

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

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Developing players' tactical knowledge

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2 **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

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

59 The constraints-led approach to coaching and teaching emphasizes how, through task  
60 constraint manipulations, athletes can gain a profound, adaptive relationship (i.e.,  
61 development of a specialized comprehension underpinning tactical configurations of play  
62 under the effects of different, interacting environmental constraints (Davids & Araújo, 2010)).

63 This type of 'knowledge of' a performance environment facilitates a deeply entwined and  
64 integrated relationship between knowledge, perception, and action to support learning and  
65 performance in sport (Araújo, Hristovski, Seifert, Carvalho, & Davids, 2019). In ecological

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66 psychology, a performer's contact with a performance environment is based on *knowledge of*  
67 the environment, which is deeply integrated with processes of perception and action that  
68 support decision-making. Gibson (1966) advocated a functionalist approach by arguing that  
69 *knowledge about* the environment involves perception - mediated by language, symbols,  
70 pictures, and instructions - that can all help analogical reasoning, problem solving, decision-  
71 making, and cognitive processes to verbally describe what an information source means. In  
72 contrast, *knowledge of* the environment involves perceiving the layout of the performance  
73 environment as it relates to an individual's body and action capabilities (Turvey & Shaw,  
74 1999). According to Gibson (1966), *knowledge of* the environment leads to knowing how to  
75 (re)organize actions because it involves the perception of information used to regulate actions  
76 needed to utilize affordances. *Knowledge of* the environment involves acquiring perceptual  
77 information to directly constrain functional behaviors, such as perceiving the flight of a ball  
78 in space and the movements of an opponent in preparing an action. The development of  
79 players' knowledge of the environment can be achieved by practice under meaningful and  
80 representative learning designs.

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

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

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

100 Despite these important insights, few investigations have focused on development of  
101 TK in volleyballers, with much of that assessing the impact of different pedagogical  
102 approaches. In recent years, several emerging, second-generation pedagogical models (e.g.  
103 Teaching Games for Understanding, among others) (Ennis, 2014) have gained support.  
104 Conceived as player-centred practices, these contemporary models provide an applied basis  
105 for the development of skillful and tactically astute players who are engaged in actively  
106 building their own learning programs. The idea to place players at the centre of the learning  
107 process emerged simultaneously from constructivist and ecological learning principles. Such  
108 principles state that players develop their own performance understanding through the  
109 connection between their prior experience and knowledge that mediates their perception-  
110 action coupling in representative learning contexts (Mahoney, 2002; McKay & O'Connor,  
111 2018). The acquisition of TK from constructivist and ecological perspectives implies that  
112 performers enhance their deep tactical understanding (e.g., acquiring specific game-related  
113 'knowledge of' a performance environment, in Gibsonian terms, to support perception and  
114 action) by engaging in practice designs shaped by the specific task constraints of each sport.

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115 From a constructivist viewpoint, the Step-Game Approach (SGA) was didactically conceived  
116 according to the specificities of non-invasion team sports (Mesquita, Graça, Gomes, & Cruz,  
117 2005). Based on the didactical assumptions from the Teaching Games for Understanding  
118 (Bunker & Thorpe, 1992) and the Skill Development Approach (Rink, 1993), this player-  
119 centred approach advocates the specific development of performance abilities in volleyball,  
120 in which players are presented with step-by-step game tactical problems during practice  
121 designs which allow them to develop a functional coupling between tactical behaviors and  
122 movement skills (see Table 1 for further details). Here, the question arises whether these  
123 practice designs are an important tool that s guide the players towards self-reflection, self-  
124 regulation and adaptation, and problem solving through posing open-ended questions in  
125 practice (Metzler, 2011). The SGA approach has typically been applied in physical education  
126 contexts, indirectly assessing children's TK using GPAI measures (e.g., Araújo, Mesquita,  
127 Hastie, & Pereira, 2016).

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

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

157

### 158 *Purpose of the study*

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



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

171

## 172 **Method**

### 173 *Context and Participants*

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

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

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

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

201

### 202 *Study Design*

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

212 A total of three AR-cycles were completed as Figure 1 depicts. Each cycle included  
213 the processes of planning, acting and monitoring, and reflection. As suggested by Gilbourne  
214 (1999), the first AR cycle addressed context exploration by players. Additional diagnostic

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

224 *\*\*\*please insert Figure 1 around here\*\*\**

225

### 226 ***Coaching Practice Protocol***

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

232 *\*\*\* please insert table 1 around here \*\*\**

233

### 234 ***Instructional and treatment validity***

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

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240 team (first author and coauthors). A ten-item checklist was adapted from the studies of  
241 Práxedes, Álvarez, Moreno, Gil-Arias, and Davids (2019) and Pereira, Graça, Blomqvist, and  
242 Mesquita (2011) to test the behavioral fidelity of the coaching intervention. Accordingly, 18  
243 training sessions - more than 10% of the total sample - were randomly examined by both, the  
244 external observer and one of the coauthors for the presence of items included in Table 2  
245 (Tabachnick & Fidell, 2007). Items 1, 2, 4, 5 and 6 are characteristics of SGA, while items 3,  
246 7, 8, 9, and 10 are related to CLA. The external researcher and one of the coauthors, both  
247 pedagogical experts, confirmed that all key aspects of CLA and SGA content were used in  
248 each observed training session. A 100% agreement between these observers confirmed the  
249 absence of doubt regarding to the integration of both pedagogical approaches.

250 *\*\*\* please insert table 2 around here \*\*\**

251

## 252 **Data Collection**

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

### 258 *Reflexive Diary*

259 The RD was written by the coach (first author) and contained information from a  
260 critical and emotional perspective about the events, providing evidence of context  
261 comprehension, self-awareness, and professional judgment (Thomas, Morgan, & Mesquita,  
262 2013). A total of 39 coach reflections were collected. The RD's purposes were: (i) to think  
263 critically about the influence of the coaching intervention applied on development of players'  
264 TK, (ii) to inform the training process, (iii) to generate useful questions that guide focus

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

#### 268 *Focus-Group*

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

283

#### 284 **Data Analysis**

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

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

301

### 302 **Trustworthiness**

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

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

317

## 318 **Results**

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

328

### 329 *1<sup>st</sup> AR-cycle [September 2017 - December 2017] – What is the baseline of players' TK?*

#### 330 *Tactical Awareness*

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

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

341

*5<sup>th</sup> RD, 16<sup>th</sup> October*

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

347           *“Rose: After some rallies we understood where we should have attacked.*

348           *Researcher (R): But did you change your attack trajectory for any reason?*

349           *Rose: Sometimes we have a purpose, others not... sometimes we just want to try new actions*  
350 *for instance, when we aren't able to score through a line-attack, we try the diagonal-attack.*

351           *1<sup>st</sup> FG, 23<sup>rd</sup> November*

## 352           ***Emerging Understanding***

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

363           *“I clearly explained why we were doing each task. For instance, in a structured task I*  
364 *explained that we were training the line-attack because we needed to attack against the*  
365 *smaller blocker [...] Indeed, I feel that players’ performances improved when they*  
366 *understood the purpose of the task”*

367           *5<sup>th</sup> RD, 16<sup>th</sup> October*

## 368           ***Playing Tactically***

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



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

377 *“R: In your opinion, which is the best zone to serve to? Why?”*

378 *Elizabeth: Zone 1, because I serve with my right arm, so I have a larger area to serve*

379 *Kate: And the ball arises on the back of the opponent's setter*

380 *[...]*

381 *R: Kate, do you feel that your setting options changed since 20 points?*

382 *Kate: I cannot vary the game, I only set to the player who I know is going to score more.”*

383 *I<sup>st</sup> FG, 23<sup>rd</sup> November*

384

## 385 *2<sup>nd</sup> AR-cycle [January 2018 – March 2018] – interpreting constraints to evolve TK*

### 386 *Tactical Awareness*

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

393 *“R: You said that you are currently better able to understand the game. Is there any*  
 394 *connection with the increase in game complexity?”*

395 *Katherine: Yes, because this forced us to think.*

396 *Kate: We are more focused now.*

397 *Katherine: Yes, once the game became more complex we needed to stay focused, think more*  
 398 *and this ends up affecting us [...] for instance, during the attack, now I can see the block but,*  
 399 *in the past, I only did what the coach told to me, without think about it.*

400 *2<sup>nd</sup> FG, 20<sup>th</sup> January*

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

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

409 *Mariah: [...] For instance, if I saw the block is open, I would attack between the blockers*  
 410 *Katherine: yes, likewise, if we saw the defense moves up, we would attack the back of the*  
 411 *court*  
 412 *[...]*  
 413 *R: Emily, you said that currently you understand the game better... in what actions?*  
 414 *Emily: Now, I know who I should set to.*  
 415 *R: [...] what do you think that helped you improve?*  
 416 *Emily: the coach, for example, you [coach] asked me why I set to someone that failed 5*  
 417 *consecutive service-receptions."*  
 418 *2<sup>nd</sup> FG, 20<sup>th</sup> January*

## 419 ***Emerging Understanding***

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

428  
 429 *"R: What did you think helped you develop your understanding of the game?*  
 430 *Ellen: The coach planning a lot of specific tasks and through them, we can develop our mind*  
 431 *Emily: And complex tasks [...] conditional game-forms*  
 432 *Katherine: Where we have to be focused*  
 433 *[...]*  
 434 *R: Do you think that the training tasks have a connection to the formal game?*  
 435 *Penny: The best players usually attack to the same zones, and we practice this type of defense*

## Developing players' tactical knowledge

436 *Liz: Yes! And the block! There are also several block tasks based on the team features of our*  
 437 *next opponent*

438 *R: Are these types of tasks important?*

439 *Lisa: Of course!*

440 *Loren: It is much more similar, it's identical [to the official game]*

441 *Liz: And it is much more specific, so then it's easier to solve problems during the game"*

442 *2<sup>nd</sup> FG, 20<sup>th</sup> January*

443 *"R: Do you think we play more game-forms?*

444 *Katherine: yes, and we do it at the end of the training session, meaning we can use what we*  
 445 *had practiced before [...] For instance, when we are training collective block organization,*  
 446 *then during the game we can apply it. We train with a purpose"*

447 *3<sup>rd</sup> FG, 4<sup>th</sup> April*

448 Use of convergent questioning, while supporting the players' awareness of team role  
 449 responsibilities, also contributed to perception of opposition tactical features and weaknesses.

450 This process helped inform players how to instigate a competitive strategy to exploit  
 451 perceived opposition limitations.

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

457 *25<sup>th</sup> RD, 18<sup>th</sup> February*

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

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

470 *27<sup>th</sup> RD, 4<sup>th</sup> March*

471

## Developing players' tactical knowledge

472 ***Playing Tactically***

473

474 Because of the players' initial difficulties in identifying opposition weaknesses and

475 tactical application during competitive performance, while considering the contextual

476 performance constraints, the coach increased the use of divergent questioning during training.

477 The main aim was to allow players to make sense and apply meaning to the information that

478 they perceived, as well as induce links between new information, their previous knowledge

479 and experiences. Players were also encouraged to explore different technical skills and to

480 develop diverse tactical performance solutions. The next excerpt clarifies this process:

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

485

28<sup>th</sup> RD, 11<sup>th</sup> of March)

486 Additionally, before each match, the coach started to discuss tactical configurations of

487 play with players to simulate their strategic thinking. These principles emerging from these

488 discussions were defined according to the shared understanding of the coach and players, as

489 well as specific opposition features. Subsequent training tasks were constrained by these

490 tactical principles, meaning that players had the opportunity to stabilize perceptual-action

491 couplings aligned with the key events of a competitive context. As a result, players started to

492 act intentionally, understanding how exploit perceived opposition weaknesses.

493 *“R: What do you think about when we build a game plan?*494 *Rose: In almost all matches this help us, because during the game we know exactly what the*  
 495 *weaknesses of the opponent are and where we should attack*496 *Katherine: Now, we did not feel so lost on the court because we had an idea of what they can*  
 497 *do*498 *Kate: And we know what we need to do to score*499 *Lilian: For instance, we attack according to the opponents' defensive organization, if they*  
 500 *defend using another form, we certainly execute different type of attacks*501 *Kate: and sometimes we cannot remember what the coach told us to do, and so we see the*  
 502 *videos again and figure out what we are supposed to do”*

503

3<sup>rd</sup> FG, 4<sup>th</sup> April504 ***3<sup>rd</sup> AR-cycle [April 2018 – June 2018] – achieving a sustainable and adaptable TK***

## Developing players' tactical knowledge

505 ***Tactical Awareness***

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

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

519 *33<sup>rd</sup> RD, 15<sup>th</sup> April*

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

528 *"R: How do you think the game evolved across the season?"*

529 *Kate: I think we started to understand the game moments better. For example, at 24/24 we*  
 530 *will set to a player that is displaying higher consistency across the game.*

531 *Emily: Yes, at the beginning I only set to Mariah, now I vary the game, for example, if she*  
 532 *fails, I know that I cannot set to her again, immediately [...] I always look for the opponent*  
 533 *blockers', for instance, if Liz is in zone 2, I play a stick with middle-blocker*

534 *R: And do you think that the conditional game-forms helped you?"*

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535 *Emily: Yes [...] and... sometimes I set to the best attacker, but the coach told me she is*  
 536 *attacking against the best blocker and let me think about it [...] the coach also helped me*  
 537 *[...] and I started to understand. At the beginning I set without looking at the blockers”*  
 538 *4<sup>th</sup> FG, 2<sup>nd</sup> June*

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

544 *“Mariah: It depends because I can attack against block or not. I know that block will*  
 545 *probably close the cross-attack once is my best spike trajectory, therefore I to try the line-*  
 546 *attack.*  
 547 *Agatha: During the last game, when I was performing the service, I was trying to serve to*  
 548 *zone 1 with the purpose of increasing the odds of zone 2 attacks. I’m not able to dig [she digs*  
 549 *in zone 5] and I knew that zone 2 only executes cross-attacks, so as I’m digging the line-*  
 550 *spike, I thought it could be a good strategy [...]”*  
 551 *4<sup>th</sup> FG, 2<sup>nd</sup> June*

### 552 ***Emerging Understanding***

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

559 *“The training plan was centred on a formal conditional game, constrained according to*  
 560 *features of the next opponent [...] this is the most representative and specific task that I could*  
 561 *do. Specifically, I introduced many freeballs [i.e., an easy ball played by opponents when*  
 562 *they have no attacking options] which only zone 4 and 2 could attack because our next*  
 563 *opponent rarely uses the middle-blocker attack”*  
 564 *36<sup>th</sup> RD, 5<sup>th</sup> May*

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

## Developing players' tactical knowledge

570 *Penny: For instance, when we train the block action, during the game-form a positive block*  
 571 *action is rewarded with an extra point*  
 572 *4<sup>th</sup> FG, 2<sup>nd</sup> June*

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

577       *"R: [...] reading the game... what do you mean?*  
 578 *Katherine: For instance, when someone is attacking, and we are defending... now we look to*  
 579 *their arm and we anticipate the attack trajectory*  
 580 *R: Did you think about it initially?*  
 581 *Katherine: I did not look so much, and if I looked, I couldn't understand it. Now, we also see*  
 582 *the block and the setter, the setter cannot trick me anymore.*  
 583 *Mariah: Yes, when I'm attacking, I can see the block and, as a result, I know where I should*  
 584 *hit [...]*  
 585 *R: And at the beginning, what did you look for?*  
 586 *Rose: ball*  
 587 *Agatha: I only stayed in my defense zone*  
 588 *Rose: We were just worried about the purpose, that is, to defend*  
 589 *Liz: Yes, we did not think to look at the hitter's arm "*  
 590 *4<sup>th</sup> FG, 2<sup>nd</sup> June*

### 591 ***Playing Tactically***

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

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

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607 *Lisa: We couldn't serve to a specific zone*

608 *[...]*

609 *R: Do you think that game plans helped you to increase your game understanding?*

610 *Group: Yes!*

611 *R: But what does that mean?*

612 *Ellen: To understand the opponents' weak features and to know how to exploit it."*

613 *4<sup>th</sup> FG, 2<sup>nd</sup> June*

614

## 615 **Discussion**

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

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



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

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

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

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

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

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

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

700

### 701 **What does this article add?**

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

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

713

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