcomes. However, such enhancements in tactical awareness and anticipation of events were mostly emphasized for attacking and defensive actions.

"Mariah: It depends because I can attack against block or not. I know that block will probably close the cross-attack once is my best spike trajectory, therefore I to try the line-attack.
Agatha: During the last game, when I was performing the service, I was trying to serve to zone 1 with the purpose of increasing the odds of zone 2 attacks. I'm not able to dig [she digs in zone 5] *and I knew that zone 2 only executes cross-attacks, so as I'm digging the line-spike, I thought it could be a good strategy […]"*

4th FG, 2nd June

Emerging Understanding

As players improved at satisfying tasks constraints during practice, the thematic games became more specifically constrained by considering key tactical features of specific opponents. In addition, players were praised for their performance of technical or tactical actions required of these specific performance constraints. These specifying learning designs motivated players and encouraged their cooperation and self-organization to achieve specific performance goals.

"The training plan was centred on a formal conditional game, constrained according to features of the next opponent […] this is the most representative and specific task that I could do. Specifically, I introduced many freeballs [i.e., an easy ball played by opponents when they have no attacking options*] which only zone 4 and 2 could attack because our next opponent rarely uses the middle-blocker attack"*

36th RD, 5th May

"R: Do you think that what we practice during the initial part of the training session is also related?
Kate: Yes, because if we trained block and defense, these technical actions give us extra points during the game-form

Penny: For instance, when we train the block action, during the game-form a positive block action is rewarded with an extra point

4th FG, 2nd June

Such interventions allowed players to perceive and understand performance constraints and attend to critical information sources (e.g. attention on orientation of an opponents' arm and hand, and not only on the ball). This learning design helped players to anticipate opposition moves and adapt accordingly.

"R: […] reading the game… what do you mean?
Katherine: For instance, when someone is attacking, and we are defensing… now we look to their arm and we anticipate the attack trajectory
R: Did you think about it initially?
Katherine: I did not look so much, and if I looked, I couldn't understand it. Now, we also see the block and the setter, the setter cannot trick me anymore.
Mariah: Yes, when I'm attacking, I can see the block and, as a result, I know where I should hit […]
R: And at the beginning, what did you look for?
Rose: ball
Agatha: I only stayed in my defense zone
Rose: We were just worried about the purpose, that is, to defend
Liz: Yes, we did not think to look at the hitter's arm"

4th FG, 2nd June

Playing Tactically

Gradually, the process of recognizing and tactically exploring opposition weaknesses became more efficient, although this applied mostly to service actions. Here, enhanced understanding of tactical principles of play, discussed with players throughout the season, played a critical role. Overall, by the end of the season, the players' performance actions clearly showed how they considered ecological constraints underpinning competitive performance. This is highlighted in the next excerpt:

R: Do you remember how we exploited that weakness?
Kate: Through a consistent service and serving on the other side of the team's best attacker.
R: When you are on the service line, do you think about it?
Emily: Sometimes
Mariah: It depends on the game moment
R: And was it always like that?
Group: NO!!!!
R: So, what happened at the beginning of the season?
Agatha: Initially, we only executed

Lisa: We couldn't serve to a specific zone
[…]
R: Do you think that game plans helped you to increase your game understanding?
Group: Yes!
R: But what does that mean?
Ellen: To understand the opponents' weak features and to know how to exploit it."
4th FG, 2nd June

Discussion

Using a three-cycle action-research (AR) design, this study examined the impact of combining methodologies from the CLA and SGA on the development of tactical knowledge of performance in youth volleyballers throughout a competitive season. Overall, results showed how, by combining both approaches, players progressed from an initial start point where they were able to verbally describe game scenarios, relying on knowledge about how to perform (declarative and procedural knowledge, respectively) without considering tactical game constraints. After the intervention they had progressed to an end point where they had begun to think strategically, act intentionally, narrow their attentional focus to perceive different informational constraints, and understand and share affordances to act tactically. By using an AR design, it was possible to closely monitor the entire dynamical coaching process involved in participants' TK development. Indeed, the immersion of the coach-researcher in the context of youth volleyball training allowed for daily adjustments to the design of the ecological practice tasks, based on the tactical needs of the players and team.

The first AR-cycle diagnosed the players' tactical limitations (essentially based on their lack of tactical awareness). At this initial stage, players displayed the ability to verbally describe scenarios (knowledge about the performance environment) but could not actively identify critical constraints during play. Instead, they merely reacted to affordances (opportunities for action during competition) rather than utilising, sharing, or even anticipating them. These findings suggest it was difficult for players to use tactics in

competitive environments because they were not aware of interacting constraints (e.g. opponents' weaknesses) and could not focus their attention on key information sources.

To resolve this issue, during the second AR-cycle the complexity of volleyball practice settings was increased via the manipulation of representative task constraints. Here, the purpose was to introduce a desirable instability that encouraged players' problem-solving and intentionality in their actions. During these learning tasks, tactical solutions were built, and assessed constructively, using questioning strategies. Combining ecological and constructivist perspectives, it was interesting to find that the increase in complexity of representative learning tasks was accompanied by a growth in players' awareness of their own TK development. Globally, during the second AR-cycle, the players affirmed that the greater task complexity improved their attentional focus, tactical understanding, and strategic thinking. This finding aligns with recent work by Shaw et al. (2018) that showed how increases in task demands led to increased mental engagement and consumption of attentional resources. Nonetheless, two possible reasons could also explain the players' perceptions. First, the convergent and divergent questions asked during practice might have invited participants to recognize and think about relationships among sources of information, activating their prior knowledge and helping them to establish connections between the tactical purpose of the task and the competitive game-environment. Second, representative task constraints might have guided participants' attentional focus, thus facilitating the perception and utilization of shared affordances.

Also, within the 2nd AR-cycle, tactical configurations of play started to be discussed constructively between coach and players. Such discussions were aimed at reducing the difficulties portrayed in perceiving opponent weaknesses. A strategic plan was then built during the study of opposition performance characteristics through video analysis. Afterwards, practice tasks were designed according to emerging tactical principles. This

coaching intervention enabled players to redefine their understanding of the link between performance constraints and appropriate tactical skills, and thus increased action-oriented and adaptive gameplay skills (Araújo et al., 2019; Mitchell et al., 2013).

At the end of third AR-cycle, players showed a substantial improvement in TK. For example, in the first AR-cycle, Kate's record revealed that her tactical setting decisions did not consider contextual constraints (e.g., final set moments). However, by the end of the season, Kate was able to consider the match status, the performance of her teammates, and the performance features of immediate opponents during the game. Emily's report also showed a significant development in setting using tactical criteria. Overall, she emphasized the crucial role of strategic planning and the manipulation of representative constraints during thematic games. Indeed, as Gréhaigne, Caty, and Godbout (2010) postulated, the process of studying predominant configurations of tactical problems seemed to sustain the players' capacity to identify emerging regularities in opposition patterns of play, facilitating an anticipation process.

As a result of the strategic plan and manipulation of representative task constraints, by the third cycle, players had increased their perception and understanding of informational constraints of performance (e.g. especially weaknesses of individual opponents). Consequently, they collaborated and self-organized with teammates to intentionally exploit such perceived vulnerabilities. Players had improved their anticipation of opponents' moves, implying tactical knowledge development. These anticipatory capacities were mostly observed in spike and dig actions, possibly because these tactical actions were directly related to opposition tactical moves. Anticipatory responses have greater tactical value in team sports where players are constantly required to make rapid, accurate decisions in a dynamic performance environment play (Gorman, Abernethy, & Farrow, 2018). Here, the building of

representative learning designs played an important role in simulating task constraints that enabled performers to act adaptively, as required in competitive performance environments. In practical terms, our findings recommend that coaches constrain their learning tasks designs according to: (i) the individual needs of players and the team , (ii) the specificities of the sport, and (iii), the tactical problems that need resolution, identified by performance analytics. Coaches should focus on building representative learning designs in practice. Finally, we endorse the combined use of convergent and divergent questions during the practice training session rather than simply prescribing tactical solutions for the players. Due to the complex relationship between perception, cognition and action underlying tactical knowledge development in youth players, we recommend the integration of different yet complementary pedagogical approaches in future investigations. This recommendation is aligned with our main findings revealing the development of players' tactical knowledge through the combination of SGA and CLA approaches. The data highlighted that continuous exposure to ecological and meaningful contexts helps players develop a deeper knowledge of a performance environment for constructing novel performance understanding to adapt and evolve tactically.

What does this article add?

This article presents novel, qualitative longitudinal information about the impact of combining two distinct pedagogical approaches in practice designs. The combination of two different approaches that have traditionally been studied in parallel (i.e. the integration of ecological and constructivist ideas), represents a potentially useful way to enhance the cognition, perception and action of developing athletes. This study emphasizes the potential to integrate these approaches in order to address the complexity of practice demands and the individual needs of players and teams. Moreover, the innovative use of an action-research

design during training sessions offered a deep, contextualized analysis of the coaching process throughout a competitive season. There was a specific focus on the continuous *process* of TK development, rather than just on the *end product* (i.e., comparing how players started and ended a season in terms of TK).

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