Institution:		
Sheffield Hallam University		
Unit of Assessment:		
UOA24 - Sport and Exercise Sciences, Leisure and Tourism		
Title of case study:		
Improving Elite Coaching and Talent Development through Ecological Dynamics		
Period when the underpinning research was undertaken:		
2013 - 2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	**Role(s) (e.g. job title):**	**Period(s) employed by submitting HEI:**
Professor Keith Davids	Professor of Motor Learning	2013 - present
Dr Joseph Stone	Senior Lecturer	2014 - present
Martyn Rothwell	Senior Lecturer	2014 - present
Period when the claimed impact occurred:		
2014 – 2020		
Is this case study continued from a case study submitted in 2014? Y/N		
No		

1. Summary of the impact

Traditional approaches to sport coaching and physical education teaching have been criticised for reducing enjoyment and having negative effects on athlete health and wellbeing. To address these problems, research at Sheffield Hallam University has theoretically conceptualised, empirically tested and practically applied a new approach to motor learning, sport coaching and physical education: ecological dynamics. This applied science research has shaped practical applications in 25 professional organisations globally, including national sporting institutes, government departments and professional sports organisations. The research has resulted in: i) improved preparation and performance of elite teams and Olympic athletes, ii) enhanced talent development systems, and iii) upskilled coaches and physical education teachers.

2. Underpinning research

Sport coaching and physical education has traditionally been guided by a 'deliberate practice' approach (i.e. experts 'needing' an average of 10,000 hours of deliberate practice), emphasising coach prescription, athlete compliance and highly structured teaching. Traditional pedagogical activities include demonstration and rehearsal of 'optimal' routines, continuous provision of verbal instructions with corrective feedback, and repetitive attempts to reproduce standardised techniques. However, this traditional approach has been criticised by applied scientists and athletes for negative impacts on learning - including reduced enjoyment, coach dependence and increased drop-out rates. Contemporary theories of motor learning design (i.e. ecological dynamics) advocate a more athlete-centred perspective of individual (and team) performance, learning and development. Research undertaken at Sheffield Hallam University (SHU) has played a major role in substantiating and supporting theoretical and practical applications of ecological dynamics to sport coaching and physical education.

Professor Keith Davids moved to SHU in 2013 from the Queensland University of Technology, bringing his expertise in movement science and sports pedagogy. He joined Dr Joseph Stone and Martyn Rothwell to form the Skill Acquisition Research group at SHU. The group has published over 200 outputs, establishing ecological dynamics as an important theoretical framework for skill acquisition, motor learning, expertise, athlete performance preparation and talent development. Based on theory development and empirical data, ecological dynamics proposes non-linear pedagogy (NLP) and the constraints-led approach (CLA) as practitioner models for learning design, skill acquisition and talent development. NLP provides evidenced-based pedagogical principles for the design of teaching and coaching programmes. CLA describes how interacting personal, task and environmental constraints can be manipulated to guide learning at all levels in sport. The research has contributed in three main ways:

1. Developing the Ecological Dynamics Theoretical Framework

The research developed the theoretical conceptualisation of ecological dynamics, combining ecological psychology with dynamical systems theory. It provided a scientific basis for understanding movement coordination and its acquisition, emphasising the adaptive, functional relationship between an individual and a performance environment (**R1**). The research rejected the traditional emphasis on early specialisation in one sport, and the amount of time spent in deliberate practice, as ineffective ways to design learning and training programmes. Rather, theory and evidence substantiated ecological dynamics, as a non-linear dynamical framework, and a more effective and efficient way to design learning, practice and education - with athletes and sport participants at all levels of skill and experience (**R1**).

2. Empirical Evidence to Support the Ecological Dynamics Concepts

The research examined the effectiveness of NLP principles and CLA methods via quantitative (e.g. biomechanical investigations and notational analyses using ecological dynamics concepts) procedures in a series of empirical research programmes, spanning from children to elite performers (**R2**-**R4**). Research on children's learning programmes in tennis examined traditional vs CLA methods. Children's match-play behaviours and performance on a tennis-specific skills test after implementing the CLA, demonstrated improvements three times greater in technical skill and competitive performance, compared to the traditional methods group (**R2**). In sports requiring interceptive actions like catching, novel technology was developed integrating visual information with ball projection machines, to understand how performance is regulated. This revealed how perception and action are tightly coupled, and that the traditional extensive use of ball projection machines during sports training needs careful consideration (**R3**). Finally, research using performance analysis methods in elite athletes evidenced benefits of a CLA on elite performance preparation in national and international long-jump programmes. The findings of this provided empirical information on how coaches could design better training tasks, which are more representative of the performance environment, for athletes to exploit functional movement behaviours (**R4**).

3. Evaluation of Ecological Dynamics in Practice

To support the application of quantitative findings and recommendations into practice, qualitative methods (e.g. action-based research, semi-structured interviews, ethnographies) developed evidence on how to integrate ecological dynamics concepts, NLP and CLA, into learning designs (**R5**-**R6**). The role of the experiential knowledge (i.e. knowledge gained through extensive experience) of expert coaches (including Olympic medallist coaches), working within high performance sports organisations, was examined via semi-structured interviews. Findings demonstrated the key role of experiential knowledge, integrated with empirical evidence, to support contemporary coaching methods (**R5**). Finally, research investigated how sports coaches, sport scientists and PE specialists could implement key concepts from ecological dynamics in their work. Interviewing 15 professional coaches from six countries revealed insights and experiences of coaches who have changed from a traditional to NLP pedagogical principles. Coaches believed traditional methods of learning were relatively ineffective in developing athlete performance, leading them to adopt NLP methodologies. The research also identified key considerations for less experienced practitioners seeking to implement NLP approaches and provided evidence to guide future coach education programmes (**R6**). This combined body of research (**R1**-**R6**) demonstrated that integrating expert coaches' experiential knowledge with theory and empirical quantitative data, enabled successful application of ecological dynamics principles in sports coaching.

3. References to the research

R1.   Seifert, L., Komar, J., Araujo, D. & **Davids, K**. (2016). Neurobiological Degeneracy: A Key Property for Adaptations of Perception and Action to Constraints. *Neuroscience & Biobehavioral Reviews*, 69, 159-65. https://doi.org/10.1016/j.neubiorev.2016.08.006

R2. Fitzpatrick, A., **Davids, K**. & **Stone, J.A**. (2018). Effects of Scaling Task Constraints on Emergent Behaviours in Children's Racquet Sports Performance. *Human Movement Science*, 58, 80-87. https://doi.org/10.1016/j.humov.2018.01.007

R3. **Stone, J.A**., Maynard, I.W., North, J.S., Panchuk, D. & **Davids, K**. (2015). (De) Synchronization of Advanced Visual Information and Ball Flight Characteristics Constrains Emergent Information-Movement Couplings during One-Handed Catching. *Experimental Brain Research*, *233*, 449-58. https://doi.org/10.1007/s00221-014-4126-3

R4. McCosker, C., Renshaw, I., Greenwood, I., **Davids, K**. & Gosden, E. (2019). How Performance Analysis of Elite Long Jumping Can Inform Representative Training Design through Identification of Key constraints on Competitive Behaviours. *European Journal of Sport Science*, 19 (7), 913-21. https://doi.org/10.1080/17461391.2018.1564797

R5. Burnie, L., Barratt, P., **Davids, K**., **Stone, J.A**., Worsfold, P. & Wheat, J. (2018). Coaches' Philosophies on the Transfer of Strength Training to Elite Sports Performance. *International Journal of Sports Science & Coaching*, 13 (5), 729-36. https://doi.org/10.1177/1747954117747131

R6. **Stone, J.A**, **Rothwell., M**., Shuttleworth, R, & **Davids, K**. (2020). Exploring Sport Coaches' Experiences of Using a Contemporary Pedagogical Approach to Coaching: An International Perspective. *Qualitative Research in Sport, Exercise and Health*. https://doi.org/10.1080/2159676X.2020.1765194

All articles were rigorously peer-reviewed prior to publication in leading journals in the field. **R4** won European Journal of Sport Science's best paper of the year in 2019.

4. Details of the impact

This research has led to a shift in the way that coaches and sports organisations prepare athletes for competition. The research has also led to improved learning environments for developing athletes, and improved training for future sport science professionals, coaches and educators. As well as being a research hub of excellence itself, the research group has also established a global network of collaborating applied sports scientists.

Elite Performance Success
Dissemination of the research through professional development sessions and invited presentations has caused a shift in sport coaching practice from traditional to contemporary approaches, resulting in successful outcomes for adopters in elite sport world-wide.

SHU research was introduced to the England Rugby Union setup through the RFU's Professional Coach Development Manager Richard Shuttleworth, a former researcher in the SHU Skill Acquisition group. First team coach Eddie Jones stated:

> *"The result has been the transformation of the English national team and its players, not just its coach"* (**E1**).

This change in approach influenced the senior men's team reaching the World Cup final in 2019 and winning both the Six Nations Championship and Autumn Nations Cup in 2020.

Welsh Judo explain that since the adoption of ecological dynamics concepts, *"our performance programme has gone from strength to strength, achieving many firsts"* (**E2**). Natalie Powell became the first British Olympian for 44 years (2016), a World bronze medallist (2017) and Britain's first female world number one (2017). Welsh Judo's CEO Darren Warner states that:

> "*Having overseen this progress, I feel that much of the overarching philosophy and methodology that we have implemented here in Wales was sparked by the research from Sheffield Hallam… Their research is both valuable and a much-needed contribution to the sporting pathway, from beginner to winner"* (**E2**).

The GB Women's Hockey team coach Danny Kerry said that switching to a CLA *"transformed his coaching approach"* (**E3**). He was subsequently awarded high performance coach of the year (2015). GB Women's Hockey's went on to win their first ever Olympic gold medal (2016).

Port Adelaide Australian Rules Football Club have acknowledged how the research impacted on their approach to coaching. This revision resulted in them topping the league table in 2020, with player engagement recorded at a 10-year high. The club state that SHU research is considered a substantial part of the positive change (**E2**). Fellow club Western Bulldogs moved from 13th in the league in 2018 to making the AFL finals in 2019 by altering their coaching philosophy, based on the research. Players there have expressed perceived benefits of moving away from traditional practice towards a CLA, in implementing research recommendations (**E2**).

Garrett Lucash, USA figure skating champion and professional coach, stated: *"this research has vitally influenced figure skating in the United States in recent years"*, noting that the athletes in Lucash's National Development Team at the most recent competition (September 2020) achieved nine personal best scores (**E2**). Also in America, the University of Miami volleyball team have adopted an ecological dynamics model which, in 2019, resulted in their highest national ranking in the team's history (**E2**).

Transforming Talent Development Programmes
Parallel to changes in elite sport coaching, the group's research has also influenced structural changes in how talent development programmes are designed and implemented worldwide. International governing bodies and professional sports organisations now include the group's work on NLP and CLA to underpin their talent development programmes. Sport England's Talent Plan (2018) for creating the 'world's best talent system' now contains ecological dynamics concepts of talent being a 'complex system' and a 'non-linear process', encouraging use of a CLA for athlete development (**E4**). Further examples include: GB Hockey's Talent Development Framework strategy (2018), English Football Association Advanced Youth Coaching Award (core concept #4 in 2018), Basketball England's Talent Plan, and Football Federation Australia's Technical Department (**E5**).

Davids presented expert advice to the English Institute of Sport and UK Sport in 2019, informing their Pathway Coaching Position Statement (2020). This document now supports professional development and preparation of all UK coaches who work with high potential athletes and guides strategic planning on athlete and coach support for future Olympic games (**E6**).

In 2017 Dennis Hortin (**E2**), Head of Research and Development at AIK Stockholm football club's academy (with 1,600 6-19 year olds), announced the disbanding of their early selection policy, shifting in 2018 to an ecological dynamics framework to support future player development. Many of the concepts of the academy's new framework have been directly inspired by the NLP and CLA research and have set a template for the future evolution and repositioning of AIK youth football. This transition resulted in the AIK Youth Academy being awarded the highest rating of five-stars in the certification of youth academies, carried out by Swedish Elite Football (**E2**). The Swedish Football Association followed suit, implementing NLP as their main framework for their UEFA 'A' Licence professional coach training programme. AIK's changed methodologies subsequently attracted the attention of the Dutch Football Association (KNVB), who are changing their player development strategies, based on the SHU/AIK model (**E7**).

Benefits for Sport Coaches and Physical Education Teachers
The SHU research has attracted invitations to deliver professional development sessions for applying CLA methods and NLP principles to practice. Sessions have been delivered to 25 sporting organisations, in seven countries, supported by related publications of applied practitioner-focused books (**E8**). These books have been translated into Swedish, Korean and Mandarin. The research also continues to influence practical application at all levels via online media, including the *Perception & Action* sports science podcast (1 million downloads), the *Opposite Direction* YouTube channel (110,000 views), and the group's 20,000 followers across two Twitter accounts (**E8**). Specific examples of the research benefitting coaches include:

Gerard Jones, Elite Coach Educator at Fédération Royale Marocaine de Football, who creates content for the Confederation of African Football (CAF), confirmed that the research

> *"made me think differently about how I design training sessions, the role of the coach as a learner designer, and how I can use augmented feedback to develop autonomous decision makers. As a result, this has had a significant impact on how I mentor and develop coaches and how I personally coach players."* (**E2**)

Andrew Sheaff, University of Virginia Swimming and Diving Coach, expressed how the research has

> *"changed my coaching practice significantly and that change has undoubtedly been for the better, to the benefit of the athletes I coach. The research has evolved my coaching practice, resulting in improved performances and experiences of the athletes I coach."* (**E2**)

Brad Keller of Fremantle Australian Rules Football Club states:

> *"The ability for the group to explain theoretical concepts, whilst having real world application, is extremely important for our industry. I have really embraced the ecological dynamics approach in my current role after years of seeing the downsides of other methodologies and frameworks. This has had significant impact on my career to date, and more importantly in applied sport."* (**E2**)

In the area of physical education, NLP as a pedagogical approach has been adopted by the Singapore Ministry of Education onto their national school curriculum. (**E2**)

In 2016, a panel of 40 coaching experts at the International Council for Coaching Excellence, recognised SHU's constraints-led approach as one of two essential motor learning theoretical frameworks for professional development. Consequently, they advocated that the research should underpin the delivery of skill acquisition and motor learning theory in the *"many hundreds of coaching science undergraduate degrees across the world"* (**E9**). This coaching framework is now improving the education of the sport science practitioners, coaches and physical education teachers of the future, across the globe.

5. Sources to corroborate the impact

E1.   Kieran Shannon interview with Richard Shuttleworth: Open to what the game teaches

E2.   Compiled testimonial letters from: Darren Warner (CEO Welsh Judo), Garrett Lucash (USA Figure Skating), Andrew Sheaff (University of Virginia), Kasey Crider (University of Miami Volleyball), Gerard Jones (Fédération Royale Marocaine de Football), Ian McKeown (Port Adelaide Football Club), Brad Keller (Fremantle AFL), Peter Browne (Western Bulldogs ALF) and Benjamin Tan (Ministry of Education, Singapore)

E3.   UK Coaching: How High-Performance Coach of the Year Danny Kerry has put the Great into British hockey

E4.   Sport England. The Talent Plan for England: Creating the world's best talent system

E5.   Sections of Talent Development Frameworks underpinned by NLP and CLA: GB Hockey, English Football Association, GB Canoe, Basketball England, Football Federation Australia

E6.   UK Sport Coach Development Team & EIS Performance Pathways-Pathway Coaching Position Statement

E7.   Royal Dutch Football Association (KNVB). Pilot clubs share insights on alternative education models for equality in youth soccer

E8.   Sheffield Hallam Internal Report on Skill Acquisition professional development sessions

E9.   ICCE 2016 Coaching Framework