

**Representative co-design: Utilising a source of experiential knowledge for athlete development and performance preparation**

WOODS, Carl T., ROTHWELL, Martyn <<http://orcid.org/0000-0002-3545-0066>>, RUDD, James, ROBERTSON, Sam and DAVIDS, Keith

Available from Sheffield Hallam University Research Archive (SHURA) at:

<http://shura.shu.ac.uk/27333/>

---

This document is the author deposited version. You are advised to consult the publisher's version if you wish to cite from it.

**Published version**

WOODS, Carl T., ROTHWELL, Martyn, RUDD, James, ROBERTSON, Sam and DAVIDS, Keith (2020). Representative co-design: Utilising a source of experiential knowledge for athlete development and performance preparation. *Psychology of Sport and Exercise*, p. 101804.

---

**Copyright and re-use policy**

See <http://shura.shu.ac.uk/information.html>

1 *Representative co-design: Utilising a source of experiential knowledge for athlete development and*  
2 *performance preparation*

3

4 **Carl T. Woods<sup>1\*</sup>, Martyn Rothwell<sup>2</sup>, James Rudd<sup>3</sup>, Sam Robertson<sup>1</sup>, Keith Davids<sup>2</sup>**

5

6 <sup>1</sup>Institute for Health and Sport, Victoria University, Melbourne, Australia

7 <sup>2</sup>Sport & Human Performance Research Group, Sheffield Hallam University, Sheffield, UK

8 <sup>3</sup>Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Liverpool, UK

9

10 \*Corresponding Author

11 Carl Woods, Institute for Health and Sport, Victoria University, Melbourne Australia

12 Email: carl.woods@vu.edu.au

13 **Abstract**

14 Contemporary models for athlete development and performance preparation in sport have advocated a  
15 role re-conceptualisation for coaches grounded as *learning environment designers*. Within this re-  
16 conceptualisation, expert practitioners are encouraged to draw upon their experiential knowledge to  
17 design representative and meaningful learning activities that place the performer-environment  
18 interaction at its core. However, we propose that currently, a critical source of experiential knowledge  
19 is often overlooked within the process of learning design – that of performers. Specifically, practitioner-  
20 performer interactions could enrich the design of learning environments by promoting the utilisation of  
21 soliciting affordances and encouraging the psychological engagement of performers. This position  
22 paper introduces the concept of *representative co-design* – a notion which builds on existing research  
23 by framing how the insights and experiences of performers can be negotiated within the design of  
24 practice tasks that seek to faithfully simulate interacting constraints of competition to enrich learning  
25 environments. We frame the notion of *representative co-design*, and contend its importance within more  
26 contemporary athlete development and performance preparation models, at two levels: (i) that of  
27 enriching physical education curricula to develop thought provoking, ‘intelligent’ child / adolescent  
28 learners, and (ii) that of enriching contemporary athlete preparation models in high-performance sport  
29 to enhance learning and engagement, and to develop ‘next generation’ coaches within current athletes.  
30 To bring this conceptualisation to life, we present two exemplars demonstrating the notion of  
31 *representative co-design*, while concurrently highlighting areas for future empirical research.

32 **Key words:** Ecological dynamics; Athlete development; Contemporary performance preparation;  
33 Experiential knowledge; Representative co-design

34

## 35 **Introduction**

36 Skilled movement behaviour evolves over timescales of performance, learning and development  
37 (Button, Seifert, Chow, Araújo, & Davids, 2020). In sport, practitioners such as psychologists, coaches,  
38 managers, trainers, analysts, and applied scientists are challenged to develop models that prepare  
39 athletes for the demands of both current and future competition. This ubiquitous challenge is addressed  
40 by contemporary models that facilitate behavioural change along two timescales: (i) at the micro-scale  
41 of practice (hourly, daily, weekly and monthly), and (ii) at the macro-scale of talent and expertise  
42 development (observed over annual periods) (Davids, Güllich, Araújo, & Shuttleworth, 2017). The  
43 challenge of addressing development and performance preparation is as important for athletes on the  
44 pathway, as it is for senior, experienced professionals at the height of their career. At the core of such  
45 contemporary models is the need to foster a functional, evolving relationship between each individual  
46 performer and the competitive performance environment.

47 In this position paper, we contend that contemporary models would be enhanced by a performer  
48 (e.g., athlete or student) being actively engaged with the learning process, not just passively receiving  
49 instruction and direction from an authoritative figure (such as a sports coach or teacher). More directly,  
50 we introduce the concept of *representative co-design* – a notion which builds on existing research, by  
51 framing how personal insights and experiences of sport performers (at all levels of development) can  
52 be negotiated within the design of practice tasks that seek to faithfully simulate interacting constraints  
53 of competition. We argue that this pedagogical approach could extend current and contemporary models  
54 of performance preparation by empowering individual performers to take greater ownership of their  
55 learning activity designs, promoting a deeper understanding of their expertise domain. In doing so,  
56 practitioners are affording a platform that encourages the performer to engage in greater thought  
57 provocation about his/her learning, which may ultimately function to support the performer's  
58 'intelligence'. To conceptualise the notion of *representative co-design*, we feel it is important to first  
59 discuss the more salient features of contemporary performance preparation models in sport.  
60 Specifically, positioned within an ecological dynamics framework, the following sections detail the

61 integration of experiential and empirical knowledge and the role that expert practitioners have in  
62 performance preparation.

### 63 **Contemporary performance preparation models in sport**

#### 64 *Situating an ecological dynamics framework*

65 The work of Davids, Handford and Williams (1994) and Handford, Davids, Bennett and Button  
66 (1997) indicated the need for a bio-physical perspective on skill acquisition and movement  
67 development. These papers called for sport practitioners to appreciate the complex and entwined  
68 interactions between an individual performer, task and environmental systems on movement  
69 organisation (Newell, 1986). Over two decades later, these conceptual ideas have evolved into  
70 ecological dynamics (Araújo, Davids, & Hristovski, 2006), a contemporary theoretical framework on  
71 performance and learning that integrates concepts from ecological psychology (Gibson, 1979),  
72 constraints on dynamical systems (Newell, 1986), the complexity sciences (Edelman & Gally, 2001)  
73 and evolutionary science (Araújo, Davids, & Renshaw, 2020). An ecological dynamics rationale views  
74 perceptions, cognitions and actions as interacting and self-organised phenomena that emerge from the  
75 continuously dynamic interplay of a performer's action capabilities (defined as their *effectivities*) and  
76 the affordances (defined as *opportunities for action*; Gibson 1979) offered in a specific competitive  
77 environment (referred to as an *ecological niche*) (Araújo et al., 2006; Ross, Gupta & Sanders, 2018).

78 This theoretical conceptualisation underpins contemporary models of athlete development and  
79 performance preparation in sport, including nonlinear pedagogy (NLP) (Chow Davids, Hristovski,  
80 Araújo, & Passos, 2011), constraints-based coaching (CBC) (Renshaw, Davids, & Savelsbergh, 2010),  
81 and the Athletic Skills Model (ASM) (Wormhoudt, Savelsbergh, Teunissen, & Davids, 2017). In such  
82 models, practitioners are challenged to shift their role perspective from one of performance compliance  
83 with 'optimal' movement templates that are captured in coaching manuals grounded in historico-  
84 cultural ideology (i.e., 'in an organisation's DNA'), to one of a *designer* of a learning environment who  
85 fosters self-organised (and self-regulated) performer-environment interactions (Woods, McKeown,  
86 Rothwell, Araújo, Robertson, & Davids, 2020). This re-conceptualisation of a sport practitioner's role  
87 is captured within the notion of *representative design* (Brunswik, 1955). Initially discussed with

88 reference to the alignment of methods and designs used in psychological research with behavioural  
89 contexts, representative design was later re-configured as *representative learning design* in sport  
90 performance contexts by Pinder and colleagues (2011a; 2011b).

91         Representative learning design promotes the design of learning activities in sports practice that  
92 are aligned with (i.e., representative of) the constraints experienced within a particular competitive  
93 performance environment. This ecological ontology eschewed representational accounts to emphasise  
94 key properties of task constraints present within practice and competitive environments that afford a  
95 performer with opportunities to both *select* and *control* actions (Golonka & Wilson, 2019). Specifically,  
96 through prolonged exposure to practice tasks that represent (or faithfully simulate) the constraints of a  
97 competitive environment, a performer learns to detect the information that specifies the relational  
98 properties of the affordances in their environment, encouraging their realisation (Headrick, Renshaw,  
99 Davids, Pinder, & Araújo, 2015; Seifert, Papet, Strafford, Coughlan, & Davids, 2019).

100         In ecological dynamics, representative learning design has a fundamental basis in early  
101 psychological research in motor learning that advocated the principle of specificity of learning (see  
102 Henry, 1958). In this early interpretation, the specificity principle in learning was needed to ensure that  
103 the central nervous system (CNS) of the learner was exposed to specific stimuli for channelling neural  
104 impulses to centres for motor control and coordination to support learning of specific movements.  
105 However, an ecological dynamics rationale avoids the problem of over-emphasising specificity of  
106 learning (higher in representative design), to the expense of more general learning experiences (lower  
107 in representative design) for developing physical literacy in individuals (see Rudd, Pesce, Strafford &  
108 Davids, 2020). It emphasises a deeply enmeshed relationship between action, cognition and perception  
109 which is needed by ‘intelligent’ performers, high in physical literacy, at all stages of the life course. As  
110 we elaborate later, this preference for achieving a nuanced balance between specificity and generality  
111 of motor learning does not favour particular developmental moments when individuals are more  
112 receptive to learning. However, athlete development models like the ASM do imply that there may need  
113 to be a greater emphasis on more general learning experiences earlier in life, and a greater emphasis of  
114 more specialised activities later in life (Wormhoudt et al., 2017).

115 A team of multidisciplinary practitioners can play an integral role in the design of representative  
116 practice tasks to enhance the specificity of learning contexts. Undoubtedly, the considerable experiential  
117 knowledge of practitioners such as psychologists, coaches, managers, analysts, and skill acquisition  
118 specialists can enrich the sampling and integration of relevant constraints from competitive performance  
119 within practice task designs, ensuring they are correctly targeted at the individual needs of each athlete  
120 or sports team (Greenwood, Davids, & Renshaw, 2012). However, while the importance of practitioner  
121 experiential knowledge is well accepted, contemporary athlete performance development and  
122 preparation models, grounded in ecological dynamics, imply how they can be further enriched by  
123 unlocking the experiential knowledge of the performers (learners / athletes) themselves.

124 *A welcomed shift toward the blending of empirical and experiential knowledge*

125 Traditionally, sport science has focused on developing empirical support for performance  
126 preparation through harnessing experimentation in separate sub-disciplines, such as psychology,  
127 physiology and biomechanics (Balagué, Torrents, Hristovski, & Kelso, 2017). Unquestionably, this  
128 knowledge transfer has enriched the understanding of many applications of sport science. However,  
129 empirical knowledge has often been adopted in a hierarchical way and treated as *the* sole knowledge  
130 source needed to design effective practice tasks and learning environments. As illustrated in Figure 1,  
131 this hierarchical approach to knowledge transfer between sport scientists and practitioners has tended  
132 to neglect the experiential knowledge of expert practitioners gained through prolonged exposure to, and  
133 analysis and experimentation in, diverse and varied practice environments in the support of athlete  
134 development. Concurrently, this traditional hierarchical approach typically relies on an implicit  
135 assumption of the validity of its methods and data, and is likely to have driven dissonance between  
136 theory and practice within sport science.

137 **\*\*\*\*INSERT FIGURE ONE ABOUT HERE\*\*\*\***

138 Comparatively, as shown in Figure 2, a contemporary approach to performance preparation seeks  
139 interdisciplinarity, integrating empirical knowledge with sources of experiential knowledge (e.g.,  
140 Greenwood et al., 2012; Burnie, Barrett, Davids, Stone, Worsfold, & Wheat, 2018; McCosker,

141 Renshaw, Greenwood, Davids, & Gosden, 2019). In this more integrative and interdisciplinary  
142 approach, interactions between the different rich knowledge sources could emerge in a more  
143 heterarchical way. For example, the experiential knowledge of expert practitioners and performers  
144 could be viewed as a complementary source of knowledge, gained from many years of competing, and  
145 developing and preparing athletes for competition, that guides the integration of theory into practice  
146 (Greenwood et al., 2012). In doing so, performance preparation models would be underpinned by  
147 rigorous theoretical constructs, while being presented, or brought to life, in a way that is rich in meaning  
148 from the ‘lived experience’ of practitioners and performers.

149 **\*\*\*\*INSERT FIGURE TWO ABOUT HERE\*\*\*\***

150 Related to this special issue of Psychology of Sport and Exercise, in the theory of Direct  
151 Perception, the ecological psychologist James Gibson (1966) distinguished between *knowledge of the*  
152 environment, which underpinned use of affordances to regulate interactions with a performance  
153 landscape, and *knowledge about* the environment, which facilitates an internalised symbolic  
154 manifestation (in the CNS) of the environment available (i.e., in ‘white board’ tactical analyses of sport  
155 performance – see Araújo, Hristovski, Seifert, Carvalho, & Davids, 2019b). An integral component of  
156 an ecological dynamics rationale is, therefore, an appreciation of the roles of expert coaches within the  
157 competitive performance context, conceptualised as an important member of a team of practitioners  
158 tasked with designing representative learning activities that develop an athlete’s *knowledge of a*  
159 performance environment (Woods et al., 2020).

160 *The practitioner as a learning environment designer*

161 A performance environment has been conceptualised as a *rich landscape of affordances* in  
162 ecological psychology (Rietveld & Kiverstein, 2014). In sport, practice task designs could then be  
163 conceptualised as a means to direct or educate the search and attention of athletes for utilising relevant  
164 affordances (Button et al., 2020). Contemporary perspectives on this idea suggests that with experience,  
165 continued exposure, and informed design, performers enhance their decision-making by becoming  
166 increasingly competent at realising the most *soliciting* or *inviting* affordances within their ecological



167 niche (Withagen, de Poel, Araújo, & Pepping, 2012; Withagen, Araújo, & de Poel, 2017; Araújo et al.,  
168 2019b). It is important to consider that these affordance solicitations in competition are not static, rather,  
169 they emerge and decay based on athlete intentions during performance, the action capabilities developed  
170 by an athlete, and the emergence of critical information sources (detected using a variety of modalities  
171 such as haptic, proprioceptive, visual and auditory) that specify relevant properties of the performance  
172 environment (Turvey, Shaw, Reed, & Mace, 1981; Fajen, Riley, & Turvey, 2009; Withagen et al., 2017;  
173 Guerin & Kunkle, 2004; Pinder et al., 2011a). Thus, certain affordances attract individuals to act upon  
174 them at different timescales and a central role of the practitioner is to match the current action  
175 capabilities of a developing performer to the constraints designed into a practice task (van Andel, Cole,  
176 & Pepping, 2017; Araújo, Dicks, & Davids, 2019a). This idea captures the skill of practice design,  
177 indicating how an expert practitioner (learning environment designer) can ‘nudge’ a developing athlete  
178 toward the acceptance of certain affordances while rejecting the less relevant opportunities or  
179 invitations for action. Importantly, this process of nudging attention toward soliciting affordances  
180 through the use of practice design is one that practitioners progressively learn through ‘doing’ and  
181 careful reflection and continuous adaptations to practice – that is, observing how performers interact  
182 with the opportunities for action designed in to the practice task.

183         These ideas underline that a central aspect of the sport practitioners’ role in contemporary  
184 performance preparation is to identify the information that a performer can use to regulate behaviours  
185 within a competitive environment. It is constant exposure to representative practice task constraints that  
186 will help athletes progressively attune to specifying properties of relevant affordances within their  
187 environment through the detection of information to support actions. Further, through prolonged  
188 exposure to representative training tasks, athletes will be encouraged to develop a functionally adaptive,  
189 self-regulating relationship with their competitive environment, learning when and how to accept or  
190 reject emerging or decaying affordances in dynamic performance contexts (Guerin & Kunkle, 2004).

## 191 **Representative co-design**

192 *Utilising the experiential knowledge of experienced performers in athlete development*

193           While contemporary models of performance preparation and athlete development are advocating  
194 a role re-conceptualisation for sports practitioners grounded as *designers* (Araújo et al., 2019a; Woods  
195 et al., 2020), we propose that currently, a critical source of experiential knowledge is often overlooked  
196 – that of *intelligent performers*. Here, the term ‘intelligent’ refers to a highly adaptive, emotionally  
197 engaged and motivated performer who learns quickly (i.e., constantly (re)adjusting behaviours during  
198 learning and performance to achieve an intended task goal based on prior experiences), and who relies  
199 on cognitions, perceptions and actions to function effectively in sport and physical activity. In this sense,  
200 the ‘intelligent’ performer is an individual who effectively uses cognition (integrated with perception  
201 and action) in the way defined by Turvey and Carello (1981, p. 313). They argued that the process of  
202 ‘cognition’ should be considered at a general level to refer to the interactive coordination of an  
203 individual (especially his/her perceptions, decisions and actions) and a performance environment. For  
204 example, successful performance in team games involves the ‘intelligent’ performer being challenged  
205 beyond mere action template imitation to critically interpret emerging events in performance and  
206 autonomously make decisions to resolve issues and problems that challenge him/her. It is enriched  
207 ‘intelligent’ performer-practitioner interactions that could subsequently inform the design of practice  
208 tasks that consist of affordances available within a specific competitive performance environment,  
209 soliciting their realisation based on a performer’s action capabilities at a certain stage of development.  
210 In high-performance sports like soccer, this approach could exemplify how the use of temporal or spatial  
211 constraints (jointly selected by the player and coach) could nudge players toward the use of affordances  
212 that enable varying speeds of ball movement. Comparatively, in early physical education experiences,  
213 a child could be free to manipulate the spacings between ‘monkey bars’, leading to more challenging  
214 and functional climbing behaviours based on his/her current arm span dimensions and perceptions of  
215 self-competence.

216           Contemporary performance preparation models across all developmental levels would, therefore,  
217 benefit greatly from the insights and experiences of ‘intelligent’ performers (Gee, 2005), providing  
218 practitioners with a deeper understanding on specific solicitations experienced in a rich landscape of  
219 affordances. Metaphorically, this idea would be synonymous with an architect (coach) working with an

220 engaged and knowledgeable client (athlete) to design a building (representative practice task) that  
221 functionally suits the needs of the specific client. Although it is the architect who designs the building,  
222 it is this enabling platform that firmly places the client's needs at the core of the design. Further, the  
223 process of *co-design* would not only increase the functionality of the relationship between the client  
224 and building (athlete's performance environment), it would likely engage the client to develop a deeper  
225 understanding of the building's properties (performance environment) so that they can make informed  
226 decisions about how to shape its design.

227 We propose that *representative co-design* can be harnessed through multidisciplinary, where  
228 the 'intelligent' performer would be considered as another integral member of a team of sporting  
229 practitioners who co-design practice landscapes rich in information (Chow et al., 2011). However, the  
230 practicalities of multidisciplinary are not straightforward, with issues raised over the integration of  
231 multiple scientific sub-disciplines and practitioners, in addition to the hierarchical relationship between  
232 theory and practice mentioned earlier (Ross et al., 2018). From a practical point of view, the relationship  
233 and integration between the 'intelligent' performer and practitioner could be challenged when  
234 communications are taking place during the co-design process. In this situation, specific sub-discipline  
235 language and principles may complicate and confuse co-design ideas, meaning that further  
236 specialisation and fragmentation hinders integration. To address these challenges, effective  
237 multidisciplinary working can be more formally embedded within the Department of Methodology  
238 (DoM) concept (Rothwell, Davids, Stone et al., 2020a).

### 239 *Situating representative co-design within a Department of Methodology*

240 From an ecological dynamics perspective, the design of a DoM considers that a form of life  
241 describes the everyday activities of sports organisations, capturing how surrounding social, cultural,  
242 and historical constraints shape the expression of inherent values, beliefs, traditions, customs,  
243 behaviours, and attitudes in a system (see Rothwell, Davids, Stone, Araújo & Shuttleworth, 2020b).  
244 Moreover, the aim of a DoM would be for the 'intelligent' performer and practitioner to work within a  
245 unified framework to: (i) coordinate activity through shared information, principles and language, (ii)  
246 communicate coherent ideas, and (iii) collaboratively design practice landscapes rich in information

247 (i.e., visual, acoustic, and haptic) to guide the emergence of multidimensional behaviours in athlete  
248 performance.

249 To illustrate this, interacting constraints on a form of life in performance sport is particularly  
250 compelling in the pathway to one of the world's greatest sports teams: the New Zealand All Blacks.  
251 The form of life in New Zealand elite rugby union is predicated on self-regulation (players adapting  
252 and organising without external input) as a philosophy of a contemporary All Black being a 'faster  
253 learner than someone else', with the ability to 'adapt and adjust in the moment and then afterwards  
254 reflect and learn' (Napier, 2018, p. 3). Interestingly, coach Steve Hansen traced the All Blacks'  
255 philosophy of self-regulation back to the country's cultural heritage, where, due to its geographical  
256 isolation, New Zealanders had to be 'innovative, good decision-makers and do things for themselves'  
257 (Napier, 2018, p. 5). His perspective provides rich insights on the relationship between these historically  
258 relevant cultural values and attitudes and the potential benefits of co-designing practice environments  
259 in an everyday form of life proliferating in New Zealand rugby union. It is interesting to note how these  
260 capacities for self-regulation are well aligned with outcomes of a co-designing approach to sport  
261 practice methods for 'intelligent' performance. It is also noteworthy that the influence of cultural and  
262 historical constraints on sports performance preparation and athlete development has surfaced in a more  
263 context-driven sport psychology (see Schinke & Stambulova, 2017).

264 In the remaining sections of this position paper, we illustrate how the notion of *representative*  
265 *co-design* could enrich preparation for performance models across different developmental stages in  
266 sport – starting within a physical education curriculum and then progressing to a high-performance  
267 sport environment. In both examples, we propose that *representative co-design* could foster a rich  
268 platform where children / adolescents and professional athletes are empowered to take greater  
269 ownership of their learning and practice environments in a safe, but still uncertain way. Specifically,  
270 within physical education, we propose that the engagement of the student through the *co-design* of  
271 learning activities will beneficially develop their general physical activity 'intelligence', as they engage  
272 in deeper thought provocation of how to affect future learning designs within a curriculum.  
273 Additionally, within a high-performance environment, it is likely that the rich experiential knowledge

274 exchange between a coach and athlete could foster not only an athlete’s personal performance  
275 development, but the continuing development of ‘next generation’ coaches: athletes who are  
276 empowered to regulate the perceptions, cognitions, actions and emotions of themselves and teammates  
277 through the informed *co-design* of representative practice tasks in performance preparation.

278 **Representative co-design: Enriching a physical education curriculum through the development**  
279 **of ‘intelligent’ performers**

280 An important goal of physical education curricula worldwide is to progress learners beyond the  
281 scope of simply reproducing physical skill templates (such as an idealized ‘swim stroke’ or ‘tennis  
282 stroke’), towards the development of self-regulating ‘intelligent’ performers who effectively use  
283 cognitive, perceptual and movement capacities to achieve strategic decisions and outcomes in complex  
284 and dynamic performance situations (Moy, Renshaw, Davids, & Brymer, 2019). As such, across the  
285 globe, government publications, national standards, professional bodies and curriculum documents in  
286 education have recognised that the development of ‘intelligent’ performers needs to start in childhood,  
287 emphasising the role of problem-solving, thinking and decision-making skills in physical education.  
288 For example, the UK’s National Curriculum Physical Education, the USA’s NASPE (National  
289 Association for Sport and Physical Education) and the Queensland Physical Education Senior Syllabus  
290 (Queensland Studies Authority, 2010), incorporate this outcome in all three of the major domains of  
291 learning: psychomotor, cognitive, and affective (see also the Australian Curriculum, Assessment and  
292 Reporting Authority, 2015; Department for Education, 2013; National Association for Sport and  
293 Physical Education, 2009; Queensland Studies Authority, 2010). Notably, the Studies Authority in  
294 Queensland, Australia (2010, p. 3) states that:

295 *“Intelligent performance is characterised by high levels of cognitive functioning, using*  
296 *both rational and creative thought. Students are decision makers engaged in the active*  
297 *construction of meaning through processing information related to their personal*  
298 *experience and to the study of physical activity.” (emphasis added)*

299 Existing ideas on ‘intelligent’ performers in sport are well aligned with connotations of physical literacy  
300 in physical education. Intelligent performers may be considered as physically literate individuals who

301 can apply their physical, psychological, emotional and social competencies in a specific, high-level  
302 performance environment (Rudd et al., 2020).

303 The development of ‘intelligent’ performers in physical education leads imperviously to the  
304 notion of *representative co-design* within an ecological dynamics framework, exemplified through  
305 diverse and continuous interactions between a teacher and student. Initiated within early physical  
306 education settings, the experience of co-designing learning activities will not only enrich learning  
307 designs, but will develop a child’s general performance ‘intelligence’, as (s)he is challenged to think  
308 more deeply about critical features of their learning environment that support self-regulated perceptions,  
309 cognitions and autonomous actions in performance (Gee, 2005). More specifically, co-design will  
310 empower the student to develop *knowledge of* their learning environment so they can make informed  
311 choices about how to manipulate its design (Gee, 2005).

312 As highlighted above, there is a *want* to create ‘intelligent’ performers in physical education.  
313 However, it too often fails to deliver on this aspect of the curriculum. A potential reason for this is not  
314 due to a lack of participation in physical education, an often-cited barrier, but due to popular curriculum  
315 designs used by teachers not allowing children to experience autonomous decision-making (Pelletier,  
316 Séguin-Lévesque & Legault, 2002). Traditionally, physical education teachers have been found to  
317 utilise more controlling, autocratic, strategies within their lesson designs compared to more autonomy-  
318 supportive strategies (Barrett & Boggiano, 1988; Taylor, Ntoumanis & Smith, 2009). This issue  
319 signifies that physical education professionals are prone to making the majority of decisions in regards  
320 to content and its pace of delivery, leaving students bereft of opportunities for taking responsibility for  
321 their learning (De Meyer, Soenens, Aelterman, De Bourdeaudjuij & Haerens, 2016). Another challenge  
322 for physical education curricula is an over-emphasis / specialism on team games (such as football or  
323 netball) and a lack of opportunity to explore actions through other forms of movement education, such  
324 as dance and gymnastics. Thus, in the following section, we explain how a creative dance curriculum  
325 that is *co-designed* by the teacher and student, can support the development of physical literacy in self-  
326 regulating, ‘intelligent’ performers.

327 *Developing 'intelligent' performers in a co-designed dance curriculum*

328 A creative dance curriculum allows students to explore different elements of dance, such as body,  
329 space, time, force, flow, and relationships. The creation of movements occurs through improvisation  
330 and spontaneous performance of movements in response to music and other environmental information,  
331 such as lesson themes (e.g., 'deep under the sea'). This informationally enriched landscape will offer  
332 many invitations to diverse action, encouraging students to explore their environment. To instantiate  
333 the development of an 'intelligent' performer through a dance curriculum, the student will first be  
334 challenged to couple (novel and diverse) movement solutions with the music's beat and tempo. With  
335 clear lesson intentions / expectations (such as creating a dance routine that follows an ABA form and  
336 structure<sup>1</sup>), they will progressively see the emergence of a dance routine. A teacher can further promote  
337 explorative behaviours through a learner-centred cyclical process, which is supportively aligned with  
338 an 'athlete-centred' approach to coaching. Specifically, the teacher could manipulate the tasks through  
339 the creation of scenarios or posing problems to be solved. Once a student becomes comfortable in their  
340 routine, the teacher's role is again challenged to re-engage them in exploratory (searching) behaviours.  
341 In such an instance, the teacher may engage the notion of *co-design*, inviting the student to: (i)  
342 manipulate the environment (e.g., the student being free to design features that invite specific  
343 behaviours), (ii) the theme of the lesson (e.g., the student being free to theme the intention based on  
344 special interests), or (iii) incorporate partner work (e.g., the student being free to engage peers within a  
345 co-designed environment or chosen theme). Through this process, it is likely that the student will engage  
346 in a deeper level of thought, being empowered to develop *knowledge of* the environment as he / she  
347 begins to control the richness and diversity of the learning experience, and in doing so, progressively  
348 develop into 'intelligent' performers.

349 At the start of this paper, it was highlighted that skilled movement behaviour evolves over  
350 timescales of performance, learning, and development (Button et al., 2020). Thus, the *co-designed*  
351 curriculum between the student and teacher will see each lesson become the performance. Learning

---

<sup>1</sup> ABA form begins with an opening theme, leads into a contrasting theme that complements the first, and concludes with a return to the opening theme. This conclusion is recognisable but somehow changes in order to bring the piece to its resolution. There is a cyclic feel, a sense of continuity, order and inevitability.

352 emerges through a unit of work (such as creative dance), as physical literacy develops through the  
353 schooling years. The experience of physical literacy will set up the majority of engaged students for a  
354 lifetime of recreational level physical activity and exercise. For a minority, it will also form a  
355 fundamental basis of a career in high-performance sport, leading us to the next section.

356 **Representative co-design: Harnessing ‘local-to-global’ synergy formation processes in high-**  
357 **performance sport to develop ‘next generation’ coaches in current athletes**

358 A central tenet of performance preparation in contemporary high-performance sporting  
359 environments is the appreciation of the athlete’s needs being placed at its core (Woods et al., 2020).  
360 This approach is in stark contrast to the more traditional models of performance preparation, which  
361 have tended to place the coach at the centre of the instructional process (criticised earlier by Handford  
362 et al., 1997). In contemporary models of athlete development and performance preparation, the coach  
363 and athlete are envisioned as working in unison to *co-design* learning environments replete with critical  
364 information sources that solicit affordance realisation, supporting the development of self-regulating  
365 perceptions, cognitions, emotions and actions.

366 Contemporary models such as NLP, CBC and the ASM conceptualise athletes and sports teams  
367 as *complex adaptive systems* (e.g., Glazier & Davids, 2009; Komar, Chow, Chollet & Seifert, 2015). In  
368 complex adaptive systems, learning results in synergy formation (i.e., coordination and adaptations)  
369 between system components, such as muscles, joints and limb segments and synaptic connections in  
370 the brain, or between members of a sports team, resulting in functional performance adaptations  
371 (Glazier & Davids, 2009). Synergy formation in complex adaptive systems are shaped bidirectionally:  
372 *locally* between the players themselves or *externally*, shaped by practitioners in training (Ribeiro,  
373 Davids, Araújo, Guilherme, Silva, Garganta, 2019). For sport practitioners observing athletes in  
374 performance preparation, it is important to understand how different types of constraints (related to the  
375 task, individual and environment) converge to facilitate synergy formation for realising novel  
376 affordances. In ecological dynamics, learning involves constraints-induced synergy formation between  
377 players or parts of the body through exploration, invention and adaptation of action possibilities (Glazier  
378 & Davids, 2009; Davids, 2012).



379 Rich experiential knowledge from the athlete and coach can assist with the exploitation of  
380 *bidirectional synergy formation* (i.e., emphasising self-organising and self-regulating tendencies in  
381 athletes and teams, as well as the external influences of sport practitioners) (see Ribeiro et al., 2019).  
382 To exemplify, a coach may offer experiential knowledge that could guide the design of *global*  
383 ‘principles of play’ – affording flexible synergy formation from *global-to-local* levels. In contrast, the  
384 athlete could provide rich context to these principles based on current action capabilities, what  
385 information is being detected, and insights on the most soliciting affordances they perceive to be  
386 available for use within the performance environment. This is likely to drive *local* self-regulating  
387 interactions (between teammates and opponents) that lead to emergence of *global* behavioural patterns  
388 (Ribeiro et al., 2019).

389 This perspective uncovers an important feature of *representative co-design* in developing  
390 ‘principles of play’, or tactics perceived as important to overcome specific opponents or performance  
391 challenges. Notably, such strategising has historically been considered the sole domain of the coach,  
392 who develops a ‘game model’ or performance plan that athletes simply adhere to (Ribeiro et al., 2019).  
393 Framed through *representative co-design*, however, ‘intelligent’ athlete(s) and coaches work together  
394 to share rich experiential knowledge surrounding performance principles or tactics. Indeed, such  
395 principles are developed with the players’ needs and action capabilities placed at the core – fostering  
396 greater player engagement, self-regulation and ownership of the learning and preparation environment.  
397 Thus, instead of offering putatively ‘optimised’, ‘ready-made’, and pre-programmed task solutions  
398 (according to personal preferences), a coach would work *with* the athlete to develop individualised and  
399 creative solutions for performance problems, which are continually evolving in line with tactical  
400 developments in a sport. In this way, both coaches and athletes find solutions to the emergent problems  
401 encountered in dynamic competitive performance environments *together* (Araújo, Davids, Chow, &  
402 Passos, 2009). We will specifically address this point in a practical example in proceeding sections of  
403 this paper.

404 It is likely that such sharing of experiential knowledge will foster a platform in which the athlete  
405 is challenged to become more self-regulating and engage in deeper thought. It is through this deeper

406 level of engagement and thinking that the athlete may develop richer *knowledge of* the performance  
407 environment and its affordances (Araujo et al., 2019a; 2019b), facilitating a progressive evolution into  
408 a ‘next generation’ coach. Specifically, we propose that the process of *representative co-design* may  
409 foster a platform where the athlete will be safely challenged to develop their *knowledge of* the  
410 performance environment, enabling him / her to design in information they perceive is integral to the  
411 achievement of specific task goals through the realisation of relevant affordances. Further, in team  
412 sports, *representative co-design* would encourage these ‘next generation’ coaches to develop a deeper  
413 understanding of their teammates action capabilities given the intent of designing in relevant  
414 affordances that can be utilised within practice tasks based on the current action capabilities of their  
415 teammates. They could exploit this deeper understanding during practice tasks by educating a  
416 teammates attention toward the most relevant affordances within the environment based on their action  
417 capabilities and the intended task goal. Thus, such an approach will reflect upon them following  
418 *representative co-design*, in much the same way a coach’s role has been re-conceptualised through a  
419 *designer lens* (Woods et al., 2020). We envisage these ‘next generation’ athlete ‘leaders’ as integral  
420 members of a team of sport practitioners who function collectively to *co-design* and enrich performance  
421 preparation programmes.

## 422 **Bringing life to the notion of representative co-design in contemporary performance preparation** 423 **models: Examples in high-performance sport**

424 The notion of *representative co-design* being an integral component of contemporary athlete  
425 development and performance preparation in sport would be complemented by offering exemplars to  
426 bring the conceptualisation to life. The following sections of this position paper, therefore, present two  
427 examples from high-performance sport, in which a team of sporting practitioners, inclusive of coaches  
428 and ‘intelligent’ athletes, function within a DoM to exemplify *representative co-design*. These examples  
429 do not intend to offer comprehensive insight or hypothesis testing relative to *representative co-design*,  
430 but act as a conduit for current sports practitioners interested in applying its notions to salient features  
431 of their performance preparation models in high-performance sport.

432 *Example 1: Co-designing a practice task to promote the exploration of varied passing interactions*  
433 *between elite Australian footballers*

434 A foundational component of performance preparation in elite Australian football orients the  
435 design of practice tasks that enable players the opportunities to develop their disposal skill, specifically,  
436 their kicking skill. In this example, a practice task consisting of two teams of 9 players are challenged  
437 to outscore each other through the accumulation of ‘points’ by successfully passing the ball (via a  
438 ‘kick’) to a teammate who ‘marks’ (i.e., catches) it in a defined scoring zone. It is important to note  
439 here that, within an ecological dynamics framework, this initial practice design would have been  
440 informed by a team of practitioners, who worked to sample and integrate relevant informational  
441 constraints experienced by players within competition that shaped kicking skill. Following this, and in  
442 accordance with the notion of *representative co-design*, the coach discusses the practice design with an  
443 identified game ‘intelligent’ player (deemed as being a ‘next generation’ coach) prior, during and  
444 following the practice task intervention. Through this rich dialogue, the player is free to share his/her  
445 opinions (both verbally and through actions) regarding the design features of the practice task, with a  
446 specific focus on its representativeness. Examples of this coach-player dialogue prior, during and  
447 following the practice task intervention are offered below:

448 Prior to the practice task:

- 449 • Design feature: *The scoring system*
  - 450 ○ Coach-player reflections and discussions prior to the task could orient whether (or not)
  - 451 certain kicks should have a greater point allocation (i.e., kicks perceived by the player
  - 452 to be more ‘difficult’), which could enhance their invitation within the affordance
  - 453 landscape. Accordingly, these discussions could lead to kicks agreed as being ‘more
  - 454 challenging’ by both the coach and player yielding a greater point allocation,
  - 455 encouraging, or inviting, players to explore their action capabilities and undertake a
  - 456 variety of kicks of differing levels of perceived difficulty during the task.

457 During the practice task:

- 458 • Design feature: *The dimensions of scoring zones*

459           ○ Coach-player reflections and discussions during the task could orient whether (or not)  
460           the dimensions of the scoring zones are appropriately scaled to invite exploration of  
461           certain kicks based on players' action capabilities. Specifically, if the scoring zones are  
462           perceived to be too small to invite its score exploitation, a player could be free to  
463           manipulate its dimensions to encourage teammates to utilise it during the task.

464 Post the practice task:

- 465           • Design feature: *The global 'representativeness' of the practice design*
  - 466           ○ Coach-player reflections and discussions following task completion could orient  
467           whether (or not) they perceived that the design actually facilitated the exploration of  
468           kicks, shaped by representative informational constraints experienced in competition.  
469           Importantly, a player could be prompted to offer a 'perceived representative value'  
470           which (s)he felt reflected how 'game-like' the design was. This arbitrary value could  
471           be presented on a 0-10 scale (0 being 'not competition conditions at all', and 10 being  
472           'complete competition conditions'), and used to inform the design of future task  
473           iterations.

474 *Example 2: Co-designing 'principles of play' for attack in elite Rugby League*

475           Beyond practice task design, the notions of *representative co-design* could be applied to the  
476           establishment of 'principles of play'. As discussed earlier, more traditional models of performance  
477           preparation advocate the coach as the sole individual (global source) responsible for the development  
478           of a 'game model' (Ribeiro et al., 2019). However, conceptualised through *representative co-design*, it  
479           would be the coach and 'intelligent' player(s) who each contribute rich experiential knowledge and  
480           insights surrounding the establishment of performance principles. An important consideration here is  
481           that the player(s) could voice opinions from the perspective of their teammates (and their teammates'  
482           action capabilities), which would concurrently empower ownership of, and responsibility for, the  
483           learning, development and preparation environment. Through such a lens, both coaches and 'intelligent'  
484           player(s) would develop 'principles of play' capable of exploiting emergent problems encountered in  
485           competition, such as specific opposition tactics or external environmental constraints (e.g., weather

486 conditions or idiosyncrasies of opposition grounds). Thus, in this example, a group of rugby league  
487 coaches and ‘intelligent’ players are working collectively to establish a set of ‘principles of play’ in  
488 attack.

489 To best unlock the bidirectionality of synergy formation under constraint, both players and  
490 coaches could develop a set of *global* principles in attack based on their experiential *knowledge of rugby*  
491 league, while mutually acknowledging that players are free to actualise these principles *locally*, based  
492 on their action capabilities and emergent interactions with environmental and task constraints. From  
493 this perspective, the set of principles in attack would not formally define a ‘structure’ (as is typified in  
494 more traditional models of preparation), but enable a flexible (less structured) performance landscape  
495 by which players are free to explore and exploit (for an example in professional rugby union, see McKay  
496 & O’Connor, 2018). An example of one of these ‘principles of play’ in rugby league is presented below:

- 497 • Co-designed principle of play: *Fluid Ball Movement*
  - 498 ○ This principle could be converged upon by both ‘intelligent’ players and coaches given  
499 its evocation of ball movement intended to continually and dynamically challenge an  
500 opponent’s defensive stability. Importantly, players are free to exploit this *co-designed*  
501 principle through the adaptability of their action capabilities relative to the  
502 informational constraints perceived within the environment. For example, ‘fluidity’  
503 could be exemplified through dynamic ball movement, as players detect and exploit  
504 emergent and decaying affordances offered by an opponent’s defence (i.e., detecting  
505 and exploiting a sudden gap afforded in a defensive line to pass or run into), or it could  
506 be exemplified through more conservative ball movement given the inability to  
507 penetrate an opposition’s defensive structure at a given moment or within the action  
508 capabilities of the player in possession of the ball. Irrespective, the point here is that  
509 the players are free to exemplify this *co-designed* principle through any means they  
510 feel ‘brings it to life’ based on their action capabilities and interactions with the  
511 constraints of the performance environment.

512 **Where to next?**

513 *Conclusions and future research directions on the notion of representative co-design*

514 The aim of this position paper was to propose the notion of *representative co-design*, discussing  
515 its implications for contemporary athlete development and preparation for performance models in sport.  
516 It was argued that *representative co-design* would be an important methodological advancement for  
517 athlete development by closely simulating the task constraints of a competitive performance  
518 environment to exploit the experiences and insights of established performers at certain developmental  
519 stages. Concurrently, we argued that through *representative co-design*, contemporary sports  
520 organisations would not only unlock a source of experiential knowledge of use for development and  
521 performance preparation, but they would empower performers (at all developmental stages) to take  
522 greater ownership of their learning environment. It is through this process that performers are likely to  
523 develop richer *knowledge of* their competitive environment, and in doing so, develop into more thought  
524 provoking, ‘intelligent’ individuals.

525 Accompanying our propositions were exemplars demonstrating how *representative co-design*  
526 may be brought to life in a high-performance sport environment. While we feel these exemplars are  
527 integral components of this position paper as they offer readers a platform to understand how to  
528 integrate *representative co-design* into high-performance sport, they do lead to some important research  
529 questions that should be addressed. Specifically, the first example promoted an interesting aspect of  
530 *representative co-design*, that of engaging the ‘intelligent’ performer to provide a ‘perceived  
531 representative value’ to reflect the practice task’s representativeness to competition. We propose two  
532 investigations could stem from the extraction of such experiential knowledge. First, researchers could  
533 look to validate this ‘perceived representative value’ against constraints sampled from both the practice  
534 task and competition. This would likely enable the development of an additional tool (such as a  
535 questionnaire), engrained within the notion of *representative co-design*, that a coach could use in the  
536 design of practice tasks. Second, it would be of interest to unpack the information sources players detect  
537 (attune to) when basing their ‘perceived representative value’. This likely subjective analysis could  
538 unlock further experiential knowledge within the ‘intelligent’ performer, affording a practitioner with

539 deeper information of use for the continued (re)design and refinement of practice tasks that faithfully  
540 simulate competition demands. Moreover, this process could help researchers better understand what  
541 ‘information’ actually is, which in ecological dynamics is highly individualistic, continuously  
542 facilitating environmental interactions based on a range of constraints. Last, we proposed that  
543 *representative co-design* would develop an ‘intelligent’ athlete’s *knowledge of* the performance  
544 environment, leading to greater ownership and responsibility for learning and performance  
545 development. To test this proposition, it would be of interest for future work to examine the evolving  
546 behavioural tendencies (such as emergent leadership qualities) and coaching career trajectories of  
547 performers benefiting from pedagogies exploiting the notion of *representative co-design*. These  
548 analyses would provide informed insights into the capability of *co-designing* approaches to indeed  
549 develop future ‘intelligent’ athletes and ‘next generation’ coaches.

550 **References**

- 551 Araújo, D. Davids, K., Chow, J. Y., & Passos, P. (2009). The development of decision making skill in  
552 sport: an ecological dynamics perspective. In D. Araujo, H. Ripoll, & M. Raab, Markus (Eds.),  
553 *Perspectives on Cognition and Action in Sport*, (pp. 157-169). Suffolk: Nova Science Publishers,  
554 Inc.
- 555 Araújo, D., Davids, K., & Hristovski, R. (2006). The ecological dynamics of decision making in  
556 sport. *Psychology of Sport and Exercise*, 7, 653-676, doi: 10.1016/j.psychsport.2006.07.002
- 557 Araújo, D., Dicks, M., & Davids, K. (2019a). Selecting among affordances: a basis for channeling  
558 expertise in sport. In M. L. Cappuccio (Ed.), *Handbook of Embodied Cognition and Sport*  
559 *Psychology*, (pp. 537-556). Cambridge, MA: The MIT Press
- 560 Araújo, D., Hristovski, R., Seifert, L., Carvalho, J. & Davids, K. (2019b). Ecological cognition: expert  
561 decision-making behaviour in sport. *International Reviews in Sport and Exercise Psychology*,  
562 12, 1-25, doi: 10.1080/1750984X.2017.1349826
- 563 Araújo, D., Davids, K., & Renshaw, I. (2020). Cognition, emotion and action in sport: an ecological  
564 dynamics perspective. In G. Tenenbaum and R. C. Eklund (Eds.), *The Handbook of Sport*  
565 *Psychology, 4th Edition*. John Wiley & Sons Limited
- 566 Balagué, N., Torrents, C., Hristovski, R., & Kelso, J. A. S. (2017). Sport science integration: An  
567 evolutionary synthesis. *European Journal of Sport Science*, 17, 51-62, doi:  
568 10.1080/17461391.2016.1198422.
- 569 Barrett, M., & Boggiano, A. K. (1988). Fostering extrinsic orientations: use of reward strategies to  
570 motivate children. *Journal of Social and Clinical Psychology*, 6, 293-300, doi:  
571 10.1521/jscp.1988.6.3-4.293
- 572 Brunswik, E. (1955). Representative design and probabilistic theory in a functional psychology.  
573 *Psychological Review*, 62, 193-217, doi: 10.1037/h0047470
- 574 Burnie, L., Barrett, P., Davids, K., Stone, J., Worsfold, P. & Wheat J. (2018). Coaches' philosophies on  
575 the transfer of strength training to elite sports performance. *International Journal of Sports*  
576 *Science and Coaching* 13, 729–736, doi: 10.1177/1747954117747131
- 577 Button, C., Seifert, L., Chow, J. Y., Araújo, D., & Davids, K. (2020). Dynamics of skill acquisition: an  
578 ecological dynamics approach. Champaign, IL: Human Kinetics



- 579 Chow, J. Y., Davids, K., Hristovski, R., Araújo, D., & Passos, P. (2011). Nonlinear pedagogy: learning  
580 design for self-organizing neurobiological systems. *New Ideas in Psychology* 29: 189-200, doi:  
581 10.1016/j.newideapsych.2010.10.001
- 582 Davids, K. (2012). Learning design for nonlinear dynamical movement systems. *Open Sport Science*  
583 *Journal*, 5, 9-16, doi: 10.2174/1875399X01205010009
- 584 Davids, K., Güllich, A., Araújo, D., & Shuttleworth, R. (2017). Understanding environmental and task  
585 constraints on talent development. analysis of micro-structure of practice and macro-structure of  
586 development histories. In J. Baker, S, Cobley, J. Schorer, & N. Wattie (Eds.), *Routledge*  
587 *Handbook of Talent Identification and Development in Sport* (pp. 192-206). London, Taylor &  
588 Francis Group
- 589 Davids, K., Handford, C. & Williams, M. A. (1994). The natural physical alternative to cognitive  
590 theories of motor behaviour: An invitation for interdisciplinary research in sports science?  
591 *Journal of Sport Sciences*, 12, 495- 528, doi: 10.1080/02640419408732202
- 592 De Meyer, J., Soenens, B., Aelterman, N., De Bourdeaudjuij, I., & Haerens, L. (2016). The different  
593 faces of controlling teaching: implications of a distinction between externally and internally  
594 controlling teaching for students' motivation in physical education. *Physical Education and Sport*  
595 *Pedagogy*, 21, 632-652, doi: 10.1080/17408989.2015.1112777
- 596 Department for Education. (2013). National curriculum in England: Physical education programmes of  
597 study.
- 598 Edelman, G. M., & Gally, J. A. (2001). Degeneracy and complexity in biological systems. *Proceedings*  
599 *of the National Academy of Sciences of the United States of America*, 98, 13763-13768, doi:  
600 10.1073/pnas.231499798
- 601 Fajen, B. R., Riley, M. A., & Turvey, M. T. (2009). Information, affordances, and the control of action  
602 in sport. *International Journal of Sport Psychology*, 40, 79–107
- 603 Gee, J. P. (2005). Learning by design: good video games as learning machines. *E-Learning*, 2, 1-12
- 604 Gibson, J. J. (1966). *The senses considered as perceptual systems*. Boston: Houghton-Mifflin.
- 605 Gibson, J.J. (1979). *The ecological approach to visual perception*. Boston, MA: Houghton Mifflin
- 606 Glazier, P. S., & Davids, K. (2009). Constraints on the complete optimization of human motion. *Sports*  
607 *Medicine*, 39, 15-28, doi: 10.2165/00007256-200939010-00002

- 608 Golonka, S., & Wilson, A. D. (2019). Ecological representations. *Ecological Psychology*, *31*, 235-253,  
609 doi: 10.1080/10407413.2019.1615224
- 610 Greenwood, D., Davids, K., & Renshaw, I. (2012). How elite coaches' experiential knowledge might  
611 enhance empirical research on sport performance. *International Journal of Sport Science &*  
612 *Coaching*, *7*, 411-422, doi: 10.1260/1747-9541.7.2.411
- 613 Guerin, S., & Kunkle, D. (2004). Emergence of constraint in self-organizing systems. *Nonlinear*  
614 *Dynamics, Psychology and Life Sciences*, *8*, 131-146
- 615 Handford, C., Davids, K., Bennett, S., & Button, C. (1997). Skill acquisition in sport: some applications  
616 of an evolving practice ecology. *Journal of Sport Sciences*, *15*, 621-640, doi:  
617 10.1080/026404197367056
- 618 Headrick, J. J., Renshaw, I., Davids, K., Pinder, R. & Araújo, D. (2015). The dynamics of expertise  
619 acquisition in sport: a conceptual model of affective learning design. *Psychology of Sport and*  
620 *Exercise* *16*, 83-90
- 621 Henry, F. M. (1958). Specificity vs. Generality in Learning Motor Skills. *Proceedings of College of*  
622 *Physical Education Association*, *61*, 126-128
- 623 Komar, J., Chow, J. Y., Chollet, D., & Seifert, L. (2015). Neurobiological degeneracy: supporting  
624 stability, flexibility and pluripotentiality in complex motor skill. *Acta Psychologica*, *154*, 26-35,  
625 doi: 10.1016/j.actpsy.2014.11.002
- 626 McCosker, C., Renshaw, I., Greenwood, D., Davids, K. & Gosden, E. (2019). How performance  
627 analysis of elite long jumping can inform representative training design through the identification  
628 of key constraints on behaviour. *European Journal of Sports Science* *19*, 913-922, doi:  
629 10.1080/17461391.2018.1564797
- 630 McKay, J., & O'Connor, D. (2018). Practicing unstructured play in team ball sports: a rugby union  
631 example. *International Sport Coaching Journal*, *5*, 273-280, doi: **doi.org/10.1123/iscj.2017-**  
632 **0095**
- 633 Moy, B., Renshaw, I., Davids, K. & Brymer, E. (2019). Preservice teachers implementing a nonlinear  
634 physical education pedagogy. *Physical Education and Sport Pedagogy*, *24*, 565-581, doi:  
635 10.1080/17408989.2019.1628934
- 636 Napier, L. (2018). [https://www.theguardian.com/sport/2018/nov/09/the-all-blacks-secret-never-stand-](https://www.theguardian.com/sport/2018/nov/09/the-all-blacks-secret-never-stand-still-or-you-get-overtaken-england-rugby-union)  
637 [still-or-you-get-overtaken-england-rugby-union](https://www.theguardian.com/sport/2018/nov/09/the-all-blacks-secret-never-stand-still-or-you-get-overtaken-england-rugby-union)
- 638 National Association for Sport and Physical Education USA. (2009). *Opportunity to learn: Guidelines*

- 639           *for high school physical education*. 3rd ed. Reston, VA: NASPE
- 640 Newell, K. M. (1986). Constraints on the development of coordination. In M. G. Wade & H. T. A.  
641           Whiting (Eds.), *Motor development in children: aspects of coordination and control* (pp. 341-  
642           360). Dordrecht, Netherlands: Martinus Nijhoff
- 643 Pelletier, L. G., Séguin-Lévesque, C., & Legault, L. (2002). Pressure from above and pressure from  
644           below as determinants of teachers' motivation and teaching behaviors. *Journal of Educational*  
645           *Psychology*, *94*(1), 186–196, doi: 10.1037/0022-0663.94.1.186
- 646 Pinder, R. A., Davids, K., Renshaw, I., & Araújo, D. (2011a). Representative learning design and  
647           functionality of research and practice in sport. *Journal of Sport and Exercise Psychology*, *33*,  
648           146-155, doi: 10.1123/jsep.33.1.146
- 649 Pinder, R. A., Renshaw, I., Davids, K., & Kerhervé, H. (2011b). Principles for the use of ball projection  
650           machines in elite and developmental sport programmes. *Sports Medicine*, *41*, 793-800
- 651 Queensland Studies Authority. 2010. *Physical education senior syllabus*. Brisbane: QSA.
- 652 Renshaw, I., Davids, K., & Savelsbergh, G. J. P. (2010). *Motor learning in practice: a constraints-led*  
653           *approach*. Abingdon, Oxon: Routledge.
- 654 Ribeiro, J., Davids, K., Araújo, D., Guilherme, J., Silva, P., & Garganta, J. (2019). Exploiting bi-  
655           directional self-organizing tendencies in team sports: the role of the game model and tactical  
656           principles of play. *Frontiers in Psychology*, doi: 10.3389/fpsyg.2019.02213
- 657 Rietveld, E., & Kiverstein, J. (2014). A rich landscape of affordances. *Ecological Psychology*, *26*, 325-  
658           352, doi: 10.1080/10407413.2014.958035
- 659 Schinke, R. J., & Stambulova, N. (2017) Context-driven sport and exercise psychology practice:  
660           Widening our lens beyond the athlete. *Journal of Sport Psychology in Action*, *8*, 71-75, doi:  
661           10.1080/21520704.2017.1299470
- 662 Ross, E., Gupta, L. & Sanders, L. (2018). When research leads to learning, but not action in high  
663           performance sport. *Progress in Brain Research*, *240*, 201-217, doi: 10.1016/bs.pbr.2018.08.001
- 664 Rothwell, M., Davids, K., Stone, J., O'Sullivan, M., Vaughan, J., Newcombe, D., & Shuttleworth, R.  
665           (2020a). A department of methodology can coordinate transdisciplinary sport science support.  
666           *Journal of Expertise*, *3*, 55-65
- 667 Rothwell, M., Davids, K., Stone, J., Araújo, D. & Shuttleworth, R. (2020b). The talent development  
668           process as enhancing athlete functionality: Creating forms of life in an ecological niche. In J.

- 669 Baker, S. Cobley, J. Schorer & N. Wattie (2nd Ed.), Routledge Handbook of Talent Identification  
670 and Development in Sport. Abingdon, UK: Routledge.
- 671 Rudd, J. R., Pesce, C. Strafford, B., & Davids, K. (2020). An ecological dynamics rationale for  
672 individual enrichment: enhancing performance and physical activity in all. *Frontiers in*  
673 *Psychology*, doi: 10.3389/fpsyg.2020.01904
- 674 Seifert, L., Papet, V., Strafford, B. W., Coughlan, E. K., & Davids, K. (2019). Skill transfer, expertise  
675 and talent development: an ecological dynamics perspective. *Movement & Sport Sciences*, 102,  
676 39-49, doi: 10.1051/sm/2019010
- 677 Taylor, I. M., Ntoumanis, N., & Smith, B. (2009). The social context as a determinant of teacher  
678 motivational strategies in physical education. *Psychology of Sport and Exercise*, 10, 235-243,  
679 doi: 10.1016/j.psychsport.2008.09.002
- 680 Turvey, M. T., Shaw, R. E., Reed, E. S., & Mace, W. M. (1981). Ecological laws of perceiving and  
681 acting: in reply to Fodor and Pylyshyn. *Cognition*, 9, 237–304, doi: 10.1016/0010-  
682 0277(81)90002-0
- 683 Turvey, M. T., & Carello, C. (1981). Cognition: the view from ecological realism. *Cognition*, 10, doi:  
684 10.1016/0010-0277(81)90063-9
- 685 van Andel, S., Cole, M. H., & Pepping, G. J. (2017). A systematic review on perceptual-motor  
686 calibration to changes in action capabilities. *Human Movement Science*, 51, 59–71, doi:  
687 10.1016/j.humov.2016.11.004
- 688 Withagen, R., Araújo, D., & de Poel, H. J. (2017). Inviting affordances and agency. *New Ideas in*  
689 *Psychology*, 45, 11-18, doi: 10.1016/j.newideapsych.2016.12.002
- 690 Withagen, R., de Poel, H. J., Araújo, D., & Pepping, G. P. (2012). Affordances can invite behaviour:  
691 reconsidering the relationship between affordances and agency. *New Ideas in Psychology*, 30,  
692 250-258, doi: 10.1016/j.newideapsych.2011.12.003
- 693 Woods, C. T., McKeown, I., Rothwell, M., Araújo, D., Robertson, S., & Davids, K. (2020). Sport  
694 practitioners as sport ecology designers: How ecological dynamics has progressively changed  
695 perceptions of skill ‘acquisition’ in the sporting habitat. *Frontiers of Psychology*, doi:  
696 10.3389/fpsyg.2020.00654

697 Wormhoudt, R., Savelsbergh, G. J. P., Teunissen, J. W., & Davids, K. (2017). The athletic skills model:  
698 Optimizing talent development through movement education. Abingdon, Oxon; New York, NY:  
699 Routledge.

700

701 **List of Figures**

702 **Figure 1.** The traditional hierarchical approach predicated on human performance being considered  
703 unidimensional.

704 **Figure 2.** Contemporary athlete development and preparation for performance models in sport informed  
705 by the integration of experiential and empirical knowledge