Ecological dynamics: a theoretical framework for understanding physical literacy in children

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The candidate confirms that the work submitted is their own, except where work which has formed part of jointly authored publications has been included. The contribution of the candidate and the other authors to this work has been explicitly indicated below. The candidate confirms that appropriate credit has been given within the thesis where reference has been made to the work of others.

The work in Chapter Four of the thesis has appeared in publication as follows:

Wilkie, B., Foulkes, J., Rudd, J., Lewis, C., Woods, C., Sweeting, A., & Robinson, E. (2021). Measuring Physical Literacy: A Fresh Approach. In *Nonlinear Pedagogy and the Athletics Skills Model* (pp. 161-168). Routledge.

This book chapter reported on the feasibility of assessing physical literacy through an approach informed by ecological dynamics. I was responsible for initial conception and formulation of research aims and objectives alongside the research design, data collection, analysis and writing in conjunction J.F. and J.R. (supervisors). C.L., C.W., A.S., and E.R. supported data collection and analysis, in addition to acting as critical friends during writing and revisions of the work.

The work in Chapter Five of the thesis has appeared in publication as follows:

Wilkie, B., Foulkes, J., Woods, C. T., Sweeting, A., Lewis, C., Davids, K., & Rudd, J. (2022). A games-based assessment in ecological dynamics for measuring physical literacy. *Asian Journal of Sport and Exercise Psychology*, *2*(1), 50-58.

This publication focussed on the pilot an assessment of physical literacy conceptualised in an ecological dynamics theoretical rationale. I was responsible for initial conception and formulation of research aims and objectives alongside the research design, data collection, analysis, and writing in conjunction J.R. and J.F. (supervisors). J.R., J.F., C.W., A.S., C.L., and K.D. acted as academic and technical experts, contributing to defining and endorsing the key pillars of an ecological dynamics rationale used in the paper. Additionally, they acted as critical friends during writing and revision of this study.

The work in Chapter Six of the thesis has appeared in publication as follows:

Wilkie, B., Jordan, A., Foulkes, J., Woods, C., Davids, K., & Rudd, J. (2023) Examining the Validity, Reliability and Feasibility of capturing children's Physical Literacy through Games-Based Assessment in Physical Education. *Frontiers in Sports and Active Living*, *5*(203), 1-13.

This study reported on the validity and reliability of the emergent game-based assessment tool. I was responsible for initial conception and formulation of research aims and objectives alongside the

research design, data collection, analysis, and writing in conjunction A.J. and J.R. (supervisors). J.F., C.W., and K.D., assisted with purposeful sampling of the 'expert' panel and acted as critical friends during writing and revision of this study.

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Abstract

Thesis abstract

In recent years the concept of physical literacy has (re)emerged, gaining global popularity as an increasingly influential concept. Commonly expressed themes within academic literature highlight that physical literacy involves the equal consideration of movement competence, affective behaviours, knowledge, understanding, and the valuing of physical interactions with the environment. Developing a framework for the assessment of a multifaceted phenomenon such as physical literacy is acknowledged as being difficult. The often-taken route of decontextualised assessment, or disconnected evaluation fails to fully account for the role that environment and context have within the revelation of physical literacy. There has been encouragement to develop creative, nonconventional approaches to the evaluation of physical literacy that better reflect the holistic nature of the construct. In an attempt to address such shortcomings, this thesis outlines how the assessment of physical literacy, conceptualised in an ecological dynamics theoretical rationale might be undertaken. The emergent games-based assessment developed through this thesis is the first tool of its type which frames physical literacy assessment and evaluation through an ecological dynamics rationale, providing insight to children's knowledge *of* the environment, revealed through their perception of affordances, their intentionality, and how they functionally move to effectively wayfind within performance environments. The studies presented provide a foundation for new perspectives on physical literacy assessment, providing a mechanism to successfully differentiate higher- and lower-physical literacy behaviour, while remaining more faithful to the philosophically complex and holistic nature of the concept.

Study One

Research has previously identified the necessity to explore novel methods of evaluating physical literacy. This study, using an ecological dynamics framework, aimed to highlight that the current reductionist approach to the measurement of physical literacy is not appropriate to capture the embodied dimension of the concept. Face validity and the development of categorical items that accurately represent the revelation of physical literacy through observed behaviour within small-sided games were established. Through exploratory analysis it was feasible to gain insight to children's perception of affordances in the performance-task, illustrating embedded examples of knowledge *of* the environment and attunement to key performance variables. In terms of establishing the feasibility of an observational instrument designed to capture embedded, embodied behaviours representative of the physical literacy construct, the unique approach introduced in this study provides a glimpse of the richer possible interpretations of physical literacy 'in action'. Progressing understanding beyond

what is offered through the isolated, reductionist examination of movement competence, confidence, and knowledge and understanding.

Study Two

Ideas and concepts taken from ecological dynamics might provide an alternative perspective on physical literacy assessment. The aim of this study was to pilot an assessment of physical literacy conceptualised using an ecological dynamics theoretical rationale. The assessment was designed with a number of unique features: its scale of analysis is captured at an individual-environment interaction level during game play and it captures key affordances that a child is attuning to and how they are functionally playing the game. Data collection involved observing 10 mixed gender, mixed ability, primary school children playing invasion games in physical education classes. Digital, video-based tagging (Dartfish Pro) of children's behaviours using the emergent game-based assessment tool was completed. Pilot data provided insights on the potential rich interpretations possible, such as readily differentiating between low and high physical literacy learners' behaviours when playing small-sided games. Greater knowledge *of* the performance environment was observed in children with higher-physical literacy, noted through a greater capacity to favourably regulate their relative positioning between competing and cooperating players, adopting more varied offensive functionality, and exhibiting greater attunement to key affordances. Better understanding children's knowledge *of* the environment during games play, provides practitioners novel insight into how physical literacy reveals itself through embedded actions. This appreciation can help inform practice more holistically, contributing to richer learning environments and task design.

Study Three

Observational tools can help refine practice design and guide the creation of effective learning environments. The intention of this study was to design and validate an observational instrument for assessing physical literacy that remains more faithful to the philosophically complex and holistic nature of the concept. Framed by ideas taken from ecological dynamics, the emergent games-based assessment tool enables capture of children's interactions with their environment, providing insight on the manifestation of physical literacy within physical education games. Following expert qualitative and quantitative evaluation, Aiken's *V* coefficient was used to determine content validity. Results achieved demanding levels of validity ($V \geq 0.78$) for all retained measurement items. Cohen's κ values for inter- and intra-observer reliability ranged from 0.331 to 1.00 and 0.552 to 1.00, generally reporting 'substantial' agreement during inter-observer analysis and 'substantial' to 'almost perfect' agreement during intra-observer analysis. The final model of the emergent games-based assessment

tool, with 9 ecological conceptualisations of behaviour, 15 measurement variables, and 44 categorical observational items was found to be valid and reliable, providing both educators and researchers with a useful mechanism to assess physical literacy during gameplay.

Study Four

Physical literacy progress is increasingly being recognised and understood to be a dynamic, occasionally transient, nonlinear phenomenon, making traditional linear measurement assumptions unsuitable. Consequently, there has been encouragement to develop creative, nonconventional approaches to the evaluation of physical literacy that better reflect the holistic nature of the construct. Using ideas and concepts taken from ecological dynamics, this study focuses on how physical literacy reveals itself through individual-environment interactions in performance settings. Data collection involved observing 54 primary school children playing small-sided, modified, team invasion games. Digital, video-based tagging (Dartfish Pro) of children's behaviours using the emergent game-based assessment tool was completed. Results indicated higher-physical literacy children performed more penetrating passes, distributing the ball more quickly when in possession. Out of possession, higher-physical literacy children exhibited multiple off-ball movements more often and were able to find space more frequently during attacking phases of the game. In defence, higher-physical literacy children moved more often, more effectively tracked play, marked opponents without the ball more frequently, attempted more blocks and interceptions, and successfully intercepted distribution more often. Lower-physical literacy performers were observed to be stationary more often when defending and were not able to as effectively regulate their movement in support of attacking play, frequently moving into contested space when out of possession. This study has provided evidence that a games-based assessment informed by ecological dynamics successfully differentiates higher- and lower-physical literacy children's behaviour, providing fresh insight to understanding children's physical literacy.

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Chapter One – Introduction

1.1 Introducing the field of interest

What is physical literacy, really? Perhaps it is nothing more than a powerful metaphor that has effectively captured the imagination of practitioners and policy makers. Perceived as a collection of fundamental movement qualities allowing engagement in activity and sport. Or, alternatively is it seen as a philosophical negation of mind-body dualism that offers hope to those invested in the provision of high-quality physical education. Keegan, Barnett and Dudley (2017) highlight the significant continuing examination with how the construct is articulated and defined, alongside the possibilities that exist for evaluation and assessment. There remains the threat however, that continuing conceptual incoherence might compromise the scope and efficacy of successful adoption and implementation of physical literacy into practice (Bailey, 2020b).

The multiple qualities associated with physical literacy are what makes it both challenging and unique when it comes to the adoption and implementation of practice informed and aligned to the concept. Physical literacy involves the parallel consideration of movement competence, affective behaviours, knowledge, understanding, and the valuing of physical interactions with the world (Whitehead 2013; Edwards et al., 2017; Wilkie et al., 2022). There remains however considerable debate concerning the definition, implementation and assessment of physical literacy (Pot, Whitehead & Durden-Myers, 2018; Robinson, Randall & Barrett, 2018; Tremblay et al., 2018; Whitehead, 2019). This thesis aims to provide an overview of the philosophical foundations of physical literacy, discussing how this philosophy can be effectively accommodated into assessment and evaluation in physical education, operationalised using an approach informed by ecological dynamics. To do this, the thesis will explore the tensions that have emerged with the Whiteheadian (2001) construction of the concept, the variable successes of assessing and evaluating physical literacy, the central role that ecological dynamics has in capturing embedded, authentic physical experiences, and how evaluating and monitoring the physical literacy journey might be a realistic possibility in physical education practice.

Although recognised as having meaningful contribution throughout the life course and being positioned as a basis for lifelong activity and engagement, there has been particular focus on child and adolescent populations within physical literacy research and practice. Formative experiences of physical education have a significant influence on lifelong activity (McNamee, 2005; Green et al., 2018) and have been proposed as being critical to the facilitation of the physical literacy journey (Almond, 2013a; Roetert & MacDonald, 2015; Durden-Myers & Whitehead, 2018). As a consequence, understanding and supporting physical literacy development during formative school years has the capacity to positively influence behaviours in later life and contribute to the developing body of

knowledge in existence (Cairney et al., 2018). Recent UK strategy documents relating to children's physical activity have begun to adopt the idea and phraseology of physical literacy in policy: For example, *Sporting Future: A new strategy for an Active Nation* (Sport England, 2016)*;* the *National Plan for Sport and Recreation Committee report* (House of Lords, 2021); and the Youth Sport Trust's *Primary School Physical Literacy Framework* (Youth Sport Trust, 2022). The adoption and promotion of the term by these national bodies seemingly indicates a growing focus on holistic and inclusive approaches to understanding and promoting physical activity, health and well-being (Roetert, Ellenbecker & Kriellaars, 2018).

The physical literacy concept has undergone revisions, edits, streamlining, and distortion from the original conceptualisation (Harvey & Pill, 2018), resulting in difficulties when trying to compare, evaluate, and develop best practice (Keegan et al., 2019). A similar debate also permeates the discourse regarding assessment and evaluation of physical literacy. Developing a framework for the assessment of a multifaceted construct such as physical literacy is acknowledged as being difficult (Dudley, 2015), and there remains tension between Whitehead's (2001, 2010, 2019) characterisations of physical literacy and the manner in which it is typically assessed. Traditional assessments of physical literacy have been criticised, identifying that they are predisposed towards remaining reductionist in nature, product focussed, and overly privilege movement competency components of the wider construct (Ng & Button, 2018; O'Sullivan et al., 2020). Additionally, Barnett et al. (2019) highlight that it has been difficult to establish consensus amongst policy makers, researchers and practitioners on approaches towards evaluation. This is understandable considering in effect they are trying to navigate the complexity of measuring something that is, in essence a *process* (Rudd, 2021) and a *state* (Cairney et al., 2019a).

Edwards and colleagues (2017, p660) highlight the necessity to "assess beyond the constructs of physical proficiencies" calling for the adoption of a more holistic perspective towards physical literacy evaluation. Ecological dynamics may provide a suitable theoretical framework to explore how physical literacy can be evaluated in practice. Developing an assessment tool that is capable of providing insight into the physical literacy of school-aged children is a critical area for future physical literacy research and practice. Providing a gateway to understanding of this more holistic perspective of how children move, learn and interact with their environment, and providing valuable insight when it comes to the assessment *of* and *for* learning. Consequently, this thesis will focus on the theoretical conceptualisation, design, pilot, review, and outcomes of a novel approach to assessing physical literacy utilising a games-based assessment tool. Such a resource can inform and facilitate the physical literacy journey by providing an authentic, alternate assessment method that could be used in physical education assessments.

1.2 Introduction to the thesis

This thesis explores children's emergent behaviours using principles of ecological dynamics to provide insight to the physical literacy of learners based upon observed child-environment interactions during physical education lessons. The thesis does not however fully reflect the preliminary ideas and original project design. Consequently, this section outlines the final submitted work, in conjunction with detailing the challenges and forced changes that led to a reimagining of the data collection, data analysis and the conceptual field of investigation.

Developing an assessment that provides detailed insight to a child's physical literacy while remaining feasible for teachers and practitioners to administer would enable progress in both research and practice relating to physical literacy. Such a tool would provide ipsative and summative evaluation opportunities, helping to evaluate practice and establish the effectiveness of physical literacy focussed interventions. Consequently, the primary aim of this thesis is to demonstrate the development of a physical literacy assessment tool for school-aged children utilising a framework informed by ecological dynamics that places value on the individual-environment interactions taking place. This thesis is comprised of four studies, outlined in the thesis study map (p.7). Following this introduction, Chapter Two (Literature Review), reviews and critiques the current and relevant research relating to physical literacy, ecological dynamics and current assessment practice. This review highlights opportunities to progress knowledge in the field of physical literacy, providing an overall rationale for the thesis, and the aims and objectives for the ensuing study chapters. Chapter Three (Shared methods and measures) outlines a number of shared methodologies utilised within discrete study chapters of the work. Chapter Four (Measuring Physical Literacy: A Fresh Approach) presents study one of the thesis, exploring physical literacy measurement through an ecological dynamics framework. Chapter Five (Assessing Physical Literacy, Conceptualised in an Ecological Dynamics Theoretical Rationale) presents study two of the thesis, offering a design narrative explaining how ideas and concepts taken from ecological dynamics can provide an alternative perspective on physical literacy assessment. Chapter Six (Examining the Validity, Reliability and Feasibility of Capturing Children's Physical Literacy through Games-Based Assessment in Physical Education) describes study three of the thesis, building upon the previously developed games-based assessment tool, this study establishes the validity and reliability of the psychometric properties of the tool, including face and content, combined with inter- and intra-observer reliability. Chapter Seven (An Ecological Insight into the Revelation of Physical Literacy in Children during Small-Sided Games) details study four of the thesis, reporting the findings from a more extensive deployment of the observational assessment, evaluating school-aged children in representative settings employing the emergent games-based assessment tool. To conclude, Chapter Eight (Synopsis) provides a synthesis of the results from the

previous chapters, drawing together their findings and implications for the research field, before exploring tool applications, personal growth, and providing recommendations for future research and practice.

1.3 Journey of the project, from conceptualisation to conclusion

1.3i Project design & original conception

Initial ideas proposed and developed were subsequently abandoned as a consequence of changes in supervision or mitigating circumstances. Within the first 18 months of the thesis study (January, 2019 – June, 2020), I had six supervisors and a significant period with no supervision whatsoever. Original ideas presented during the transfer meeting (January, 2019) were orientated towards exploring teachers' capacity to facilitate a fulfilling physical literacy journey, exploring how national curriculum physical education delivery reflects pedagogical approaches conducive to progressing the physical literacy journey. While this idea was not pursued in terms of becoming the focus of the thesis it has been realised through research and publication (Wilkie et al. 2023a, Is the development of physical literacy ubiquitous in high-quality physical education?). Revisions to the focus of the thesis came about as a consequence of changes in supervisory personnel and the opportunities their expertise and networks presented (internal supervisors leaving May, 2019 and July, 2019, and external supervisors being appointed November, 2019). Consequently, a project examining the effectiveness of a games-based intervention on physical literacy in key stage 2 children was developed in consultation with the supervisory team. Initial project design at this stage intended to explore the impact of manipulated task constraints upon the engagement characteristics of higher- and lower-physical literacy children as well as report on the physical literacy of children before and after the intervention.

1.3ii Pandemic induced changes

Baseline assessment (detailed in Chapter Three) of 114 children from six primary schools located in the North-West of England was completed (January-February, 2020). Following baseline measures, delivery of weekly physical education classes to the intervention group was undertaken (February-March, 2020). The COVID-19 pandemic and government intervention resulted in schools initially discontinuing external partners from working with pupils before a nationwide lockdown was later introduced. This forced a premature conclusion to the delivery of the intervention and data collection. The absence of a completed intervention and with no capacity to undertake post-intervention data collection the project in its original guise was impossible to progress. These circumstances and the wider impact of the pandemic resulted in pragmatic abandonment of the initial project, resulting in necessary major revisions to the original project focus. Through extensive discussion with the

supervisory team (two additional, internal supervisors appointed May/June, 2020) and wider colleagues a significant reimagining of the data collection, data analysis and the conceptual field of investigation was undertaken (May-July, 2020). These conversations led to the proposal of investigating whether, through an ecological dynamics lens a framework for understanding how physical literacy in children manifests itself during games play was possible. Ideas were developed and shared with both internal and external supervisors to establish their endorsement while remaining mindful of wider extenuating circumstances. The resultant, revised thesis is quite a significant departure from the original conceptualisation, but nonetheless satisfied doctoral quality criteria in terms of an original contribution to the field of interest, being able to demonstrate evidence of independent critical ability, and having potential for content suitable for publication (Wilkie et al., 2021, 2022, 2023b). On a personal level I believe the final, revised thesis and its orientation is a much richer, deeper, thought-provoking piece of work as a consequence of the changes made, with layers of sophistication not necessarily possible in the earlier iterations of project development and proposal.

1.3iii Chronology of data collection

As a consequence of the COVID-19 pandemic, a pragmatically organic research approach was adopted, maximising the potential for something to be salvaged from the original data collection (January, 2020-March, 2020) and the investment of time, resource, and personnel. Study One (June, 2020-February, 2021) explored the feasibility of measuring physical literacy as it reveals itself more holistically in applied settings, providing a basis upon which to build the wider investigation. Study Two (March, 2021-February, 2022) reports on how ideas and concepts taken from ecological dynamics provide an alternative perspective on physical literacy assessment. Study Three (April, 2022-March, 2023) reports the outcomes of the multistage process followed during the design and validation of the observational instrument used in the final study. Study Four (January, 2023-July, 2023) reports on the employment of the observational tool to investigate how features of the physical literacy construct reveal themselves through children's behaviours in a game setting.

1.3iv Participants and settings

Study One (Chapter Four): 10 primary school children (Age: 8.70 ±0.46 yrs.) were observed as participants of the feasibility study. Children in this study were part of the original project's 'control' group and were placed into teams of mixed movement ability for the purposes of game play evaluation, based on their functional movement skill performance captured through the Dragon challenge.

Study Two (Chapter Five): 10 primary school children (Age: 10.48 ±0.25 yrs.) were observed as part of piloting an assessment of physical literacy conceptualised in an ecological dynamics theoretical rationale. Children in this study were part of the original project's 'control' group and were placed into teams of mixed physical literacy for the purposes of game play evaluation. The physical literacy of children was calculated through a composite score of Working Memory (McClelland et al., 2014), Game Play Perception (Miller et al., 2019), and an assessment of fundamental movement skills using the Dragon Challenge (Stratton et al., 2015).

Study Three (Chapter Six): 15 expert practitioners (7 teachers and 8 academics) with an average of 12.86 years' experience in their respective fields were recruited to provide expert qualitative and quantitative review with the aim of establishing content validity of the observational tool. All experts held post graduate qualifications in pedagogy or Sports Science, leadership or senior academic positions within their educational institutions, and were able to demonstrate knowledge transfer within their field of expertise. All expert practitioners involved in this stage of the research project were unfamiliar with the ongoing development of the observational tool. Additionally, two active practitioners and researchers in the field of pedagogy and physical education, with over 10 years' experience within their field undertook observer training before coding a 90-clip movie-test with the aim of establishing instrument objectivity.

Study Four (Chapter Seven): 54 primary school children (Age: 10 ±0.9yrs) were observed as part of this study, investigating how features of the physical literacy construct reveal themselves through children's emergent behaviours. Children in this study were part of the original project's 'intervention' group and were placed into teams of mixed physical literacy for the purposes of game play evaluation. The physical literacy of children was calculated through a composite score of Working Memory (McClelland et al., 2014), Game Play Perception (Miller et al., 2019), and an assessment of fundamental movement skills using the Dragon Challenge (Stratton et al., 2015).

1.3 Thesis study map

For the purposes of reader comprehension each of the studies in this thesis will be prefaced by a thesis study map, outlining objectives and key findings. Presenting a map in this manner demonstrates where and how each study fits within with the overall thesis.

Study	Objectives
Study One (Chapter Four) Measuring Physical Literacy: A Fresh Approach	Objectives: • Establish the feasibility of capturing children's behaviour and environmental interactions during games-play that would reveal their physical literacy. • Establish face validity of a novel approach to assessment, framed by an ecological dynamics conceptualization to capture and measure physical literacy. • Highlight that the current reductionist approach to the measurement of physical literacy is not appropriate, especially when attempting to capture the embodied dimension of physical literacy.
Study Two (Chapter Five) Assessing Physical Literacy, Conceptualised in an Ecological Dynamics Theoretical Rationale	Objectives: • Pilot an assessment of physical literacy conceptualised in an ecological dynamics theoretical rationale. • Demonstrate the underpinning ecological dynamics principles and conceptualisation applied to the measurement of physical literacy.
Study Three (Chapter Six) Examining the Validity, Reliability and Feasibility of Capturing Children's Physical Literacy through Games-Based Assessment in Physical Education	Objectives: • Establish the validity and reliability of the psychometric properties of the emergent games-based assessment tool following a systematic process including face and content validity, combined with inter- and intra-observer reliability.
Study Four (Chapter Seven) An Ecological Insight into the Revelation of Physical Literacy in Children during Small-Sided Games	Objectives: • Investigate how features of the physical literacy construct reveal themselves through children's behaviours using the emergent games-based assessment tool. • Establish key differentiating behaviours of higher- and lower-physical literacy children when playing small-sided games. • Promote the role of ecological dynamics when employed as a theoretical framework to investigate physical literacy.

Chapter Two – Literature Review

The purpose of this chapter is to review the literature related to physical literacy, physical education, assessment and ecological dynamics. This review will seek to critically: 1) introduce the concept of physical literacy, exploring the history, definition and philosophical roots of the concept; 2) explore the physical literacy journey, with a particular focus on youth, physical education, and assessment; 3) elaborate on the novel insight afforded by ecological dynamics with particular reference to individual-environment interactions; and 4) provide a summary and rationale for the investigation, outlining the aims and objectives of the thesis, with an exploration of the methodological approaches employed.

2.1 Introducing physical literacy

2.1i Emergence and adoption

In recent years the concept of physical literacy has (re)emerged, gaining global popularity and developing within the consciousness of practitioners and researchers, particularly in countries such as England, Wales, Canada and Australia (Corbin, 2016; Durden-Myers & Whitehead, 2018; Edwards et al., 2018; Green et al., 2018; Ke et al., 2022). As an increasingly influential concept, physical literacy has stimulated significant research scrutiny, extensive employment in education settings, and is being woven into policy development and the promotion of physical activity (Edwards et al., 2017). Jurbala (2015, p367) reported that interest in physical literacy continues to grow with "breath-taking rapidity", although critically, this celebrity has somewhat preceded empirical evidence for the adoption of the concept, resulting in calls for caution regarding the fantasmical claims made by physical literacy (Quennerstedt, McCuaig & Mårdh, 2021). As such, the field of interest is now seen to be entering a critical period for the intellectualisation of the concept (Cairney et al., 2019a).

Countries such as England have eulogised about physical literacy, becoming early adopters of the concept (Roetert & Jefferies, 2014), with the Aspen Institute noting England as one of a number of countries that have well-established physical literacy initiatives (Aspen Institute, 2015). The importance of physical literacy in youth populations was initially acknowledged within national government policy and strategy in Sport England's (2016) *Sporting Future: A new strategy for an Active Nation*, where they identified as a key performance indicator an "increase in the percentage of children achieving physical literacy standards" (Sport England, 2016, p.78). More recently, the House of Lords *National Plan for Sport and Recreation Committee report* articulated the central role of physical literacy in their proposals, identifying that "improving physical literacy must be a key principle at the heart of a national plan" (House of Lords, 2021, p.102) and that "the physical literacy of children should be valued as highly as their literacy and numeracy" (House of Lords, 2021, p.55). From an education perspective, the Youth Sport Trust have recently developed the *Primary School Physical*

Literacy Framework (Youth Sport Trust, 2022). This aims to support practitioners working in primary education to effectively structure Physical Education and school sport provision to maximise opportunities to develop physical literacy. The addition of physical literacy in governmental sport, recreation and education policy has been central to popularising the physical literacy concept and guiding the initiatives aimed at operationalising it. The swiftness and degree of adoption evident in national policy makes the physical literacy concept of particular interest due to its potential role in transforming society from a movement-supressed culture to a movement rich one (Keegan et al., 2013).

Often, physical literacy has been discussed in a metaphorical sense, as progressing literacy in a physical setting, synonymous to reading and writing (Edwards et al., 2018). Orientating physical literacy to the well-established literacy movement has resonated well with practitioners and policy makers (Dudley et al., 2017). By drawing comparisons to literacy, the physical literacy construct draws upon the power of a metaphor that is very much entrenched in social policy, recognised as a human right, and central to the fulfilment of personal endowment and flourishing. Literacy is typically related to the ability to read and write, but includes elements of knowledge, understanding, thinking, and application (Faigenbaum & Rebullido, 2018). More broadly, literacy refers to having knowledge or competence in an area (Lounsbery & McKenzie, 2015). Similarly, literacy in the physical sense is not only about an individual's knowledge of physical activity or their general participation, but also their capacity to move efficiently, with confidence, competence and enthusiasm across a range of environments (Faigenbaum & Rebullido, 2018).

2.1ii Physical, affective and cognitive domains of physical literacy

Despite there being multiple definitions of physical literacy, common themes within the literature identify the integration and simultaneous consideration of physical, cognitive, and psychosocial processes that contribute to the holistic development of individuals. Young people who are physically literate are able to demonstrate the physical skills needed to participate; the confidence to approach diverse physical challenges; a motivation towards physical pursuits; the understanding to effectively moderate their behaviours mindfully in their setting; and the valuing of interactions with the physical world (Whitehead, 2001). Physical literacy is considered an inclusive concept, comprised of these interconnected components that are capable of evolution over time to support physical activity throughout the lifecycle (Whitehead, 2010, 2013; Edwards et al., 2017). Physically literate individuals will foster a passion for physical learning, seeking out challenges, valuing physical effort, and persisting with activities to meet objectives (Dudley, 2018). Greater physical literacy is theorised to improve movement proficiency (Faigenbaum & Rebullido, 2018), increase levels of physical activity (Edwards

et al., 2017), boost activities of daily life (Green et al., 2018) and reduce injury and sedentary related illness susceptibility, forming a virtuous cycle supporting improved quality of life (Jurbala, 2015). Conversely, being physically illiterate can result in an inability to match active peers both socially and physically. The associated lack of confidence and competence in physical endeavour results in a tendency to avoid nonessential activity, which in turn affects motivation, desire and capacity to be active across the lifecycle (Zwolski, Quatman-Yates & Paterno, 2017).

Physical literacy is constructed from component elements that in themselves are not new (Tremblay et al., 2018), however as an over-arching construct it has stimulated significant discussion through the contributions of Whitehead (2001, 2010, 2013, 2019). Since the reimagining of the construct there has been mounting interest in elaborating on what the construct means and how it can be employed in educational settings (Lundvall, 2015). Current interest originates from the work of Whitehead (2001, 2010), who presented the concept as a mechanism to address the low levels of physical activity reported worldwide and critically within the UK, as a response to the perceived focus (to the detriment of the holistic wellbeing of less-able pupils) on performance orientated outcomes and competitive sport within physical education. Whitehead conceived physical literacy to incorporate the equal or parallel consideration of skills, knowledge and affective qualities that an individual utilises to support their physical activity throughout the lifecourse. Physical literacy, with this emphasis on the holistic development of individuals offers some degree of hope against a background of numerous failed approaches to inspire physical activity both nationally and internationally. Consequently, Cairney and colleagues (2019) suggested the value of Whitehead's contribution lies not necessarily in the creation, but in the re-envisioning of the concept at a crucial period in time. The original, and arguably most prominent, conceptualization of physical literacy was initially put forward by Whitehead (2001, p.131), who stated that:

> *A physically literate individual moves with poise, economy and confidence in a wide variety of physically challenging situations. The individual is perceptive in 'reading' all aspects of the physical environment, anticipating movement needs or possibilities and responding appropriately to these, with intelligence and imagination. Physical literacy requires a holistic engagement that encompasses physical capacities embedded in perception, experience, memory, anticipation and decision-making.*

Since this conceptualisation, there have been further definitions, with Whitehead's most recent definition describing physical literacy as "the motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engaging in physical activity for life" (Whitehead, 2019, p.8). Although Whitehead's original definition of physical literacy was grounded in the philosophical traditions of phenomenology, existentialism and monism, more recent iterations of the construct have demonstrated fluid interpretations and abstract alignment to the original ideas resulting in contextually subtle permutations of the concept. Nevertheless, it remains typical that core

features of the construct remain, although the emphasis on discrete elements shift and evolve based upon deployment in research and practice. Central to the concept is the notion that moving and interacting with the immediate environment is a critical aspect of life – a fundamental and existential challenge that defines human experience (Keegan et al., 2013; Shearer et al., 2021).

2.1iii Physical literacy's uniqueness

The physical literacy concept was constructed from philosophies that make a strong case for the merits of capitalising on human embodiment from an ontological perspective (Whitehead & Durden-Myers & Pot, 2018). In their unique but interrelated ways monism, existentialism and phenomenology outline the critical contribution that the human embodied dimension can make. Purposeful physical endeavour is capable of *affecting* people in a ubiquitous manner: when involved in something perceived as worthwhile the value attached to being physically engaged can help individuals to thrive, develop resilience, self-efficacy and wellbeing (Almond, 2013a). Crucially, physical literacy redefines how physical activity is currently understood, placing value on the holistic development of individuals. Consequently, the capacity for a person to realise their potential is facilitated by the quantity and quality of their movement experiences (Robinson, Randall & Barrett, 2018). By embodying the physical nature of movement and exploiting experiences and knowledge to meaningfully interact with environments, individuals would be defined as being physically literate (Whitehead & Murdoch, 2006; Sum et al., 2016). As a consequence, Liu and Chen (2021) identify physical literacy as more than simply a composite, wrapping literacy within the cocoon of the physical, encapsulating an embodied understanding of how to be physical by interacting with diverse, testing environmental challenges and opportunities.

The past twenty years has seen an invigoration of research in the fields of physical education and physical activity, generating improved understanding of both their importance, and how to facilitate promotion of activity and engagement among children (Allan, Turnnidge & Côté, 2017). Physical literacy has subsequently emerged as a valid goal to work towards within, and beyond education (Durden-Myers, Green & Whitehead, 2018). Interest in the construct suggests there is belief that the totality of the concept has merit surpassing the discrete elements taken individually and is consequently novel, rather than a rebranding of existing ideas (Dudley, 2018). Physical literacy characterises the desire to both engage in physical activity, in addition to experiencing meaningful, fulfilling experiences as a result of participation (Durden-Myers, Whitehead & Pot, 2018; Shearer et al., 2018). It is suggested that physical literacy impacts health related outcomes of individuals, improving motor skills, cardiovascular and muscular fitness, and reduces obesity status (Gately, 2010; Cairney et al., 2019b). Beyond the physical benefits, physical literacy has been positively associated

with a wide range of behavioural, psychological, and social variables (Edwards et al., 2017; Durden-Myers, Whitehead & Pot, 2018), resulting in Collins and MacNamara (2017) suggesting Physical Literacy might be the 'magic bullet' to many of the problems currently faced by practitioners in relation to practice.

On a personal level purposeful physical endeavour can affect individuals in a very pervasive way as physical pursuits come to represent activities that have significant impact and value to the individual. Participation, when engaged with something considered valuable has the capacity to enhance wellbeing, enable fulfilment and allow the flourishing of the self (Almond, 2013a; Durden-Myers, Meloche & Dhillon, 2020). As a result, individuals come to appreciate physical activity as a key priority in their lives and accordingly adopt measures to embed movement opportunities into their life style. From a professional perspective, several authors have acknowledged the critical role that teachers fulfil in nurturing physical literacy in children and adolescents (Almond, 2013b; Stoddart and Humbert, 2017; Whitehead, 2010). By virtue of the UK school system, teachers represent the sole compulsory custodians of physical activity and subsequently remain central to engineering a fulfilling physical literacy journey (Wilkie et al., 2023a). Practitioner understanding of the physical literacy construct permits access to an increasingly evidence-based, inspirational model of practice, providing teachers with a series of guiding principles that can shape learning episode design, facilitating the promotion of purposeful physical pursuits amongst youth populations. Appropriate content and effective pedagogies within context are vital to the development of a favourable disposition towards movement and when done in the correct manner, learners come to value and enjoy being physically engaged (Robinson, Randall & Barrett, 2018). Furthermore, advocates for physical literacy within the fields of research and practice agree that the guiding principles put forward to support practice represent an inclusive approach to physical education and encourages more diverse forms of engagement (Cairney et al., 2019a; Keegan et al., 2019; Shearer et al., 2021). The outcomes of which are to develop intrinsically motivated children, with confidence in their physical abilities, who are more likely to regard movement experiences as worthwhile and as a consequence seek activity opportunities outside of formal settings (Dudley, 2015).

Robinson, Randall, and Barrett (2018) examined how the seminal introduction and early adoption of physical literacy, in addition to the ensuing uptake, has not been without dispute. Reflective of a research field still in its infancy there have been instances of resistance, confusion, and uncertainty, leaving numerous important research questions unanswered (Lounsbery & McKenzie, 2015; Longmuir & Tremblay, 2016). Currently there appears to be many more outstanding questions than established answers. For practitioners and researchers appreciating what physical literacy is, how it is comprised, and critically how to evaluate the concept is vital to the further development and

advocacy of concept. Recent physical literacy scholarship has been principally focussed upon the examination of various understandings of the concept, combined with refinements to the interpretation and administration of the construct (e.g., Tremblay & Lloyd, 2010; Jurbala, 2015; Edwards et al., 2017; Gunnell et al., 2018; Young, O'Connor & Alfrey, 2021). This work and the progression of the ideas within the literature reinforces that physical literacy has robust philosophical foundations, but is perhaps lacking obvious examples of translation into practice (Whitehead, 2010; Longmuir & Tremblay, 2016; Pot, Whitehead & Durden-Myers, 2018). Allan, Turnnidge, and Côté (2017) acknowledged that two different approaches to physical literacy have emerged throughout the literature. One approach focusses on individuals holistically, encompassing a more cohesive developmental approach and outcomes. The second, aligns more closely to performance driven metrics favouring the psychomotor domain and physical competencies over fulfilment of potential across the whole spectrum of physical literacy qualities. This division in approach and understanding has created complications when trying to make evidence-based decisions regarding practice (Edwards et al., 2017, 2018).

This brief overview has highlighted the growing scholarly interest in physical literacy, while establishing there remains gaps in knowledge and understanding of the concept and its employment. If good science and research more generally is embodied by debate, examination, critical conversation, and an openness to new ideas, then physical literacy can be seen to be thriving. Appropriate evaluation and assessment of physical literacy during childhood could raise standards, expectations, and the overall profile of physical literacy within physical education practice (Shearer et al., 2021). To progress the area of interest, fresh research impetuous is required to better explain functional, insightful methods of evaluating and monitoring physical literacy, so a more detailed understanding of the individual physical literacy journey is obtainable. The aims of this thesis are to demonstrate how a theoretical framework, informed by principles of ecological dynamics can be used to develop an assessment strategy that reveals physical literacy through embedded environmental interactions and games play.

2.2 History of the term

Numerous scholars have proposed that the use of the term physical literacy is a comparatively new occurrence (Corbin, 2016; Longmuir & Tremblay, 2016), however this is not entirely true. The earliest documented use of the term physical literacy was in reference to the quality of the movements of the indigenous people of America. Movement, for these people, was not formally taught, but rather embedded in the very fabric of their hunter-gatherer way of life, helping them navigate and 'wayfind' through their world (Maguire, 1884; Cairney et al., 2019b; Woods et al., 2020b). The history of the

construct has seen it rise to prominence on the back of waves of interest throughout much of the twentieth century. Cairney et al. (2019a), associated these periodic rises in interest with activity and lifestyle threats brought about by modernisation and mechanisation, before dissipating once again from public consciousness. Rogers (1930), as director of the National Physical Education Service in America, identified schools should be responsible for physical literacy, in addition to mental literacy. Williams (1942) proposed education *through* the physical as an ongoing development of the education *of* the physical, to assist in the development of 'wholeness' of children (Whitehead, 2001; Mandigo et al., 2009; Allan, Turnnidge & Côté, 2017). McCloy (1957) was the first academic to specifically associate physical literacy with physical education, emphasising that pupils could acquire physical and motor literacy through the technical improvement of motor skills in physical education. The characterisation of the physically literate person was first articulated by Morrison (1974), who identified the ability to undertake efficient, competent, creative movements with enthusiasm as representative of becoming physically literate. Domestically, the Sports Council UK (1991) introduced the notion of 'literacy in movement' to raise understanding and appreciation for sport literacy. Finally, Whitehead (1993) initiated what was to become a seminal moment in the history of the concept by proposing a contemporary definition of physical literacy, outlining the expected qualities a physically literate individual would be able to demonstrate.

In contrast to the literacy and mathematical literacy movements that successfully established robust footholds and strong impetus through the twentieth century, physical literacy failed to achieve any meaningful, lasting traction until it was reenvisaged at the start of the twenty-first century. Examination of the literature in the field indicates that it was Whitehead's (2001) *The concept of physical literacy* that inspired the popular usage of the phrase in academic and practice settings. Whitehead (2010) argued against the typically articulated, traditional motivations for the deployment of physical literacy as a method to combat the problems associated with modernisation. Instead emphasising the embodied nature of physical activity and the contributions it can make to being human. It is reasonable to suppose that it was this redevelopment of physical literacy at the start of the century, with its greater emphasis on confidence and motivation that stimulated widespread use (Bailey, Glibo & Koenen, 2019) and is considered the 'birth' of the modern concept (Cairney et al., 2019a).

2.3 Defining physical literacy 'unpacking the terminology'

2.3i Concept evolution

It is inevitable that concepts such as physical literacy become reinterpreted and refashioned as they increase their popularity or get redeployed to satisfy increasingly varied purposes and contexts. This inescapable concept evolution has not been avoided by physical literacy with consequences for research, theory development and applied practice. The concept of physical literacy has been interpreted differently within and between countries and organisations that have embraced the concept (Edwards et al., 2017), resulting in fears about the concept becoming lost, confused, or poorly implemented relative to its core philosophies (Jurbala, 2015; Shearer et al., 2018). Kaleidoscopic interpretations and applications have led to an "obscurification of foundational ideas" (Young, O'Conner & Alfrey, 2019, p.2) and complicated what can already appear to be a somewhat esoteric concept. Almond and Whitehead (2012) emphasised that the Whiteheadian definition of physical literacy is both simple and complex. The simplicity of the concept has been considered a major strength as it clearly articulates a vision that can be achieved. Although, the concept also needs translating into meaningful components that would allow teachers to shape their practice and execute key principles of the construct, which is considered a complex and demanding process (Almond, 2013b). Bailey (2020b) has likened the complexity of physical literacy to that of literacy, with which it shares numerous overarching objectives. Literacy appears to be a term that everyone understands, but literacy much like physical literacy has proven to also be multifaceted and dynamic, being interpreted and defined in variety of ways. As a result, despite worldwide attention, physical literacy continues to be an elusive concept in respect to definition, evaluation, and intervention (Keegan et al., 2019).

Advocates for physical literacy have been able to reinterpret and redefine the construct for instrumental purposes dependent upon context. Which has undoubtedly assisted in the increasing popularity of the construct, but has also led to competing definitions and ongoing discussion about how best to employ it in practice (Higgs, 2010; Whitehead, 2010; Jurbala, 2015). While the term has been interpreted numerous different ways and comprises numerous features, frequently expressed themes within motor skill literature highlight the present-day definition of physical literacy involves the parallel consideration of movement competence, affective behaviours, knowledge, understanding, and the valuing of physical interactions with the environment (Whitehead 2013; Edwards et al., 2017; Wilkie et al., 2022). Individuals who have confidence and competence with a variety of movement skills and are able to interact effectively in diverse physical settings are more likely to enjoy themselves and develop a positive disposition towards activity compared to those individuals who lack the required qualities for play and physical activity (Whitehead, 2007; Jurbala,

2015; Edwards et al., 2017; Pot, Whitehead & Durden-Myers, 2018). Virtually all existing definitions are composed of these interconnected elements of movement competency, a positive affective temperament towards activity, motivation, and knowledge and understanding of movement opportunities as an essential (embodied) condition of human existence (Dudley, 2018).

Although similarities are evident across the definitions of physical literacy, absolute agreement remains idealistic. The evolution and understanding of the term has been leveraged against societal constitutive influence, moving away from a theory-rich metaphor to a metaphor of convenience (Jurbala, 2015). The notion that the language employed permits the layperson to connect the perceived value assigned to language literacy to the physical domain was highlighted by Higgs (2010). The work of Whitehead is most frequently cited in reference to the concept of physical literacy and she has been credited as raising the consciousness of the construct amongst both academic and practice communities (Longmuir & Tremblay, 2016; Edwards et al., 2017; Bailey, Glibo & Koenen. 2019). Insightful reviews of the broader physical literacy literature have been undertaken by Keegan, Barnett, and Dudley (2017), Edwards et al. (2017), Hyndman and Pill (2018) and Shearer et al. (2018), serving to emphasise that there are numerous, wide-ranging definitions of physical literacy, some compatible, but others not (Bailey, 2020b). Perhaps Whitehead's most important contribution was to reimagine the concept within a specific philosophical existentialist perspective. By embracing embodiment as a fundamental experiential principle and through the provision of a more extended critique of physical literacy's features and position within physical education practice, Whitehead (2001, 2010) was able to offer an appealing, original and contemporary perspective.

The available definitions and interpretations of physical literacy have gradually grown as the popularity, awareness and implementation of physical literacy has developed across discipline areas, governing bodies, sports organisations, and nations (Shearer et al., 2018). Variations in definition and endorsement have resulted in physical literacy regularly being used dissimilarly across the contexts of physical education, health, and sport. Even superficial engagement with the literature and more prominent publications discussing the concept reveals numerous understandings, definitions and implementation strategies are in evidence. Over time, available definitions have become more abstract, with less defining qualities (Young, O'Conner & Alfrey, 2019), exacerbating the tensions that exist, acting as a possible obstacle to adoption and evolution (Tremblay et al., 2018). These alternate, opposing definitions, while retaining familiar characteristics of the construct, often lack the philosophical foundations advocated within Whitehead's work. However, influential reviews in the field reveal that the majority of published papers (>70%) retained elements of embodiment, monism and a focus on holism, adopting Whiteheadian definitions of physical literacy (Edwards et al., 2017; Young, O'Conner & Alfrey, 2019). Whitehead (2010, p.7) herself demonstrates being cognisant of

varying interpretations and has responded by emphasising "each of these interpretations of physical literacy is of value in that each picks out an element of the concept; however, none encompasses the totality of the meaning of being physically literate". The suggested implication being that without due attention and understanding of the philosophical foundations, how the constituent facets contribute to the wholeness of the imagined concept in these variant definitions does not effectively capture the entirety of what Whitehead envisages. Bailey (2020b) counsels that perhaps having a solitary, recognised definition of physical literacy is an impossibility, or at the very least undesirable based upon the different models, aims and commensurability currently seen within and across the field of physical literacy. As a consequence, a globally embraced definition of the concept remains unrealised.

2.3ii Whiteheadian influences

The original and possibly most influential characterisation of physical literacy was put forward by Whitehead (2001, p131):

> *A physically literate individual moves with poise, economy and confidence in a wide variety of physically challenging situations. The individual is perceptive in 'reading' all aspects of the physical environment, anticipating movement needs or possibilities and responding appropriately to these, with intelligence and imagination. Physical literacy requires a holistic engagement that encompasses physical capacities embedded in perception, experience, memory, anticipation and decision-making.*

Originally the philosophical ideas of phenomenology, existentialism and monism offered a foundation for the concept, although over time physical literacy has changed to become an increasingly variable and pluralistic construct (Buckler & Bredin, 2018; Young, O'Conner & Alfrey, 2021). Whitehead's definition of physical literacy has itself taken numerous forms during the years since tendering her original proposal. However, it has always remained faithful to the key pillars of the concept (Physical competence, confidence, motivation, and knowledge and understanding). Whitehead (2010, p.5) defined the concept as follows: "As appropriate to each individual's endowment, physical literacy can be described as the motivation, confidence, physical competence, knowledge and understanding to maintain physical activity throughout the lifecourse." Later, revising the definition of physical literacy to: "The motivation, confidence, physical competence, knowledge, and understanding to value and take responsibility for maintaining purposeful physical pursuits/activities throughout the lifecourse" (Whitehead, 2013b, p.29). Most recently, refining the definition: "As appropriate to each individual, physical literacy can be described as the motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engaging in physical activity for life" (Whitehead, 2019, p.8). There have been suggestions that revisions to the definition indicate a process of refinement, but as the composition, content and underlying philosophical presumptions remain the same it seems more a case of semantics than true reappraisal. What becomes evident however over

the evolution of the definition is that physical literacy is not a pure 'bodily' capacity, instead it articulates a more holistic commitment encompassing physical qualities embedded in perception of surrounds, experience of movement, memory, anticipation of movement requirements, and insightful decision making.

Within many of the available physical literacy definitions, including Whitehead's (2001, 2010, 2013b, 2019), the core attributes of the construct encompass the affective, psychomotor and cognitive domains. The affective domain includes consideration of motivation, confidence, and enjoyment, the psychomotor domain includes elements of physical competence and the cognitive domain is distinguished by knowledge and understanding of and about physical activity. Physical literacy represents the ability and inclination to capitalise on motile potential in order to significantly contribute to quality of life. All humans display this potential, although its specific expression will be particular to the individual and revealed through their assured and fluent navigation of a range of environments. Motivation is evidenced by a positive disposition towards activity as it is regarded as a worthwhile and rewarding experience. Confidence and competence are associated to the belief individuals have in their ability to successfully use the extent of their movement vocabulary to interact effectively with their environment through general, refined and functional movement solutions. Secure and assured interaction across multiple environments acknowledges the capacity to adapt movements effectively to reflect the task challenge presented by the environment. Knowledge and understanding concerns being aware of one's embodiment, so that individuals are able to accurately reflect, narrate, and evaluate their movement for the purpose of enhancement. Physical literacy captures an individual's capacity to express knowledge *of* their environment through the choices they make and intelligent interactions with their surroundings as well as the capacity to articulate knowledge *about* their environment through identification of the core tenets of activity.

2.3iii Key features of physical literacy

One of the fundamental features of physical literacy is physical competence and the capacity for individuals to respond to physical challenge in a manner that is meaningful to them. Physical competence itself is a multidimensional concept that is considered complex and inconclusively defined (Ennis, 2015), making it a challenge to operationalise in practice and research. Durden-Myers, Green and Whitehead (2018) identify that movement and physical literacy are co-dependent. The manifestation of physical competence is witnessed through effective interactions with the world via appropriate deployment of movement skills with specific reference to both activity context and individual endowment (Pot, Whitehead & Durden-Myers, 2018; Whitehead, 2019). The development of exploratory movement patterns in infants as they determine their physicality in the world, and

young children developing fundamental movement skills enabling more uninhibited movement opportunities, through to an adolescent's more expansive expressions of competency in physical activity settings are all representative of movement competence. Physical competence represents an individual's ability to act. Qualities such as balance, flexibility, efficiency, speed, coordination, and poise are involved in the development and mastery of general, refined and specific movement forms that define the manner in which individuals can interact with their physical environment (Murdoch & Whitehead, 2010). Within the field of motor competence it is typical to group movements into three distinct categories: locomotion (gross, often whole-body movements e.g., running and jumping), object control (handling equipment or an object with coordination e.g., throwing, catching, or striking), and balance and stability (bodily control while stationary and in motion e.g., standing on one foot or walking along a bench) when considering the qualities to focus upon to support the progression of physical literacy (Almond, 2013c; Barnett et al., 2016). To successfully challenge individuals' physical potential and progress their movement competence, a wide variety of activities and settings should be accessed (Mandigo et al., 2009; Almond, 2013a; Whitehead & Almond, 2013; Roetert & MacDonald, 2015). Whitehead (2010, 2013b) notes physical competence exclusively cannot be the singular focus of the concept and does not on its own constitute physical literacy. However, from an existentialist and phenomenological perspective movement offers a conduit to the world, which in this context is central to fully realising human existence (Whitehead, 2013c).

Hyndman and Pill (2018) noted that the currently available empirical evidence over-emphasised the psychomotor domain of physical literacy, proposing additional research attention should concentrate on the affective and cognitive domains to more thoroughly foster physical literacy development. The cognitive domain is considered to comprise of perception, recognition, memory, expertise, judgement and decision making in relation to the context of activity. Additional research also highlights that the cognitive domain encompasses the ability to recount rules and employ tactics and strategy in games play (Edwards et al., 2017; Keegan et al., 2019) and the capacity to apply knowledge effectively, demonstrating innovation, creativity and imagination across multiple physical settings (Whitehead, 2010; Ennis, 2015). Kentel and Dobson (2007) recognised the merits of knowing through movement, knowing about movement and knowing because of movement. In this regard, knowledge through movement captures the embodied elements and knowledge evidenced in the implicit manipulation of (biomechanical) movement principles to achieve goals. Knowing through movement is articulated through perception, action and skilled intentionality helping establish an understanding of how individuals choose to act in specific circumstance. Knowledge about movement is demonstrated through verbal descriptions, expressing idealised ways of doing or being, combined with knowledge and understanding of the necessary factors that enable meaningful engagement in

lifelong participation. Cognitive processes can therefore be understood in terms of the association and connection that transpires between movement, the environment and the individual (Araújo, Davids & Hristovski, 2006). Knowledgeable performers are able to respond appropriately, with intelligence and imagination, to stimuli within the environment. Button et al. (2020) indicates cognition is embedded and embodied, as a consequence of perceiving affordances related to temporal, spatial and amplitude features of the physical environment to achieve success in designated tasks. Gibson (1979, p223) articulates this notion effectively by stating "we must perceive in order to move, but we must also move in order to perceive". Similar to the holistic physical literacy concept, physical literacy knowledge and understanding should likewise be considered holistically. Knowledge and understanding as an attribute, and within the cognitive domain have differing mechanisms. One concerns itself with the knowledge and understanding of health, fitness, and wellbeing constructs. Whereas the other moves beyond the capacity to recite the benefits of physical activity and is directed towards having a good grasp of your own abilities and learning the core principles of movement and performance in a manner that facilitates fluent articulation in response to the environment (Whitehead, 2010b; Cale & Harris, 2018).

Acknowledgement of the affective domain refers to the traits of confidence, esteem and motivation. Each of these are well established as antecedents and determinants of physical activity. Nurturing the triad of self-perception, self-confidence and esteem is deemed crucial to support physical literacy (Whitehead, 2010, 2013a). If any of these traits are compromised, resulting in discouraging or unpleasant episodes of physical activity there will be probable decreases in motivation and a decline in future commitment to participate in physical activity (Wilkie et al., 2023a). Qualities such as personal agency, adaptability, a willingness to attempt novel tasks and activities, resilience, and persistence are all linked to motivation, confidence and self-esteem (Ungar, Ghazinour & Richter, 2013; Dudley et al., 2017; Jefferies et al., 2019). It is widely accepted that individuals who have confidence in their ability to be active and who demonstrate greater intrinsic motivation are also more likely to judge their physical experiences positively, leading to an increased tendency to remain active in later life (Whitehead, 2010; Dudley, 2015). Core elements of the affective domain of physical literacy develop when supportive environments are created to facilitate the physical literacy journey (Almond, 2013b; Jefferies et al., 2019). Whitehead and Almond (2013) highlighted pedagogies designed to foster physical literacy development should remain mindful of creating mastery orientated environments where self-confidence, self-esteem and enthusiasm towards being active is encouraged.

2.3iv A devolved and contested concept

Although the core domains of physical literacy are well established and commonly witnessed within publication and practice, there remains a privileging of the psychomotor domains by both practitioners and academics. Traditionally, research in the field of physical literacy has focussed upon the 'physical' dimension of the concept (Edwards et al., 2017) at the expense of perhaps concentrating upon the wider, more holistic understanding of the philosophy encompassing the lived body and the embodied dimension of being (Rudd et al., 2020). Edwards et al. (2018) in their systematic review examining how physical literacy is measured, identified sixty-one percent of papers investigated the psychomotor domain specifically. In contrast, only twenty-two and fourteen percent of publications examined the affective and cognitive domains respectively. Critically, only three percent of reviewed papers studied all three domains simultaneously. Dudley et al. (2017) and Cairney et al. (2019b) suggested this may in fact be a harbinger for how a narrow conceptualisation of the concept might have major and likely damaging practical implications for policy and practice. Overall, the discrepancies in the definitions, interpretations, and operationalisation of the physical literacy concept have led to an absence of clarity regarding intervention design and evaluation strategy (Edwards et al., 2018).

To better understand the complexities and uncertainties of this highly popular, but extensively contested concept and to provide some clarity within the existing uncertainty that surrounds physical literacy, an appreciation of the nature and extent of the devolution that has occurred over time is required. As a consequence, a robust rationale can be proposed to support the definitions and philosophical underpinnings adopted throughout this thesis. Whitehead's (2001) root definition of physical literacy encompasses all the fundamental attributes of the concept, and critically retains the centrality of the construct's philosophical underpinnings. At this level, physical literacy is considered a holistic concept, viewing individuals through a monist lens where mind and body are indivisible, personal embodiment is based upon their own experiences and perceptions, and each individual has the capacity to engage uniquely with the physical world. The true nature of physical literacy at this level of devolution cannot be wholly understood without first appreciating its philosophical underpinnings. As a result, it is this root definition and conceptualisation that is most readily differentiated from the subsequent definitions and interpretations that have followed (Young, O'Connor & Alfrey, 2019). Additionally, this is the point at which the construct can be most reliably evaluated as a consequence of the definitive characterisation provided by the root definition (Mair, 2008). While maintaining numerous unique features that effectively lend themselves to investigation and evaluation, the root conceptualisation of physical literacy due to its philosophical underpinnings

has gained less traction in the literature in comparison to its more contemporary peers (Jurbala, 2015; Shearer et al., 2018).

Over time the concept has become more fluid, shedding some of the associated complexities linked to the underpinning philosophy of the concept. As a consequence, this more devolved abstraction of physical literacy is recast into something more adaptable and functional, with increased capacity to align to the needs of varied contexts (Robinson et al., 2018). At this level of conceptualisation physical literacy is typically deployed as a cluster of attributes, that may appear disconnected, decontextualised or prioritised differently based upon context. Such an approach at least moderates, at worst lessens the concept's intended holism. Interpreting and understanding physical literacy in this manner supports its instrumental use and allows for more straightforward measurement. The Canadian Assessment of Physical Literacy (Longmuir et al., 2018) for example adopts something of a dualistic approach, evaluating each of the established domains of physical literacy separately. In doing so the holistic philosophical underpinnings of the construct are overlooked, before aggregating the scores to provide appraisal and insight to individual physical literacy. There are numerous opportunities at this level of abstraction to understand and operationalise physical literacy in a manner that maintains an association with phenomenology and the philosophical foundations of the concept, or alternatively it becomes something else. For instance, the attribute of knowledge and understanding could reference the tacit, embodied forms of knowing realised and evidenced through action (Whitehead, 2007), or conversely knowledge and understanding might be evidenced in a more measurable manner, such as being able to describe fitness characteristics and frequency of exercise bouts to maintain health and wellbeing (Longmuir et al., 2018).

The necessity to even recognise the philosophical underpinnings of physical literacy construct becomes undetermined at the furthest point of devolution and abstraction from the root definition. Here the intention of the concept is more generic, definitions more simplistic, and some crucial features are omitted. At this point of abstraction physical literacy is perceived as an 'end state' as opposed to the 'cradle to grave' process proposed by Whitehead (2010). For example, the interpretation of physical literacy in the Long-Term Athlete Development model views physical literacy as a means to promote a relatively narrow range of motor skills to advance excellence and performance (Ellerton, 2019). As interpretations become increasingly abstract and devolved from the root definition, physical literacy becomes uncoupled from its fundamental purpose and meaning, becoming instead an alternate mechanism to promote the development of the physical domain. Increasingly at this level of abstraction physicality is privileged, holism is marginalised and the concept starts to resemble a more dualist, body-as machine orientation (Lloyd, 2016). Ironically, this dualist

paradigm, focussed on excellence and sports performance as the dominant discourse in physical education and organised sport was exactly what Whitehead was trying to stimulate a movement away from when she originally reimagined the concept (Whitehead, 2001, 2010).

The narrative related to abstraction of the definition has implications for how physical literacy is deployed in academic literature and wider scholarly activity. Lower-level abstraction has been identified as an academic approach, suitable to theory development and refinement, and the articulation of what is, and is not physical literacy (Higgs, 2010). At higher levels of abstraction, physical literacy becomes something for all situations, losing identity and its awareness of the fundamental attributes that make it valuable to academic investigation. This higher-level abstraction with the deployment of definitions deviating from the root conceptualisation seem more desirable to practical contexts and applications. The flexibility provided at a mid-level enables physical literacy to shape the development of intervention and evaluation tools, without becoming overly curtailed by complex philosophical ideas or the challenges associated with measuring esoteric concepts such as knowledge in practical settings. When positioned at this mid-level abstraction physical literacy may be able to provide fresh insight and guide practice in physical education contexts (Mandigo et al., 2009; Young, O'Connor & Alfrey, 2019).

This concept analysis and exploration of the devolution of the definitions of physical literacy provides some understanding of the current and emerging developments in the research area, revealing there is no secure agreement of how the concept of physical literacy is presently understood or deployed. Over time, there is the likelihood that physical literacy has gradually evolved into something it originally was not (Young, O'Connor & Alfrey, 2019). The positioning of the philosophical foundations in more abstract articulations of the concept remain unfulfilled, diminished, or in some cases deleted entirely to fashion a theory that is increasingly more instrumental in orientation. However, Cairney et al. (2019a) argue the strongest feature of physical literacy is that it is a synthesis construct, placing emphasis on the multidimensional interaction between the constituent domains. We alternatively witness approaches where practitioners and academics have blindly implemented Whitehead's low-level abstraction of physical literacy while overlooking central features of its framework during applications. Neither of the approaches articulated here are considered to be ideal. Consequently, while remaining mindful of the ongoing conflict generated by concept abstraction, this thesis intends to align to low-level abstraction of physical literacy adopting Whitehead's (2001) original conceptualisation of the construct while remaining diligent in acknowledging the philosophical foundations and core elements of the concept during theory development and application.

2.4 Philosophical roots

2.4i Philosophical considerations related to physical literacy

Whitehead (2001, 2010) has described the inspiration and motivations for the development of physical literacy. Firstly, Whitehead's fascination with existential and phenomenological works provided considerable backing for the centrality of embodiment in human existence. Secondly, the displacement of attention on movement development in young people, where movement was increasingly being marginalised and thought to be secondary to language and numeracy development during childhood. Thirdly, recognition of the developing unease associated with the levels of activity observed across developed nations. Finally, the increasing alarm being articulated within the movement fraternity regarding dissatisfaction with school-based physical education curricula and the general direction of physical education teachings. Academics and practitioners that follow Whitehead's approach maintain that monism, phenomenology and existentialism are central to the concept and that these philosophies mandate for an embodied, well-rounded view of individual being (Bailey, 2020b). These philosophical schools of thought assimilate to expose the genuine nature of physical literacy and are comprehensively detailed across the research area (e.g., Durden-Myers, Green & Whitehead, 2018; Pot, Whitehead & Durden-Myers, 2018). Whitehead introduces physical literacy as a pathway to the fuller realisation, exploration and expression of human physicality. Being physically literate draws upon existential and phenomenological views to assert a monist perspective that combats the mind-body duality often observed in physical education and activity settings (Whitehead, 2007). Since earlier definitions of the concept, it could be argued that physical literacy has moved away from an emphasis on holism, with crucial attributes identified by Whitehead regularly presented as discrete entities (Giblin, Collins & Button, 2014; Longmuir et al., 2015), or omitted entirely (Tompsett et al., 2014). Removing the metaphysical language of phenomenologists, or reducing the construct to singular attributes potentially makes the concept more accessible to practitioners but fundamentally does physical literacy as a whole, a considerable disservice (Jurbala, 2015; Shearer et al., 2018; Bailey, 2020a). Whitehead (2010) has argued that it is not possible to totally comprehend or appreciate the true nature of physical literacy without firstly understanding the philosophical roots of the construct. Stripping out these key elements and attributes of the concept removes that which makes physical literacy more than simple physical activity.

The physical literacy concept is founded on the holistic view that productive organism-environment interactions in which the embodied dimension is the focus will develop embodied human potential (Durden-Myers, Whitehead & Pot, 2018; Durden-Myers, Meloche & Dhillon, 2020). The dualist heritage prevalent within western societies continues to separate mind from body, therefore the exploration of human embodiment has remained a challenging prospect for researchers as a

consequence of these imposed dualist dichotomies (Durden-Myers, Meloche & Dhillon, 2020). Specifically in the context of physical literacy, embodiment is used to describe the "potential individuals have to interact with the environment via our embodied dimension" (Whitehead, 2010, p202-203). Physical literacy celebrates the notion of a unified, whole being, through which we observe and experience the world. The aspiration is to support and develop human embodied potential through rich, fulfilling interface with surroundings and circumstance. Discussing the physical dimension as 'the body' preserves a dualist body as machine Cartesian belief and approach (Lloyd, 2016; Robinson, Randall & Barrett, 2018; Young, O'Connor & Alfrey, 2019). Consequently, ideas of human embodiment, or the human embodied dimension are preferred (Durden-Myers, Meloche & Dhillon, 2020) as this incorporates both the body as machine and body as the perceptuomotor dimension of being. Physical literacy acknowledges the worth of movement and physical activity in nurturing a pronounced sense of the embodied self. The effects of embodiment manifest themselves in how learners are able to move, their spatial temporal interactions, and their disposition towards locomotion (Taylor, Lord & Bond, 2009). Learners should be able to establish the interaction between the physicality of movement solutions offered by utilising their experiences, knowledge, and understanding of their immediate, as well as other environments (Whitehead, 2001; Choi et al., 2018). As a result, physical literacy has the capacity to contribute to human flourishing through the capitalisation of our embodied potential. It provides an important avenue for interaction, deprived of which we would not be well positioned to realise our full potential as a human being (Whitehead, 2013c). Consequently, the construct allows recognition of the criticality of the embodied dimension as part of human nature (Durden-Myers, Whitehead & Pot, 2018).

2.4ii Monism and consideration of the whole individual

Whilst acknowledging the existence of different dimensions of the human condition, monism recognises they cannot be understood as distinct from each other. Descartes (1967) allocated little, if any, value to the human-embodied dimension, proposing it was inferior to the mind, trivialising a key dimension of the human being (Robinson, Randall & Barrett, 2018). Gibbs (2006) indicates that this more classical disembodied perception of the mind is misguided because cognition is constitutionally fashioned by embodied experiences. Recent years have witnessed an increasing commitment to monism, which rejects Cartesian dualistic proposals that isolate mind from body and individual from settings, subsequently recognising that movement is an embodied experience (Whitehead 2001; Roetert & Jefferies, 2014). Physical literacy's commitment to monism is mirrored in the definitions encompassing numerous key features of human nature – the affective, the cognitive, and the physical. Concentration on only a single area of human potential does not effectively represent physical literacy.

Appreciation of the individual as a holistic entity, encompassing mind and body indicates that development of movement skills and understanding is not simply concerned with educating the body as an object and requires consideration of how to effectively interweave emotion, cognition, and physicality into fulfilling movement opportunities.

2.4iii Existential philosophical foundations of physical literacy

Arguably, Whitehead's most significant contribution to the development of the physical literacy construct was the re-casting of the concept to include the specific philosophical paradigm of existentialism (Whitehead, 2001, 2010). In doing so, Whitehead was able to provide a novel, contemporary interpretation of the concept that embraces embodiment as a central experiential principle within the practices of physical education (Cairney et al., 2019a). Whitehead's (1990) paper, exploring meaningful existence, embodiment and physical education is acknowledged as the philosophical foundation for the advancement of the construct (Edwards et al., 2017). Her later work (Whitehead, 2001, 2010) further established the existential orientation of physical literacy and that as human beings we create ourselves through the interactions that our environment affords. The richer and more diverse these interactions, the more completely an individual may realise their potential (Pot, Whitehead & Durden-Myers, 2018). As a consequence, the environment and the organism codetermine each other (Durden-Myers, Green & Whitehead, 2018), both shaping and being shaped by their respective presence. It is not possible to understand action without firstly obtaining reference to the performance context. One mechanism of interaction with the world and subsequently contributing to the enrichment of individuals lives is the embodied dimension. Humans experience the world through movement, and from cradle to grave we are captivated by the potential for movement and what it may offer us (Robinson & Randall, 2017). Starting at birth with touch, feeling and reflexive movements; learning to wriggle and roll as new-borns; progressing to crawling and furniture walking as infants; before graduating to unassisted baby steps and basic bipedal locomotion as toddlers; humans make sense and develop understanding of their environment and their motile capabilities through the medium of movement. From this perspective it is reasonable to assume that humans are the product of their accumulated interactions with the world (Whitehead, Durden-Myers & Pot, 2018), whether they be positive or negative. By exploring embodiment, lived experience and meaning creation from interactions of a physical orientation there remains the opportunity to more prudently align to the holistic nature of the physical literacy concept. Thus, reducing the risk of marginalising or entirely missing key elements of the construct that might otherwise be jeopardised by adopting a more reductionist approach to the investigation of the phenomena. In this context,

existentialism and the embodied dimension can legitimately be viewed as valuable, highlighting the importance of activity and physical literacy.

2.4iv Phenomenological foundations of physical literacy

Phenomenology is closely aligned to existentialism in that value is placed on environmental interactions. Fundamental to phenomenological reasoning is that individuals experience the world uniquely. Learner experience and interpretation of movement episodes, and the knowledge and self-awareness that accompanies such interactions are central to the concept. Critically, detaching the phenomenological and the motor has significant consequences as reductionism in this fashion, negates Whitehead's (2001) original ideas of the inseparability of the body and mind. Phenomenology allows progression from the existential ideas introduced, describing the manner and nature of how embodiment affects interaction and recognises the reality of differences that exist between individuals. A critical aspect of phenomenology is that individuals will appreciate, understand and resolve situations differently due to the unique perspective they hold (Durden-Myers, Green & Whitehead, 2018). With each new event experienced individuals are presented the opportunity to assimilate, adjust, merge, progress, and accommodate novel knowledge with existing knowledge and understanding (Robinson & Randall, 2017). Therefore, interactions with the physical environment and importantly the positive, meaningful, or negative, meaningless nature of those interactions will influence people uniquely, governing current and future perceptions of activity and the worth of those lived experiences. Because perception can be affected from an embodied perspective through attributes including confidence and motivation the value of holistic concepts such as physical literacy is increased. With a focus and ambition to foster a positive affective disposition towards activity developing physical literacy would also engender phenomenological interests and shape how interactions with the world are perceived.

2.4v The embodied nature of physical literacy

Embodied literacy through engagement in physical endeavour is an attunement process whereby the learner is able to recognise both their limitations, and the boundaries of affordances offered through insightful interpretation of the exercise setting. Mandigo et al. (2009) documented those learners with locomotive competency do not move in isolation of their environment. Actions, particularly the application of techniques (skills) to specific gameplay circumstances cannot be understood, or consequently taught or learnt in the absence of the context for the performance (Almond, 2013b; Durden-Myers, Meloche & Dhillon, 2020). Interaction and interface with the world are perpetually changing phenomena, particularly in the sporting domain. No two contexts are ever the same, even

within supposedly identical tasks, the executed interaction with the environment and movement solution offered will incorporate minor variations in its presentation (Pot, Whitehead & Durden-Myers, 2018). Consequently, Cobo (2013) suggests the task is to find and adopt processes that nurture skills, capacity, and techniques that facilitate learning to learn, free from particular discipline constraints or performance regulations. Decontextualized expressions of physicality such as striking, or catching an object for example, removed from consideration of setting, or organism constraints such as skill, experience, or maturity has consequences for the ecological system that the learner is part of. Such behaviour might in fact be deemed a pointless exercise and objectification of our embodied relationship with the environment (Green et al., 2018). Embodiment is described as the axis of all tacit knowing, which subsequently is the basis for all explicit knowing (Durden-Myers, Meloche & Dhillon, 2020). A person's motile capability is the medium through which observations, interactions and responses to the surrounding environment are framed, therefore evolving an embodied sense of the self will stimulate richer perception, interaction and expression opportunities. In the physical education setting, learner experiences are events that reveal the intersection of lived body and an embodied mind. Physical activity therefore, when viewed through this lens has an interconnected embodied nature that gives meaning and value to the lived experience. Various philosophers and indeed neuroscientists now value the crucial role this dimension has in human life (Whitehead, Durden-Myers, Pot, 2018), further endorsing the merit of physicality and physical literacy.

The embodied dimension therefore is a very powerful way in which to interact with the world. Through provision and experience of human movement, potential can be nurtured and enriched (Robinson, Randall & Barrett, 2018). Individuals develop as unique beings and become who they are as a consequence of the interactions they have with their environment and the manner in which these interactions are interpreted and understood. As we proceed to interact with the world our understanding of it will continue to change. Actions and interpretations deemed appropriate responses previously will be continuously moderated to reflect our understanding. Fundamentally, literacy signifies a capacity for fluent and productive interactions with the environment (Whitehead 2013a). This is achievable through numerous different mediums and physical literacy recognises that movement can be a very important one. The embodied dimension offers a significantly unique, means of interacting with the world, which is fundamental to human development (Whitehead, Durden-Myers & Pot, 2018). Consistent with other human capabilities, every individual has the right to call upon and benefit from this potential. Humans are fundamentally moving, interacting beings, and the totality of their existence is experienced from this perspective. Embodied experience is an expression of life and to be physically literate is to appreciate and hold in high regard the physicality of embodiment (Goddard Blythe, 2005; Tompsett, Burkett & McKean, 2014).

2.5 Physical Education and physical literacy

2.5i Physical literacy in schools

In physical education the concept of physical literacy has become a prevailing topic of discourse among practitioners and policy makers, with increasing publication, promotion and adoption of the concept into schools-based practice. It has been proposed that physical literacy offers a 'new approach' for physical education (Jurbala, 2015). Among the various claims supporting physical literacy's deployment in schools are that it: offers a richer and more rewarding educational experience (Killingbeck et al., 2007); provides robust philosophical grounding for the subject (Durden-Myers, Meloche & Dhillon, 2020); utilises familiar language and terminology common to other school subjects (Roetert & MacDonald, 2015); suggests pedagogical models supporting best practice in the subject area (Almond, 2013c); presents an inclusive curriculum offer focussed on success and enjoyment (Faigenbaum & Rebullido 2018); has various mechanisms to contribute to fulfilment and human flourishing (Durden-Myers, Whitehead & Pot, 2018); and focusses upon the holistic development of individuals recognising the value of movement and physical interactions with the world (Whitehead, 2001, 2013, 2019). It is typical for physical education curricula to articulate aims, objectives and themes synonymous with physical literacy. In England, the National curriculum highlights that physical education should provide opportunities for children to become 'physically confident', to 'build on and embed physical development and skills', with a focus on developing 'competence to excel in a broad range of physical activities' (Department for Education, 2013). In addition to the psychomotor domain of physical literacy, the national curriculum also articulates objectives aligned to the affective and cognitive domains of the concept. For example, developing 'confidence and interest to get involved', alongside 'an understanding of how to improve in different physical activities' (Department for Education, 2013). Knowledge, and examples of embodied understanding are represented through demonstrating 'a range of tactics and strategies' and the ability to 'understand what makes a performance effective' (Department for Education, 2013). Tremblay (2012) proposed that the concept of physical literacy captures the essence of what high-quality physical education is trying to accomplish, with Corbin (2016) suggesting that an argument could be put forward for physical literacy to be the primary goal of physical education. Within the UK there is evidence of a fundamental policy shift to more closely align with such a notion, elevating the prominence of physical literacy in the education of young people (Sport England 2016; House of Lords, 2021). Common goals, compatible aims, and comparable models of practice has meant that the lines of demarcation that readily distinguish being physically literate from being physically educated have become quite indistinct (Corbin, 2016).

Disappointingly westernised societies have previously viewed the value of physical activity as a consequence of what it offers beyond the activity itself. As a means to other ends, often associated with prevalent dualistic beliefs, activity has been valued for the contribution it makes to maintaining appropriate function of the body as machine (Lloyd, 2016). In such a context little value is attached to the embodied dimension activity affords individuals. Similarly, also echoed within the schools-based education and governmental policy development the physical domain is often assigned secondary status. Whitehead (2001, 2013) identified the central purpose and value of movement, recognising the key role it plays in embodiment for human existence. As a consequence of movement's influence on assisting individuals to fulfil their potential Whitehead provided validation for the inclusion of physical education and associated movement episodes as worthwhile elements of the school curriculum. Contemporary views more readily contest the inferior status of embodiment and the marginalised value and contribution that physical education is able to make, supporting the inherent worth of physicality and physical literacy. Encompassing the values of physical literacy and operating from this perspective, physical education and the opportunity to interact through the physical medium of movement can enable every learner or individual to realise an important feature of being human. In the absence of appropriately generated opportunities the embodied dimension may remain a relegated notion, that is often overlooked by practitioners and participants. Accompanying the perceived risk and loss of conventional potential avenues for fulfilment and human flourishing leads supporters of physical literacy construct to advocate passionately that nurturing physical literacy not only has its own inherent value, but is also deemed essential in education (Almond, 2013a; Giblin, Collins & Button, 2014; Durden-Myers, Whitehead & Pot, 2018; Whitehead, Durden-Myers and Pot 2018).

2.5ii A focus on childhood and youth

Despite being presented as a cradle to grave concept focussed upon a lifelong participation, the majority of existing research is centred on school-aged children and adolescents (Lounsberry & McKenzie, 2015). Increased attention on this age group reveals what is widely considered to be a critical stage in the development of the fundamental physical literacy qualities required for a meaningful, fulfilling physical literacy journey (Whitehead, 2013c; Zwolski, Quatman-Yates & Paterno, 2017; Buckler & Bredin, 2018; Faigenbaum, Rebullido & Chulvi-Medrano, 2020; Shearer et al., 2021). Children in particular should be given the opportunity to express themselves and learn about, interact with, and through the physical medium. Thus, gaining an understanding and awareness of their world and how their actions can impact it, and them. Numerous authors strongly advocate the importance of the roles of physical education programmes and the professionals delivering them, to nurture the

development of physical literacy (Whitehead & Almond, 2013; Silverman & Mercier, 2015). Early childhood educators represent the sole compulsory providers of physical education and in particular have a vital role to play in the developmental processes that are instrumental to engineering a fulfilling physical literacy journey (Wilkie et al., 2023a). Faigenbaum and Rebullido (2018) suggest it would be naïve to expect individuals would achieve advanced levels of literacy in any subject without exposure to appropriately designed and delivered education, guidance and support from knowledgeable professionals. The development of rudimentary fundamental movement capabilities is a naturally occurring phenomena, and although there is some evidence that play and physical interaction in unstructured settings can lead to basic progression of physical competence it remains a misconception that refined, efficient, flexible movement qualities will emerge naturally (Logan et al., 2012; Morgan et al., 2013; Barnett et al., 2016; Foulkes et al., 2017). Additionally, not every child has access to opportunities and circumstances that would facilitate development at an appropriate rate or has the cognition and ability to evaluate, refine, and improve independently, even when circumstance and environment are favourable. For individuals to realise the full capability of their physical endowment they require developmentally suitable, organised activities with opportunity for insightful feedback (Wainwright et al., 2018).

2.5iii Implications for promoting physical literacy in the context of the national curriculum

The National Curriculum for physical education in England aims to ensure all pupils develop competence to excel in a broad range of physical activities, with particular focus in early years on mastering basic locomotor and object control skills such as running, jumping, throwing and catching (Department for Education, 2013). Despite a focus on fundamental movement development numerous authors express concerns that competency levels across Key Stage one and two remain low (Foulkes et al., 2017; Duncan et al., 2019). This is troubling, as within physical education the development and application of an extensive movement vocabulary has been shown to be essential for developing affective, cognitive and social skills (Lubans et al., 2010). From an affective position, individuals with higher levels of movement skill display higher intrinsic forms of motivation and perceived competence and confidence (Barnett et al., 2011; Duncan et al., 2018). This is significant since children who feel confident whilst taking part in physical education are more likely to enjoy the experience, and subsequently continue to make the effort to engage in other forms of play and physical activity outside of formal physical education classes. The reverse has also been shown to be true, in that poor movement skills development may have implications for motivation, confidence, perceptual skills, cognitive, social, and emotional development (Wormhoudt et al., 2018).

Although all children are entitled to and should be receiving quality physical education experiences within school, primary school physical education experiences in the UK traditionally reflect a multi-activity format, delivered by non-specialist teachers creating isolated, periodic learning opportunities focussed on introducing techniques suitable for competitive sports. Such approaches are reflective of perhaps more prescriptive teaching approaches, adopting drill style practice whereby classes are experienced as physical education as sport techniques (Kirk, 2010). Such trends, in addition to cultural conventions have led to physical education receiving reduced attention, investment and resources, diminished priority on the curriculum, and reduced training opportunities for staff (Keegan et al., 2013). As a consequence, physical education is possibly restricting its unique ability to contribute to a child's holistic development. Harvey and Pill (2019) highlight a trend that exists with many teachers reporting reducing their focus on physical literacy simply to the development of fundamental movements and motor skills. This is a narrow conceptualisation of physical literacy and represents a reductionist approach to the construct, omitting key elements of the wider concept and diminishing the overall value of physical literacy within the curriculum. Lundvall (2015) and Whitehead (2010) have expressed concerns about how the objectives of physical literacy can be realised with such a narrow perspective of what physical education could offer and the challenge of disturbing entrenched practice in sports education.

2.5iv Role of teachers in facilitating physical literacy

Physical competence is recognised as a critical pillar of the physical literacy construct although Whitehead (2010, 2013b) notes this attribute exclusively cannot be the singular focus of the concept and does not on its own constitute physical literacy. Such a proposition perhaps disputes Tremblay's (2012) suggestion that high-quality physical education would innately achieve successful progression of physical literacy because of the privileging of physical competence and skills within the National Curriculum at the expense of physical literacy's more holistic focus. Previous research has identified low levels of motor competence in children (Foulkes et al., 2017; Behan et al., 2019; Duncan et al., 2019; Lawson et al., 2021), in addition to inadequate levels of physical literacy (Longmuir et al., 2015). Movement and physical literacy are co-dependent and rely upon knowledgeable practitioners in several ways. Firstly, learning practice tasks should build upon previous achievement with respect to the nature of challenges set (Durden-Myers, Green & Whitehead, 2018). Furthermore, it is crucial that children experience a broad range of activity settings, environments and games to promote flexibility and adaptability in functional movement competence. Whitehead (2007) endorses strategies aimed to develop physical literacy, arguing that they should be less orientated towards locomotive development and motor skill execution, and instead should be directed towards establishing and

preserving embodied competencies. This is not to say motor competence should be sacrificed, or marginalised. Rather focus should be on acquiring an extensive movement vocabulary able to affect fulfilling movement experiences, enabling interactions reflective of economy, poise and confidence in a range of situations and environments (Allan, Turnnidge & Côté, 2017; Durden-Myers, Whitehead & Pot, 2018). Fostering knowledge and understanding of physical literacy is reliant upon informed, appropriate, well-designed curricula that deliver student-centric opportunities to acquire knowledge and understanding (Stoddart & Humbert, 2017). However, numerous authors counsel that without due attention to opportunities to develop the embodied knowledge aspects of physical literacy, such ambitions will be compromised (Lundvall, 2015; Cale & Harris, 2018).

Skilled movements with refined execution, aligning to technical models of performance undertaken out of context do not automatically secure effective transfer of knowledge. The presence of external dynamic affordances (team mates, opposition players, proximity to game perimeters or the goal) are engrained into the naturalistic environment of physical education game play and behaviours, highlighting the impossibility of meaningfully separating skills and competencies from the embodied attributes of knowledge, understanding and ability to read the environment. Movement, activity, exercise, and locomotion capture only the performative aspect and outcome of these interactions, but not the sensory cognitive processes involved in reading the environment, understanding the spatial temporal interactions and relations offered, and selecting or modifying suitable action. Physical literacy, when specifically concerned with the opportunity's movement affords is concerned with knowing through movement, knowing about movement and knowing because of movement (Kentel & Dobson, 2007). As highlighted previously, phenomenologically individuals construct their own personal meaning and understanding of situations founded on their previous experiences. By accepting that children learn by taking part in and reacting to the teaching they are exposed to in their programme of learning (Durden-Myers, Green & Whitehead, 2018), then it becomes vital to examine the pedagogical approaches, teaching environments and assessment strategies employed to maximise the impact of learning. The implications of this for practice are that educators need to appreciate the physical endowment and motor development of children, in addition to the more holistic features of the physical literacy construct to effectively operationalise physical education interventions. To encourage the realisation of latent or inherent abilities learners should experience a variety of appropriately challenging situations to expose broader domains for growth and fulfilment (Rasmussen, 1999).

2.6 Assessment and evaluation of physical literacy

2.6i Measurement and evaluation of Physical literacy - a contested field

Alongside the rapid growth of the physical literacy research field, there has emerged the need to fashion assessment tools that could be utilised to derive valid and reliable measures of the construct. It has been suggested that appropriate measurement and evaluation of physical literacy in youth populations has the possibility to facilitate the development of physical literacy in children, in addition to improving standards, refining expectations, and developing the profile of physical education as a subject area (Tremblay & Lloyd, 2010; Corbin, 2016). Jurbala (2015) suggests that for physical literacy to flourish, where other initiatives to promote a positive disposition towards physical activity have predominantly failed, there needs to be 'substance' to support the assertations made by advocates for the concept. Durden-Myers and Keegan (2019) suggest that to demonstrate this substance, there is a need for physical literacy to be effectively operationalised, translating the proliferation of research seen in recent years to effective practice and assessment strategies. While acknowledged as a critical feature of pedagogical practice, assessment in physical education inherently exhibits numerous associated challenges and remains one of the most problematic issues currently facing practitioners (López-Pastor et al., 2013). Historically, Whitehead has strongly resisted the idea of assessment, or evaluation of physical literacy (Whitehead, 2010). However, this initial position seems to have softened more recently with the acceptance of the value assessment can play as a motivational tool in progressing the physical literacy journey (Whitehead, 2013b; Whitehead & Almond, 2013). Research has endorsed the necessity of assessment in physical literacy, highlighting the benefits of accountable data to demonstrate impact and effectiveness of the concept in practice and subsequently exert influence on policy makers and practitioners (Longmuir & Tremblay, 2016; Shearer et al., 2021). Keegan et al. (2013) and Shearer et al. (2021) also recognised the importance of monitoring progress in physical literacy to support development and clarification of policymakers understanding of the concept and assist practitioners in the development of effective pedagogies. Evaluation also provides a mechanism for individuals to recognise their personal development and chart their physical literacy journeys over time (Tremblay & Lloyd 2010). Fundamentally assessment and evaluation of physical literacy is key to making the physical literacy construct tangible to different stakeholders (Green et al., 2018). Despite these claims, the divergent definitions, approaches, and understandings of the construct have resulted in friction within the academic literature on how and if physical literacy can be assessed, with consequences for operationalising evaluation in practice (Lundvall, 2015; Edwards et al., 2018; Whitehead, Durden-Myers & Pot, 2018; Cairney et al., 2019a).

There are limited valid and reliable measures of physical literacy that incorporate the broad range of features that are included in the concept (Longmuir & Tremblay, 2016). Contemporary

research has been reported to often adopt diverse, typically incompatible methodologies for the measurement and evaluation of physical literacy (Edwards et al., 2018). There are numerous potential explanations for the limited measures and assessments currently observed in academic literature and vocational practice. In some cases, as a consequence of evaluation tools not orientating to the philosophy and definitions of the construct held by researchers, or the fact that they are yet to determine assessments which are suitable for particular populations, environments, and settings (Goss et al., 2022). Alternatively, Edwards et al. (2018) and Liu and Chen (2021) suggested that the multifaceted complexity of the concept produces challenges as to how researchers approach the operationalisation of assessment. As a consequence of these reported divergent approaches there has emerged an obvious absence of assessments related to the affective and cognitive domains of physical literacy being used in physical education settings, and the realisation that existing measurements of physical literacy do not effectively meet the requirements of all stakeholders (Goss et al., 2022).

Popular assessment strategies in physical literacy are designed to establish learner characteristics within specific domains of the construct, or provide an ipsative, formative evaluation of capabilities to enable effective monitoring of individual progress. However, Barnett et al. (2019) acknowledged that most evaluation strategies utilised by practitioners can be considered to simultaneously reflect important elements of physical literacy, while concurrently not adequately representing the entirety of the construct. Typically, interventions, assessment, and research activity in the field of physical literacy has focussed primarily upon the 'physical' dimension of the concept, with many approaches reducing physical literacy simply to the evaluation and development of fundamental movement skills (Jurbala, 2015; Longmuir & Tremblay, 2016). There are currently very few practices that advocate the implementation of a more composite approach able to provide detailed insight into several areas of the concept simultaneously (Edwards et al., 2017).

The multidimensional nature of physical literacy, with its origins embedded in phenomenology and existentialism have resulted in questions being raised about the potential to assess the construct at all (Rudd, 2021), or at the very least debates around what may constitute appropriate methods of data collection and evaluation (Hylton, 2013). There are numerous advocates for the notion of 'charting progress' in physical literacy, as opposed to measurement, evaluation, or assessment. Charting progress allows for the consideration of physical literacy at an individual level, recognising it is unique to the person, their endowment, and organism constraints making it virtually impossible to compare directly to others (Green et al., 2018; IPLA, n.d.). Similarly, individual progress in physical literacy is increasingly being recognised and understood to be a dynamic, occasionally transient, nonlinear phenomenon, making traditional linear measurement assumptions unsuitable

(Green et al., 2018; Chow, 2021). As a result, each individual in practical environments and educational settings may chart their personal physical literacy journey, but no two will be identical. Consequently, Edwards et al. (2018) and Green et al. (2018) both encourage the development of creative, nonconventional approaches to the evaluation of physical literacy that better reflect the holistic nature of the construct.

2.6ii Challenging the use of traditional measures in physical literacy

Previous reviews have provided detailed commentary highlighting concerns that exist regarding measurement and consequently the quantification of physical literacy (Robinson & Randall, 2017; Green et al., 2018), suggesting that there is currently a lack of robust empirical tools available to effectively assess physical literacy (Giblin, Collins & Button, 2014; Lundvall, 2015). There is a clear sense that physical literacy has been deciphered differently depending on the primary objectives of particular interest groups. This has resulted in the creation of a range of physical literacy assessment protocols causing significant confusion for individuals who wish to better understand the concept, and teach or evaluate physical literacy in practice (Jurbala, 2015). Whether created explicitly, or designed for alternate purposes and subsequently applied to physical literacy there are countless assessment procedures currently available to evaluate some, or all, features of the construct that are supported by research outputs (Dowens, Dalziell & French, 2013; Corbin, 2016; Barnett et al., 2019). Such support however resides in a contested field of interest, as other authors have highlighted there remains a lack of validated instrumentation to appraise the wider attributes of the physical literacy concept (Sum et al., 2018; Shearer et al., 2021), with Barnett et al. (2019) summarising this lack of consensus effectively through the acknowledgement that there was not an 'ideal' approach to measurement.

Efforts to understand progression and individual development in physical literacy have previously been constrained to pre-existing knowledge, established psychometric, psychosocial, and psychomotor assessment instruments, or combinations thereof (Tremblay & Lloyd, 2010; Edwards et al., 2018). The development of practical testing protocols for physical literacy has led to the reductionist, reverse engineering of the original concept, resulting in incomplete, or reduced representations of the construct (Jurbala, 2015; Green et al., 2018). Consequently, it has been suggested that contemporary understandings of the physical literacy concept have been restrained to that which is already known (Dudley, 2015). Similar concerns have been raised by Giblin, Collins and Button (2014), who identified current measurement protocols as undermining the wider construct and were viewed as inappropriate, considering the individualised nature of physical literacy. Such practices may risk the evaluation of progress in physical literacy becoming diluted in nature, superfluous in purpose, and meaningless in the insight provided (Edwards et al., 2018). One of the

motivating factors for Whitehead (2001) reimagining physical literacy was to distance the subject area from more linear, simplistic, reductionist thinking, however it remains evident that designing an approach that evaluates the philosophically complex and holistic nature of physical literacy remains a challenge.

2.6iii idealistic and pragmatic approaches

The previously discussed literature highlighted the emergence of two principal approaches relative to understanding and evaluating physical literacy. These approaches are characterised by idealist and pragmatic perspectives of understanding, adopting, implementing and investigating the physical literacy construct (Higgs, 2010; Hylton, 2013; Giblin et al., 2014; Jurbala, 2015; Edwards et al., 2018; Barnett et al., 2019). Idealist perspectives relate to the holistic nature of the physical literacy construct, consequently aligning their practice and assessment approaches to nurturing and reporting on the interconnecting, inseparable components that make up the whole concept (Edwards et al., 2018; Barnett et al., 2019). Therefore, adhering to the notion that all domains of physical literacy are valued and ideally are not isolated, or reduced for the purposes of measurement, as this would be inconsistent with monist, holistic understandings of the construct (Jurbala, 2015). Consequently, it is more likely that idealists would investigate the physical literacy concept through qualitative research approaches, using methods such as observations or interviews to glean insight to the phenomenon under investigation (Edwards et al., 2018). By comparison, other authors have adopted a more pragmatic approach to assessment that preserves the value of measures that are compatible with established evidence-based practice, (Longmuir et al., 2015; Shearer et al., 2021), or consider the balance to be struck between purpose of assessment and assessment burden (Goss et al., 2022). Such approaches result in established measures, designed with alternate intentions, being deployed within physical literacy under the premise of capturing singular or certain aspects of the wider construct without necessarily conforming to the holistic nature of the concept. Pragmatists would seek approaches to assessment that are compatible with their discrete aims and consequently, would be willing to adopt both quantitative and qualitative approaches, potentially combining the advantages of both research paradigms (Edwards et al., 2018). Barnett et al. (2019) identify there is no need for idealistic and pragmatic approaches to be mutually exclusive, but it remains important for academics and practitioners to acknowledge such constraints in their practice.

The different testing batteries to have emerged worldwide, demonstrate numerous examples that adopt a more pragmatic approach to the operationalisation of physical literacy. The Basic Moves programme used in Scottish schools, employs the Test of Gross Motor Development-2 (Ulrich, 2013) to evaluate fundamental motor skills. In Wales, the Dragon Challenge movement circuit (Stratton et

al., 2015) is employed to measure physical competencies in children to provide insight to their physical literacy as part of Physical Literacy Programme for Schools (Sport Wales, 2014). Such approaches have drawn criticism in that they privilege the psychomotor components of the construct, focussing less on the psychological elements of physical literacy (Edwards et al.,2018). Barnett et al. (2016) encourages practitioners and organisations to recognise such constraints, acknowledging that these processes do not measure physical literacy in its entirety, while accepting that meaningful efforts have been made to measure elements which contribute significantly to the manifestation of physical literacy. The Canadian approach to operationalising physical literacy sought to devise and validate a bespoke assessment protocol to capture the wider elements of the construct through the Canadian Assessment for Physical Literacy (Longmuir et al., 2015). This evaluation tool endeavoured to establish the most favoured assessment approach currently employed for each of the core domains of the construct and use these to calculate a composite or 'overall' score for physical literacy. The Canadian Assessment for Physical Literacy has also been criticised, due to treating each of the domains separately, while still disproportionately anchoring the assessment methodologies and outcomes towards motor competencies (Edwards et al.,2018). The strategy has to be recognised however for the scope and ambition of the tool, with the extensive array and quantity of measures that would feasibly provide the more complete characterisation of physical literacy that Barnett et al. (2019) highlight as desirable.

2.6iv Physical literacy is not 'just' movement

Despite typically using variations of Whitehead's (2001, 2010, 2013b, 2017) conceptualisations of physical literacy, assessment approaches typically seem to have obvious assessment hierarchies that privilege one domain over another. The privileging of specific domains within physical literacy assessments is problematic as it is incongruent with the holistic orientation of the construct that views each domain equally (Green et al., 2018 Shearer et al., 2021). Reviewing the assessments presently available for charting the physical literacy journey, it becomes clear that research has concentrated nearly exclusively on independently observable features of the construct (Allan, Turnnidge & Côté, 2017; Liu & Chen, 2021; Shearer et al., 2021; Ke et al., 2022). Recording the features of physical literacy that are not directly observable, such as the affective qualities of motivation or confidence, and the cognitive features of knowledge or reading the environment, is arguably significantly more complex (Longmuir & Tremblay, 2016; Dudley, 2018) and less frequently addressed (Edwards et al., 2018). In their major systematic review investigating measurement of physical literacy Edwards et al. (2018) identified only three percent of the studies reviewed, combined all three domains of physical literacy in their measurement of the construct. The disparity between domains is highlighted further through the acknowledgement that over sixty percent of the studies were focussed solely upon the physical

domain of the construct (Edwards et al., 2018). Whitehead (2010) recognises the status and value of physical competence within the construct, while indicating that "this attribute alone can never be the sole constituent of physical literacy" (p.44). Repeating the argument more recently Whitehead (2013d, p.30), declared physical "competency on its own does not constitute physical literacy". Acknowledgment of the wholeness of the concept, going beyond simply evaluation of movement competencies to subsequently encompass knowledge, understanding, and affective features of physical literacy is recognised as being vital in progressing thinking and practice in the field.

So, while Whitehead recognises physical competencies as one dimension of the wider physical literacy construct, Robinson, Randall & Barrett, (2018) indicate that other researchers and policy makers have concentrated their efforts almost exclusively upon this quality. Additionally, there is evidence to suggest many of these assessments appear to focus narrowly upon fundamental movement skills rather than movement competence (McKee et al., 2013; Bélanger et al., 2016; Sum et al., 2018). The limitations of such approaches appear clear to physical literacy scholars and relate to dependence upon protocols meant for completely different purposes (Giblin et al., 2014; Robinson & Randall, 2017) (e.g., the Test of Gross Motor Development's focus upon fundamental movement skills to allow peer comparison and highlight children whose motor skill development has been delayed). Reducing the construct to sole attributes when designing interventions or evaluation strategies potentially facilitates accessibility for practitioners. However, it also serves to do physical literacy as a whole, a considerable disservice (Jurbala, 2015). The stripping away of particular key aspects and attributes from the concept removes that which makes physical literacy more than simple physical activity. It has been argued that such approaches are a weakness (Rudd, 2021), critically, detaching the phenomenological and the motor has significant consequences, as reductionism in this fashion negates Whitehead's original ideas of the inseparability of the body and mind. Learner experiences and interpretation of movement episodes, and the knowledge and self-awareness that accompanies such interactions are central to the concept (Wilkie et al., 2022). Additionally, Logan et al. (2017) and Edwards et al. (2018) suggest that such measures often neglect to evaluate the quality of movement, using assessments that instead rely upon outcomes of movement typically reported quantitatively (e.g., speed, time or distance) as markers to differentiate performance. Such approaches are problematic from a physical literacy perspective as performance in this more traditional sense does not represent the key tenets of physical literacy such as 'poise' or 'efficiency' of movement, particularly in children. Lundvall (2015) contended that such narrow measurement approaches are insufficient in regard to the multiplicity present in the physical literacy construct and fail to progress understanding appropriately.

Pragmatic approaches by their very nature prefer to measure more easily quantifiable features of the construct and although more recent developments in performance driven approaches suggest more sympathetic alignment to the holistic view of physical literacy, there remain numerous limitations to acknowledge. In reviewing existing assessment approaches Barnett et al. (2019) highlight how decisions have been made to prioritise the measurement of particular elements of the physical literacy construct according to the interests of the user's and the intention of the assessment. Similar to the patterns reported by Edwards et al. (2018) in their review of physical literacy measurements, Shearer et al. (2021) reported the prevalence of disconnected physical and affective assessments aimed at school-aged populations. The cognitive domain in both reviews emerged as the least represented and reported domain of physical literacy (Edwards et al., 2018; Shearer et al., 2021). This compounds the problematic nature of measurement in physical literacy, as practitioners and academics wrestle with how to address the holistic nature of the construct in the absence of established, feasible metrics against which to evaluate all aspects of the concept. The cognitive domain in particular remains understudied and consequently perhaps misunderstood (Shearer et al., 2021). Where attempts to incorporate the cognitive elements of the construct have been observed in assessment tools, they have still drawn criticism (Shearer et al., 2021). Typically, assessment of the cognitive domain has focussed upon decontextualised questioning, evaluating individual's understandings of health associated behaviours or the benefits of physical activity. Such notions align poorly with Whitehead's (2001) definition of physical literacy which is more orientated to embedded knowledge, decision making, and perception. This viewpoint draws on Gibson's (1979) insights on the distinction between knowledge *of* and knowledge *about* the environment, whereby knowledge *of* the environment is articulated through perception, action and skilled intentionality (Button et al., 2021). Whereas, knowledge *about* the environment is demonstrated through verbal descriptions, expressing idealised ways of doing or being (Woods et al., 2021). From a pragmatic perspective it is more straightforward to collect and evaluate data capturing knowledge *about* the environment as it is more easily quantifiable, although doing so arguably departs from the physical literacy construct in a similar manner as measuring fundamental movement skills to provide insight to movement competence. Fundamentally, there is a need to better define the key cognitive elements of the concept that are important to enrich evaluation of this domain.

Amidst the conceptual, definition-based, operationalisation debates occurring in the literature there is the discernible trend to strip out the inherent holism of Whitehead's definition of physical literacy (Tremblay, 2012). Critically, disaggregating the phenomenological and the physical commits the crime of reductionism (Jurbala, 2015) and demonstrates a lack of understanding of the concept (Whitehead 2019). The net effect of the typically pragmatic, reductionist approaches

reviewed is to displace physical literacy so that it is no longer viewed as an inherent human capacity, but instead a discrete collection of attributes to be taught and evaluated (Almond, 2013c; Green et al., 2018). A holistic theory of physical literacy cannot be based on such reductionist models and a determined effort must be made to challenge current approaches towards understanding, assessment, and interpretation of results. Approaches should instead, ideally favour highly personalised, developmental ipsative evaluations of individual journeys, without comparisons to peers or norm referenced scores (Whitehead, 2010; Whitehead & Almond, 2013). Encouraging self-awareness through embodied interactions with the environment is a central principle of the physical literacy concept, and one that cannot effectively be captured through how well individuals can replicate refined and sport specific skills in isolation, instead of in more authentic, applied settings (Mckee et al, 2013; Longmuir et al., 2015; Tyler et al., 2018). Opportunities to meaningfully interact with the environment are crucial to the phenomenological and existential foundations of the construct, with richer experiences facilitating the opportunity to understand and fulfil individual potential (Whitehead, 2007; Edwards et al., 2017). Invitations for action offered by the environment and the interactions that occur cannot be easily captured through quantitative research methodologies, compared to qualitative approaches that by design are more holistic in their philosophy (Edwards et al., 2018). Physical literacy, as intended represents a considerable departure from more traditional assessment-based learning towards more qualitative observational evaluations (Green et al., 2018). Physical literacy cannot be appreciated as a linear, homogenised, and universal scale of capability, but instead a disposition to deploy experience, understanding, and physical competencies to navigate environments effectively (Whitehead, 2010). Overall, it might be that qualitative approaches to inquiry, embracing a more holistic assessment philosophy have greater potential to represent the manifestation of physical literacy (Durden-Myers & Whitehead, 2018; Edwards et al., 2018).

By accepting and embracing Whitehead's definitions on physical literacy, or at the very least the language and intent of the concept, key measurement assumptions are in direct epistemological conflict with principles of monism. It makes little sense to separate physical literacy into discrete elements merely for measurement and simultaneously preserve a monism premise (Chen, 2020). The literature reviewed highlights limited attempts to capture the complete combination of domains within the construct, or to treat physical literacy as an integrated concept capable of being measured as a whole. Current measurement approaches have failed to resolve this conflict and consequently may be unable to defend against the proposition that while these assessments may be reporting on desirable qualities (e.g., motor skill, knowledge *about* sport and physical activity, and disposition towards activity) within a conventional physical education curriculum, they are not evaluating physical

literacy as defined and conceptualised by Whitehead. Supporters of this position would consider traditional, linear measurement conventions to be inappropriate, proposing instead the exploration and employment of creative, nonconventional approaches to measurement of physical literacy that present opportunity for more detailed understandings of a person's physical literacy journey. Consequently, there is an emerging rationale for research to look beyond established measures of physical proficiencies, or decontextualised, reductionist measures of the affective and cognitive domain and evaluate physical literacy from a more holistic perspective.

2.6v Issues of feasibility in the measurement of physical literacy

The broader literature highlights the most favourable environment to qualitatively evaluate physical literacy was during physical education classes (Bannon et al., 2013; Morgan, Bryant & Diffey, 2013; Longmuir et al., 2015; Sum et al., 2016). Goss et al. (2022) however highlight assessment, particularly in primary physical education is rare. Such observations would appear peculiar, and seemingly at odds with supporting a positive physical literacy journey considering the significant opportunity and realised progression typically witnessed in children at this age with regard to their physical literacy. Regular observation to effectively chart progress and capture attitudes, knowledge, understanding, and motor skill competencies in relation to physical activity is vital in this age group (Whitehead, 2010; Keegan et al., 2013; Lundvall, 2015; Foulkes et al., 2017; Li et al., 2020a). However, the feasibility of primary school physical education teachers, already balancing a burdensome work schedule being able to undertake appropriate qualitative assessments for whole classes remains unclear (Shearer et al., 2021). Time, practitioner expertise, facilities, resources, the complexity of the physical literacy concept, and environmental constraints have been identified as challenges facing assessment in physical educational settings (Hay & Penny, 2013; Longmuir & Tremblay, 2016; Durden-Myers & Keegan, 2019; Shearer et al., 2021). Essiet et al. (2021) nonetheless suggested that comprehensive evaluation of physical literacy is indeed possible within the constraints of the role. There does however remain an obvious need for a feasible physical literacy assessment tool that could be effectively employed within schools to be developed (Goss et al., 2022).

Robinson and Randall (2017) highlight how many physical education teachers may understandably feel cautious, confused, or overwhelmed due to numerous possibilities for assessment. Certainly, the complexity of undertaking an extensive testing battery to provide a comprehensive physical literacy assessment does not conflate to the time and resource poor situations many educators find themselves in (Longmuir & Tremblay, 2016). Additionally, Shearer et al. (2018) suggested very few existing physical literacy assessments could be administered by non-specialist physical education teachers (as is commonly the case in primary education settings). There

are a number of bespoke assessment instruments that have been developed and implemented in line with policy directives, with the purpose of evaluating physical literacy. Few assessments have been designed explicitly for use by teachers in traditional physical education settings (Robinson & Randall, 2017). Of these, the Canadian Assessment for Physical Literacy and the Passport for Life are methodologically robust, with good validity and reliability reported within the literature (Longmuir et al., 2015; Lodewyk & Mandigo, 2017; Dania et al., 2020; Li et al., 2020b). Both approaches capture psychomotor, affective, and cognitive aspects of physical literacy but, require considerable resource investment, either in terms of time, personnel, or both. The Canadian Assessment for Physical Literacy takes up to 60 minutes per child to complete. Comparatively the Passport for Life can take up to six physical education classes to complete. This data outlines some of the feasibility challenges associated with established testing protocols designed for school settings that use separate domain-level assessments to provide composite, more holistic overall scores of physical literacy.

There are seemingly numerous options available to practitioners for the measurement of physical literacy (or elements thereof), although little guidance is offered when determining which approach to adopt and why. Tyler et al. (2018) argued that measures of physical competence in Key Stage two children should in a time efficient manner evaluate fundamental, combined and complex movement skills in authentic settings. Such proposals align with the emerging trend to adopt more ecological, embedded, qualitative assessment approaches in school settings (Bannon et al., 2013; Durden-Myers & Whitehead, 2018; Green et al., 2018). Studies have identified numerous appropriate qualitative assessment tools as being suitable for primary school children, including interviews (Bannon et al., 2013; Morgan, Bryant & Diffey, 2013; Wainwright et al., 2018), focus groups (De Rossi et al., 2012; Sum, 2016), open ended questionnaires (Bannon et al., 2013; Francis et al., 2016), observations and video recordings (Lloyd, 2016; Wainwright et al., 2016; Larsson & Nyberg, 2017). Edwards et al. (2018) reported that compared to adolescents and adults, a greater number of qualitative measures of physical literacy were used in children under twelve years old. Barnett et al. (2019) emphasise that practitioners should be empowered to choose assessment instruments appropriate to their requirements. It is vital to remain mindful of the purpose of the evaluations to be undertaken and accept there may be justification for selecting particular assessments over others. Time, facilities, effort, affordability, and expertise needed are all reasonable considerations in terms of the feasibility of assessment choice (Logan et al., 2017).

There are many established methods supposedly offering the necessary instruments to effectively evaluate physical literacy. Popular evaluations of physical literacy are designed to establish learner characteristics within specific domains of the construct, or provide an ipsative, formative evaluation of capabilities to enable effective charting of individual progress. It has been suggested that

suitable evaluation of childhood physical literacy can improve educational standards, expectations of the physical education subject area, inform policy development, develop deeper understandings of the physical literacy construct, and support a fulfilling physical literacy journey (Tremblay & Lloyd, 2010; Keegan et al., 2013; Corbin, 2016; Longmuir & Tremblay, 2016; Shearer et al., 2021; Goss et al., 2022). Future assessments need to provide evidence of reliability and validity, remain mindful of feasibility, and value the holistic and multidimensional orientation of the construct. Development of effective alternate physical literacy assessments have the potential to enhance the credibility of the construct by showcasing physical literacy in an accessible and feasible manner.

2.7 Positioning physical literacy within an ecological dynamics framework

2.7i Dynamical Systems Theory

Physical literacy has been grounded in the philosophy of phenomenology, which has resulted in tension within academic phenomenological circles and has resulted in a loss of clarity when applying it to the subject area of physical education. The often-taken route of decontextualised assessment, or disconnected evaluation of physical literacy qualities (see section 2.6 for detail) fails to fully account for the role that environment and context have within the revelation of physical literacy (Rudd, 2021). Appearing better aligned to this view of physical literacy, ecological dynamics appreciates that perception of surrounding information is direct, and an external focus of attention is critical to achieving intended task goals, and the harnessing of embedded, self-organised, interconnected, co-dependent, behavioural sub-systems (Araújo, Davids, and Hristovski, 2006; Davids, et al., 2012; Woods et al., 2020). Such an ecological dynamics framework has grown in prominence among academics and practitioners, emerging as a guiding theoretical framework that offers a mechanism to explain human behaviour (Vilar et al., 2012; Button et al., 2020; O'Sullivan et al., 2020; Rudd, 2021). Ecological dynamics invites the re-conceptualisation of the work of sport practitioners through promoting the mutuality of the individual and the performance environment (Vilar et al., 2012; Woods et al., 2020a) Specifically, it blends concepts that primarily reside in ecological psychology (see Gibson, 1966, 1979) and dynamical systems theory (see Newell, 1986; Kelso, 1995). Emerging from the works of Davids, Handford, and Williams (1994), Araújo, Davids, and Hristovski (2006), and Warren (2006) it positions concepts such as skilled behaviour, intentional action, and learning within movement environments as emergent properties of the functionally adaptable relationships formed between interacting task, organism, and environment constraints (Davids, Handford & Williams, 1994; Seifert et al., 2018; Button et al., 2020; Passos et al., 2020; Bruineberg et al., 2021). Neurobiological systems are able to exploit their implicit complexity, accommodating environmental constraints to continuously reorganise their actions to accomplish set goals (Warren, 2006; Button et al., 2020). Within such a

framework, behaviour is viewed as a self-organising phenomenon that emerges from the ongoing and dynamic interplay of an individual's qualities and the affordances presented by specific performance settings (Davids, Handford & Williams, 1994; Araújo, Davids & Hristovski, 2006; Seifert et al., 2018). Consequently, skilled behaviour emerges as functionally adaptable movement solutions appropriate to task related goals (Araújo, Renshaw & Davids, 2020; Woods et al., 2020a).

Dynamical systems theory originated within the discipline of mathematics to model how patterns of coordinated movement are able to adapt, persevere, and change (Kelso, 2012). It has subsequently been proposed to offer a relevant model for understanding movement coordination and control in humans (Seifert & Davids, 2017; Button et al., 2020). From a dynamical systems frame of reference, functional movement solutions emerge as a result of the interplay of numerous sub-systems within the organism, task and environment (Davids, Button & Bennett, 2008). Organism sub-systems are able to spontaneously self-organise, combine and cooperate in a particular manner to determine potential movement solutions, exploring perceived efficiencies and effectiveness towards the achievement of task-goals (Davids, Button & Bennett, 2008). Learners within this context are conceptualised as complex, neurobiological systems, in which innate self-organisation tendencies underpin the emergence of adaptive behaviours (Araújo & Davids, 2009). Educational opportunities result in synergy formation between system components (e.g., muscles / limb segments, and the central and peripheral nervous system), allowing dynamic revisions across the whole system, in support of engagement in physical activity to be made (Chow et al., 2011). Such an explanatory framework has been described as 'embodied' (Araújo & Davids, 2009) attributing significant status to the individual-environment relationship that exists, consequently facilitating an understanding to be developed accounting for the complex interactions between both.

Ecological psychology assumes both mutuality and reciprocity between performer and the environment (Gibson, 1979), since information from the environment influences an individual's actions and actions shape the nature and value of information accessible from the environment (Richardson et al., 2008; Travassos et al., 2012; Seifert & Davids, 2017). Suggesting movement skill acquisition is not founded on processing information and the accruement of symbolic representations of techniques and schema. Skilled behaviour is instead, based upon the continual perceptual regulation of action within a learning context (Bailey & Pickard, 2010; Seifert & Davids, 2017; Rudd et al., 2020). An ecological dynamics framework stresses this vital relationship existing between learner and the environment as a principal theoretical tenet by which to examine skill acquisition processes (Roberts, Newcombe & Davids, 2019). Ecological dynamics draws inspiration from how neurobiological systems are able to function in a symbiotic manner, thriving within specific environments. Ecological dynamics understands perception, cognition, and action as interacting and

self-organising phenomena that arise as a consequence of the cyclical interactions observed between a learner's action capability and the affordances presented within specific performance settings (Button et al., 2020; Chow et al., 2020b; O'Sullivan et al., 2020). In sport (like other ecological systems), function is grounded on information that reciprocally fashions the continual evolution of co-habiting organisms, with each individual organism shaping their environment while simultaneously being governed by their surroundings (Woods et al., 2020). Within such a framework, surroundings are perceived in terms of affordances, where the topography, material composition, artefacts, and other people within the immediate environment provide diverse opportunities or invitations for interaction (Araújo & Davids, 2016; O'Sullivan et al., 2020). Individual-environment interactions result in the coupling of task-directed movements to available environmental information during activity. In practice, an individual's behaviour and their movements emerge as they interact with the unfolding dynamics of the environment i.e., objects (to volley or half-volley in Tennis), events (shot-clock count down in Basketball), other players (alterations in tactical patterns of play and sudden movement of opposing team players to create or limit space), and features of the playing environment (player proximity to the touchline in Rugby).

2.7ii Ecological dynamics as a viable framework for studying sports performance

An ecological dynamics philosophy has been proposed to provide a feasible framework for examining sport performance (Seifert & Davids, 2017), involving a much more embodied, embedded approach to understanding movement as it incorporates an appreciation of the whole body and how complex systems are able to adjust their behaviours to accomplish task-goals during physical activity (Teques et al., 2017; Araújo, Renshaw & Davids, 2020). While the theoretical analysis of embodied, embedded cognition is still developing, it has become clear that concepts including affordances, maintaining or breaking dyadic system stability, movement variance due to experimentation, and decision-making behaviour are rich avenues of exploration (Araújo, Davids & Hristovski, 2006). Ramos et al. (2021) reported that team sports have been considered as dynamical systems, comprising of interdependent elements (i.e., competing and cooperating players) that self-organise to achieve performance goals. Within such situations individuals can be conceived as being informationally-coupled to their environment (Davids, Araújo & Shuttleworth, 2005). As a consequence, the behaviours, actions, and outcomes of athletes cannot be completely predicted prior to performance because they are dependent on the dynamic performance environment and the people in it (Ramos et al., 2021). Goal-orientated task focus, invitations for action, and game constraints continuously emerge, persist, or transform as a result of the actions of others throughout the game. Accordingly, Button et al. (2020) described sports teams and the individual athletes comprising such groups as impressive examples of

complex adaptive systems, able to react to unexpected variations in games play while retaining the ability to reproduce high level performance consistently.

Analysis of team sports performance using ecological dynamics has attempted to explain how the interactions between athletes and the affordances within the performance environment constrains the emergence of behaviour. For example, ecological dynamics has provided insight to spontaneous, co-regulated behaviours resulting in the emergence of patterns of stability (i.e., co-ordination between cooperating and competing players when attacking and defending), symmetry breaches in organisational states (i.e., manifestation of new patterns of coordination to emerge within game play), and variability (i.e., breakdown of coordination resulting in attacking overloads being created) (Araújo & Davids, 2009; Vilar et al., 2012; Ramos et al., 2013; Passos et al., 2020). Perceptual information constrains opportunities to act, consequently necessitating ongoing revision of behaviour in relation to temporal-spatial constraints (Gibson, 1979; Passos et al., 2012, 2020; McKay et al., 2021). Research themes revealed how athletes coordinate their actions in response to key features or affordances within the performance environment, including the relative co-positioning of players, proximity to field boundaries, defensive pressure from nearest active defenders, attacking support from close team mates, relative angles and velocities of moving competitors, and proximity to the goal (McGarry et al., 2002; Passos et al., 2008; Duarte et al., 2012; Headrick et al., 2012; Passos et al., 2012; Orth et al., 2014; Passos, Araújo & Davids, 2016; Ribeiro et al., 2017; Passos et al., 2020; McKay et al., 2021). Insight obtained from investigations framed by ecological dynamics has revealed the scope of perceptual information athletes attune to in performance environments, theoretically guiding performance analytics, pedagogy, strategy and tactics, skill acquisition, and learning practice design in applied settings (Davids et al., 2017; Chow et al., 2020b; Woods et al., 2020a; McKay et al., 2021).

2.7iii Core features of an ecological dynamics framework applied to movement and physical literacy

Ecological dynamics proposes that within sport the individual's task is to exploit, to the best of their ability, the physical and informational constraints of the situation. Effective performance is built on the constraints of a performers perceptual and action capabilities (Araújo et al., 2006), and is predicated on perceptual affordances utilised for action selection and the achievement of goal-directed behaviour (Seifert, Button & Davids, 2013; Button et al., 2020). Or, to adopt language more typical of the physical literacy construct, successful engagement within physical activity domains is predicated on perceptive reading of the environment and responding with intelligence and imagination (Whitehead, 2001). From an ecological dynamics standpoint physical literacy can consequently be understood as the magnitude to which the qualities of each individual and the features of the environment match (Rudd, 2021). The unpredictable orientation of performance

environments and the embodied individual characteristics (physical literacy) and behaviours of learners within such settings imply that indeterminate solutions are available for many sporting endeavours (Ramos et al., 2020). Such ideas emphasise the circular causality and embedded relationship between individuals and their performance environment, mediated by their physical literacy. From such a perspective, physical literacy manifests itself through the continual functional adaption of behaviours observed in response to interacting constraints in an attempt to exploit them in the most meaningful manner. Within the constraints of personal endowment, individuals progress towards achieving intended performance goals. As a consequence, physical literacy can be conceptualised as the emerging functionality of the fit between environment and the individual (Seifert, Button & Davids, 2013; O'Sullivan et al., 2020; Rudd, 2021; Donaldson, Sheehan & Katz, 2022).

Seifert and Davids (2016) identify the theoretical framework provided by ecological dynamics addresses numerous weaknesses acknowledged within traditional approaches towards studying sport performance, which separately focus on environment and performer. Within the ecological dynamics theoretical orientation, several notable principles can help develop understanding and development of physical literacy in children, these are, self-regulation, wayfinding, affordances and attunement, intentionality, skill adaptation, functional movement skills, and degeneracy.

Ecological dynamics perceives action as an expression of cognition (Araújo et al., 2019), whereby understanding action, and accordingly cognition as an emergent process influenced by individual, environmental and task constraints, has implications for how we understand decision-making behaviour and sport pedagogy (Araújo et al., 2009; Chow et al., 2016; Renshaw et al., 2016). Decision making is an emergent behaviour (Araújo et al., 2006), whereby individuals will engage in intentional exploration as they seek effective solutions. Decisions are consequently expressed as actions (Beer, 2003), whereby movement within the environment will reveal additional invitations for action that will subsequently emerge and dissolve as circumstances unfold (Gibson, 1979). Decision making, explained through an ecological dynamics framework concentrates on how decisions emerge from an individual-environment system relaxing to a more attractive state as a potential task solution (Araújo, Davids & Hristovski, 2006). From this perspective individuals search their environment to arrive at a desirable, functional movement solution (Davids & Araújo, 2010), selecting the strongest attractor at any given moment even though other attractors are present and exert influence upon this process (Araújo, Davids & Hristovski, 2006; Araújo et al., 2019). Decision making ability, when considered within such a framework establishes how it is possible to differentiate between the quality of attractors in a performance landscape, learning how to attune to relevant environmental information to best support subsequent action and behaviour (Coutinho et al., 2016).

Decision making can be conceptualised within a broader behavioural framework highlighting the reality of emergent interactions with your surrounds, rather than referencing behaviours guided by internalised plans established with little appreciation for circumstance or environment (Woods et al., 2020a). Performance landscapes in sports settings are continuously evolving resulting in individuals having to self-regulate behaviours, utilising the deeply interwoven collaboration that exists between action, perception, intention, and emotion, to underpin emergent behaviour. As a consequence, individuals learn to wayfind through the performance environment by successfully adapting behaviours to match perceived action requirements and emergent constraints. Such an interpretation, underpinned by ecological dynamics is beneficial to understanding self-regulation and reading the environment as individuals progress their physical literacy journey. Effective wayfinding entails a deep engagement with the environment, demonstrating an appreciation of the many nuanced aspects of the performance setting, which in turn aids the ability to actively self-regulate during activity (Woods et al., 2020b). Such behaviour manifests itself through the ability to engage with the environment by deciphering dynamic problems, searching for and detecting information, exploiting affordances and (re)organising task-orientated actions all based upon an individual's intentionality and the constraints present in the environment (Hristovski et al., 2012; Woods et al., 2020b).

Wayfinding when considered through an ecological dynamics lens articulates the capacity individuals have to navigate regions of a (sporting) landscape by developing an embedded relationship and understanding of their surroundings (Prins & Wattchow, 2020). Through this embeddedness, based upon their current action capabilities individuals are able to exploit a deep knowledge *of* pertinent features of the environment and use this information to continuously self-regulate perceptions, actions, thoughts, and emotions to achieve intended task goals (Araújo, Davids & Hristovski, 2006; Woods et al., 2020b). Such an interpretation of wayfinding has strong connections with Gibson's (1966, 1979) perception-action coupling theory towards explaining human behaviour and has more recently been employed to enrich understandings of learner and learning processes in sport within an ecological dynamics framework (Woods et al., 2020a, 2020b). Learning to wayfind is an embodied and embedded process (Ingold, 2000), whereby the learner must deepen their knowledge *of* the environment, establishing critical features of the landscape and perceiving the invitations for action presented. Effective wayfinding requires a profound understanding of the environment and the practical knowledge to be able to effectively interact with your surroundings (Davids, 2012). Whitehead (2001) comments upon the physically literate individual being perceptive to their environment and how attributes of the environment are 'immediately understood as meaningful' as they resonate with embodied capacities. The result is that the physically literate

individual will know at once how to move, intuitively interacting with their environment. Whitehead (2001) goes on to explain how the physically literate individual would be well placed to interact successfully in novel situations because they have the capacity to effectively problem solve in unfamiliar settings.

Previous research has revealed that expertise in sports performance settings stems from the enhanced functionality demonstrated by individuals within the performance context (Araújo & Davids, 2011). The concept of dexterity proposed by Bernstein (1967) explains the ability of performers to discover motor solutions in a timely manner, effectively and economically arriving at potential solutions to emerging problems. This insight can provide a basis for skill adaptation, with features of dexterous behaviour demonstrating the interwoven links between perception, cognition, and action, as performers attempt to negotiate an evolving performance environment (Woods et al., 2020a). Bernstein's (1996) thoughts clarified how skill adaptation and observed movement variability are founded on self-organisation tendencies that can be capitalised on during sports activity and performance (Chow et al., 2011). Whitehead (2001) specifically identifies the capacity to *respond* appropriately to the physical environment, rather than recall and execute pre-learned movement schema, drawing upon holistic engagement with the environment embedded in perception, anticipation, and decision making. Concepts such as these, taken from Whitehead's (2001) portrayal of a physically literate individual are well aligned to the ecological principles of skill adaptation and degeneracy, which explains how children can structurally vary their motor behaviours without compromising function. Similar to expert performers, individuals who are further progressed in their physical literacy journey should also demonstrate an improved capacity to realise comparable performance outcomes through diverse movement and coordination patterns, rather than being reliant on programmed solutions (Button et al., 2020). The characteristic absence of singular, unique, stable states of movement organisation existing in dynamic affordance landscapes means numerous stable performance solutions may emerge based upon the key features of the performance environment to which individuals are attuned (Gibson, 1979; Rudd, O'Callaghan & Williams, 2019). Dexterity and skill adaptation improves an individual's robustness within challenging physical settings and guarantees continual functional, engagement and interaction with evolving environments (Araújo et al., 2019). Within ecological dynamics this continuous adaptation of actions, responding to the immediate requirements of environment and task has been framed through the concept of system degeneracy, which explains how the same output can be accomplished through the employment of structurally different system configurations (Edelman & Gally, 2001). The physical literacy construct captures the behaviours of physically literate individuals through a similar tone, recognising their ability to appropriately match movement needs to the physical environment.

To understand how physical activities can provide value, meaning and motivation within an ecological dynamics conceptualisation there needs to be an appreciation for how the concept of affordances shifts the traditional view of motivation from being an internalised, intrinsic process, to a situation where it is instead a process shared with the environment (Gibson, 2000). Gibson (1979) understood motivation more generally as materialising from a person's interactions with affordances present in the environment. Affordances are a further key principle taken from ecological psychology that contributes to our appreciation of perception informing action. Consequently, individuals perceive objects, equipment, events, and other people within their immediate environment based upon the possibilities and value of what they offer, or dictate with regard to displayed behaviour (Gibson, 1979; Rietveld & Kiverstein, 2014; Davids et al., 2017; Rietveld, Denys & Van Westen, 2018). Affordances have both objective and subjective properties that result in the potential invitations for action being reliant on the individual and their action capabilities (physical literacy) (Vilar et al., 2012; Davids et al., 2013a; Button et al., 2020; Rudd, 2021). Consequently, affordances can be acknowledged as properties of an individual-environment system (Davids et al., 2013b), calibrated against personal action capabilities resulting in the environment being viewed relative to its functionality and the importance of detected affordances (O'Sullivan et al., 2020). From a more existential, phenomenological perspective movement as described here provides a valuable conduit to the wider world (Whitehead, 2001) and enables the potential for fulfilment (finding value and meaning in actions) as a consequence of meaningful interaction with affordances. The different stages of the physical literacy journey will reveal pertinent affordances that match current embodied capacities, as with physical literacy itself, these affordances will be transient entities that inherently reflect the current motivations and capabilities of an individual at any single point in time. Within the parameters of an individual's endowment, affordances will invite meaningful interactions with the environment.

The invitational nature of affordances in sporting environments emphasises the role of agency (Withagen et al., 2012) and provides an influential means of understanding how processes of perception and action operate in complex neurobiological systems (Seifert & Davids 2016). As an example, the opportunity to score points in Basketball may emerge as a consequence of the ability of the performer, the distance to the hoop, and the presence of opposition players. Teammates constantly adjust court position to create separation between themselves and defenders and consequently present themselves as viable attractive affordances at a given moment. Effective performers are able to identify spatial-temporal relations between other performers (gaps that emerge allowing penetrative passes or dribbling opportunities), key environmental features of the performance environment (whereabouts of the ball and the basket), and organism constraints impacting their own behaviour (capacity to shoot the ball from outside the 3-point line) to arrive at

an action-orientated solution. Within dynamic sports environments such affordances and their perception and interpretation exert attraction in various ways, emphasising the individual-environment reciprocity (Vilar et al., 2012; Button et al., 2020). Perceiving an affordance, is to discern how one could act in particular circumstances (Araújo et al., 2019), and provides a compelling mechanism to integrate the processes of perception and action (Davids & Araújo, 2010). Contemporary views suggest that with experience, competence and understanding, individuals can become progressively more skilled at perceiving and utilising the most soliciting affordances available (Withagen et al., 2017; Woods et al., 2020a). Within an ecological psychology framework, this process has been christened attunement and describes an individual's sensitivity towards the most pertinent information available within the environment (Woods et al., 2020a; Bruineberg et al., 2021; Ramos et al., 2021). Consequently, particular affordances can invite individuals to act upon them, particularly if they reflect closely current capacities and abilities. The physically literate individual is recognised as being able to move with poise, economy, and confidence in a variety of environments and situations (Whitehead, 2001). The concept of an affordance landscape effectively articulates the multiple possibilities for action that reveal themselves as being pertinent to each individual in a given situation because of their physical literacy, and their ability to read the physical environment, anticipating movement needs and opportunities. Physically literate individuals 'know' what can, and needs to be done in a given situation due to being more perceptually attuned to the objects and events that transmit key information related to the achievement of task goals. This process provides a very authentic embodied demonstration of knowledge *of* the environment combined with the motivation to act, and the physical competencies to respond to the emergent features of the environment.

Affordances, and processes of attunement reconcile the phenomenology of skilled action with the framework presented by ecological dynamics (Seifert et al., 2013; Button et al., 2020; Bruineberg et al., 2021). With significant practice and exposure to activity settings individuals and their environment become increasingly unified as dynamical, self-regulating systems coupled by information, allowing selective engagement with numerous affordances simultaneously (Araújo, Davids & Hristovski, 2006; Warren, 2006). Consequently, it is possible to view motivation as the value or meaning given particular affordances, while intentionality captures the value and meaning of affordances during, and as a consequence of movement (Rudd, 2021). Previous literature highlights, from a physical literacy perspective, the value of the lived experience, with existentialism asserting that individuals create themselves as they interact with the world around them in a meaningful way (Whitehead, 2001; Durden-Myers, Whitehead & Pot, 2018). The richer and more diverse these interactions, the more fully human potential can be realised (Durden-Myers, Meloche & Dhillon, 2020). Anticipating and appreciating the value affordances offer within the environment presents

unique opportunities to pursue rewarding interactions of a physical nature, beneficially connecting principles taken from ecological dynamics and embedding them into enabling a fulfilling physical literacy journey. Operationalising a person's intentionality as an expression of agency within an ecological dynamics conceptualisation of physical literacy is connected to the oscillating dynamics of the activity context and the perception of relevant information to enable exploitation of the circumstances in an appealing manner (Rudd, 2021). Consequently, an ecological dynamics framework, built upon the key principles presented enables a fuller appreciation of how physical literacy emerges at an ecological scale of analysis. The reciprocity of an individual and the environment which foregrounds many of the key ideas evident in ecological dynamics is also evident in the founding descriptions of a physically literate individual (Whitehead, 2001) and their relationship with the world.

2.7iv Situating the study of physical literacy within an ecological dynamics framework

If the concept of physical literacy is to be adopted then it is important that it is viewed as a process orientated journey, rather than some outcome orientated endpoint (Rudd et al., 2020). Ecological dynamics offers a principled, theoretical framework which ideally compliments this ontology as physical literacy is represented by the dynamic, emergent behaviours of individual-environment systems, and the emotional, cognitive, psychomotor, and perceptual characteristics of each individual (O'Sullivan et al., 2020). By focussing upon the interacting dimensions of decision making, movement behaviours, and action-coupling which emerge to enable adaptable, functional relationships to be formed between individuals and their environment it is possible to enhance our understanding of how physical literacy reveals itself through meaningful interactions of a physical nature. Development of the individual, and progression of the physical literacy journey involves constraints induced synergy formation qualities across the physical literacy construct stimulated by trial, exploitation and adaptation of action possibilities (Rudd et al., 2020). Physical literacy can consequently be understood by virtue of the insights offered by ecological dynamics at the level of the individual-environment system, whereby the dynamic and reciprocal connection uniting an individual and their environment can by evaluated and modelled over time (Seifert et al., 2017; O'Sullivan et al., 2020).

A physically literate individual will employ processes of cognition, perception and action in a functionally integrated manner, acting as wayfinders who are able to self-regulate in an accomplished fashion to successfully navigate novel physical challenges and varied environments through a deeply embodied and embedded perception-action coupling. The continual dynamic exploration of the performance environment supports functional adaptation of movement actions enabling competent wayfinders to be receptive to, and act upon presented affordances. Such ideas are indistinguishable from how Whitehead (2001) defines a physically literate individual is able to perceptively read the

environment, responding appropriately with intelligence and imagination, moving with poise, economy, and confidence in diverse tasks and situations. A physically literate individual would be both capable and adept, at calling upon the different features of their physical literacy to augment performance functionality and the probability of meaningful, fulfilling engagement (Whitehead, 2001). In certain circumstances individuals may capitalise on their physical competencies (e.g., strength, power, balance) to achieve success, whereas other individuals in the same situation, or the same individual when faced with differing challenges may emphasise their perceptual skills (e.g., attending to key affordances within the environment resulting in deliberate strategic behaviours in defence and attack). Alternatively, some individuals are sufficiently motivated, or resilient enough to enhance functionality by seeking advantages by virtue of riskier behaviours (e.g., being innovative and creative in movements attempted to overcome presented challenges), whereas others will seek solace in secure functionality in the face of realised or anticipated failure by acting conservatively (e.g., being unadventurous in decision making, selecting actions with a low probability of failure). These behaviours, representative of how physical literacy can be revealed, demonstrate how the different qualities of the construct enmesh when realised through embedded behaviour.

The value of using key principles of ecological dynamics to capture physical literacy is deepened with the pervasiveness of knowledge and understanding typically being evaluated in a decontextualised manner in physical literacy research and practice. Asking questions that elicit the recall of health and wellbeing facts and information leads to the demonstration of knowledge *about* rather than knowledge *of* physical activity. Whitehead (2007) acknowledges such demonstrations of understanding within this aspect of the physical literacy construct shifts it towards a more dualist perspective, departing from the central tenets of embodiment the concept aims to embrace. The notion of knowledge can be reconceptualised however, predicated on the work of Gibson (1966) and ideas related to knowledge *of* the environment. In ecological psychology, knowledge *of* the world is founded on perception and action (Davids & Araújo, 2010), consequently necessitating an embedded appreciation of environmental attributes that would support the achievement of goals. The physical literacy journey can consequently be regarded as a progressive deepening of an individual's knowledge *of* their environment, and their place within it (Gibson, 1979; Ingold, 2000). Such ideas are intimately entwined to the concept of wayfinding described earlier, enabling successful negotiation of tasks and challenges in performance environments. Demonstrating knowledge *of* the environment is a sophisticated articulation of the process of perception and action in service of decision making (Araújo et al., 2019; Ramos et al., 2021). Gibson (1966) proposes that knowledge *of* the environment guides individuals through the (re)organisation of actions as a consequence of processes of self-regulation in response to available, subsequently exploited affordances. The acquisition of perceptual

information in this way explicitly constrains functional behaviour. The salient belief resulting from such ideas relates to knowledge *of* the environment being embedded. Although individuals can acquire knowledge *about* a physical activity environment, allowing them to describe decisions and actions they may undertake (Ramos et al., 2021), the physically literate individual should be well positioned to demonstrate knowledge *of* the environment through their embodied effectivities to successfully regulate behaviours and decisions.

An embodied model of motor learning, such as that articulated by ecological dynamics views mind, body, and the environment as continuously affecting each other. This holistic, monist perspective explains how emergent behaviours are shaped as a consequence of the mutuality of performer and performance environment. Such a conceptualisation allows physical literacy to be understood as the extent to which qualities and characteristics of the physically literate individual match environmental context throughout the life course. Within this framework, conceived as the functionality of the fit between an individual and their surrounds, physical literacy is viewed as a process rather than a goal, capturing the nonlinear, transient relationship between individual and environment which can alter depending on experiences, affective disposition and movement competencies at any given time. Progressing physical literacy is consequently, a voyage of personal enrichment through rich and varied movement experiences (O'Sullivan et al., 2020). Diverse physical experiences, encompassing organised sports, recreational play opportunities and physical activity will lead to self-regulation and the ability to effectively self-organise functional behaviour in an effective, meaningful manner, realising the assets and qualities highlighted by Whitehead (2001) in their original articulation of what characterises a physically literate individual.

Recent advances in the understanding of human movement and how it can be taught and evaluated has provided strong evidence to support pedagogical approaches that appreciate the complexities characteristic of performance environments and how individuals try to negotiate their surroundings through processes of self-regulation. Effective performance is now better understood as an ongoing, dynamic relationship that evolves between environmental constraints and the capabilities of the performer. By combining theoretical insights from ecological psychology and dynamical systems theory it becomes possible to elicit a better understanding of how physical literacy reveals itself through the adaptive behaviours of individuals during embodied experiences. As a consequence, this thesis will argue that ecological dynamics is well placed to provide a theoretical framework that will provide clarity in understanding, and support in the operationalisation of physical literacy, framing what has otherwise proven to be a somewhat esoteric concept.

2.8 Overarching conclusions and statement of purpose

An appreciation of the important trans-disciplinary principles found within an ecological dynamics framework can support and guide stakeholders to design more meaningful physical education experiences and assessments for children. The present review of literature has highlighted an over-emphasis on technique and movement proficiency, within current physical literacy assessments, diminishing perception (reading) and action (responding) during children's play, unstructured physical activity, and organised sport. This is critical, as the self-organisation of physical literacy capabilities in closed, decontextualised settings will be extremely different to those embodied experiences arising from dynamic situations that allow for action-coupling between individual and setting, task constraints, goal objectives, and other organisms. Employing an ecological dynamics conceptualisation of physical literacy allows progress towards an improved solution to the problems faced, by utilising an assessment which more effectively captures physical literacy as intended, i.e., a holistic demonstration of embodied interactions within rich physical activity settings. It is through detailed observation of children's play and physical activity that we start to appreciate all features of a child's physical literacy, mutually capturing value and meaning embedded in the environment and the depth of their demonstrated knowledge *of* the environment. Rich, informal play and structured practice settings are essential for children's learning, development, and progression of the breadth of qualities associated with leading a physically literate life. Games-based assessment provides an enriched environment for children to engage with, making it possible to gain a deeper understanding of the affordances that emerge and their functional value to that child. Such assessments are inherently individualised and offer a closer representation of the embodied experiences physical literacy advocates. Such an assessment strategy would support researchers in monitoring the physical literacy journey, and assist practitioners in developing learning practice tasks and environments which would support a fulfilling physical literacy journey. Consequently, the purpose of this thesis was to propose an ecological dynamics conceptualisation of how physical literacy could be evaluated – thereby preserving key information-movement couplings in representative contexts. This theoretical rationale has then been used to design, validate and administer a games-based assessment tool of physical literacy.

2.9 Thesis aims and objectives

The specific aims of the thesis are to:

a) Establish how ecological dynamics can be used to provide a theoretical framework to inform observational instrument design in physical education.
b) To design and validate an observational instrument for assessing physical literacy that remains more faithful to the philosophically complex and holistic nature of the concept.
c) Examine the relationship between game-based behaviours and primary school children's physical literacy.

These aims will be achieved through meeting the following objectives:

- Identifying how physical literacy is currently assessed, critically appraising existing approaches and the instrumentation employed.
- Identifying how ecological dynamics has previously been used to explain behaviour in dynamical environments where informational constraints blend to create unique and evolving problems during game-play.
- Demonstrating underpinning ecological dynamics principles and conceptualisation, applied to the measurement of physical literacy.
- Gaining the thoughts and opinions of experts within the field in order to help inform the development of an observational tool and categorical items that would capture the manifestation of physical literacy in game-based activities.
- Establishing the validity and reliability of an observational tool designed to capture physical literacy during game-play.
- Documenting through the use of the emergent game-based assessment, the features and characteristics of physically literate children during small-sided games.

Chapter Three - Shared methods and measures

3.1 Generating a composite physical literacy score

The research approach adopted for this thesis combined quantitative and qualitative approaches to data collection and analysis. There are a number of shared methodologies referenced within discrete chapters of the work that are explicitly detailed in this chapter:

Anthropometric Measurements

Children's standing height (m) and body mass (kg) was measured to within an accuracy of 0.1cm and 0.1kg, respectively. Height was assessed with a portable stadiometer (Leicester Height Measure, SECA, Birmingham, UK) and body mass was assessed using digital scales (Tanita WB100-MA, Tanita Europe, The Netherlands). All anthropometric measures were taken without shoes and whilst wearing light clothing.

Movement domain assessment (Dragon Challenge)

Assessment of fundamental movement skills and the physical competency domain of physical literacy was performed using the Dragon Challenge (Tyler, 2018). The Dragon Challenge is a dynamic measure of physical competence requiring participants to demonstrate fundamental and complex movement skills in a circuit-based exercise format. The Dragon Challenge has been previously used to measure physical movement competence (Draper, Jusary & Marshall, 2019; Morley et al., 2021), reporting good test-retest reliability for overall score (ICC, 0.80). The Dragon Challenge reported good reliability for object control skills, high-moderate reliability for locomotor skills scores, and moderate reliability for stability skills scores respectively (ICC, 0.80, 0.68, 0.60) (Tyler et al., 2018). In the test, children complete nine activities (balance bench, core agility, wobble spot, overarm throw, basketball dribble, catch, jumping pattern, t-agility run, and a short sprint) in a continuous circuit that assesses a range of stability, locomotor and object-control skills. Children typically take between 90 and 240 seconds to complete the Dragon Challenge (Stratton et al., 2015). Field testing consisted of a verbal description and single associated practical demonstration of the required locomotive skill for each element of the movement circuit. Participants were then provided the opportunity to practice in a self-paced manner each locomotive skill twice. If participants did not understand the task correctly then they were given a further verbal description of the skill and asked to repeat the trial. The familiarisation process adopted follows the guidance provided in the Dragon Challenge Manual (Stratton et al., 2015). Groups of five children were assessed at a time led by two members of the research team, taking approximately 20 minutes per group. Each participant was recorded using a tripod mounted video camera (GoPro Hero 9) positioned perpendicular to the length of the circuit with appropriate oversight of all activities. Post-event video-based (1080hp, 60Hz frame rate) observational assessment was completed following training and familiarisation with the assessment protocols and scoring utilised in

the Dragon Challenge. Assessment resulted in a mechanical motor skill competence evaluation (product and process) being completed. Process characteristics of the assessment address qualitative aspects of movement technique and focussed on how well a child moves their body when performing a task (e.g., "Drives off balls of feet, leaning forwards" (running) and "Controlled directional dribbling" (basketball dribble)). Product orientated characteristics of the assessment focus on the end product, or outcome of the movement (e.g., "Overarm throw directly hits the target" (throw)). These scores are combined with 'time' to complete the Dragon Challenge, culminating in a total composite physical competence performance score (0-54, Bronze – Platinum).

Affective domain assessment (Game Play Perception Profile)

Among children, perceived competence has been demonstrated to affect motivation towards physical activity more so than actual competence (Harter, 1982), with perceived competence appearing to mediate the relationship between motor skill competencies and physical activity (Barnett et al., 2008; Barnett et al., 2011). Assessment of confidence in games and game play, and the affective domain of physical literacy was performed using the Game Play Perception Profile (Miller et al., 2019). The Game Play Perception Profile has been previously used to provide an indication of perceived movement competence and displays high levels of test-retest reliability (ICC, 0.81 and 0.81) (Morley et al., 2021). The questionnaire consists of nine statements (e.g., "I do very well at team games"), requiring participants to score 1 to 4 the extent to which they agree with each statement (Strongly Disagree-Strongly Agree). Game Play Perception Profile questionnaires to establish perceived affective domain scores were administered in class under the supervision of the class teacher and a member of research team. Participants were required to complete a paper-based copy of the questionnaire that was subsequently transposed electronically before being destroyed.

Cognitive domain assessment (Working Memory)

Assessment of the cognitive domain of physical literacy was performed using the Head-Toes-Knees-Shoulders task (McClelland et al., 2014). The Head-Toes-Knees-Shoulders task has been previously used to assess behavioural self-regulation, cognitive flexibility, working memory, and inhibitory control (McClelland & Cameron, 2012), reporting strong inter-rater reliability ($\kappa = 0.90$) (Ponitz et al., 2008; McClelland & Cameron, 2012). The assessment is comprised of three sections with up to four paired behavioural rules: touch your head and touch your toes; touch your shoulders and touch your knees. Children start by reacting naturally to the instructions and then they are asked to switch and perform the opposite (e.g., touch their heads when told to touch their toes). If a child performs correctly after all four paired behavioural rules have been introduced, the pairings were switched (e.g., head goes with knees and shoulders go with toes). No equipment was needed with assessment relying on the interaction between instructor and child. The assessment consists of a total of 30 test items

with scores of 0 (incorrect), 1 (self-correct), or 2 (correct) for each item. A self-correct was defined as any motion to the incorrect response, but self-correcting and ending with the correct action. Each participant was recorded using a tripod mounted video camera (GoPro Hero 9) positioned in the frontal plane allowing post-event observational video assessment with the option of frame-by-frame playback (1080hp, 60Hz frame rate) to be completed. Scores ranged from 0 to 60, with higher scores indicating higher levels of behavioural self-regulation and working memory.

3.2 Games play assessment

A modified, small-sided invasion game (mat ball) was chosen for the purposes of games play assessment as it provided opportunities for combinations of motor and perceptual-cognitive skills to manifest themselves within a technical-tactical performance setting. These qualities made the game specific to the physical education curriculum requirements for Key Stage two children who are expected to be able to run, jump, throw and catch in isolation and combination, and apply basic principles for attacking and defending in modified games (Department for Education, 2013). Tactical skills within invasion games have been demonstrated to be transferrable across game contexts (Memmert & Roth, 2007; Memmert & Harvey, 2010) consequently this approach demonstrates desirable ecological validity as an assessment strategy (López-Pastor et al., 2013).

In the analysed games, participants were placed into mixed gender, mixed ability teams. Participants then played mat ball - a small-sided invasion game where the object is to score more points than the opposition. Games were played in a school gymnasium, equipped for multisport activities with a wooden sprung floor. The game court dimensions were 18m × 12m, with a goal (a gym mat with a goalkeeper kneeling upon it) placed centrally at either end of the gymnasium. Mat ball games consisted of two, competitive, five-minute periods of play with a short break in the middle. Points were scored by successfully distributing the ball to a teammate positioned in the scoring zone. Game rules included: no physical contact, no running with or dribbling of the ball, and scoring was only possible by shooting from within the opposition half. Participants wore coloured, numbered bibs, to allow participant identification for the purposes of analysis and to allow cooperating and competing players to be identified during play. Games were video recorded (GoPro Hero 9) from an elevated court side position allowing post-event analysis to be completed.

3.3 Ethical Considerations

Ethical issues and overall risk to the participants of this study was considered minimal. Due to the nature of the research being carried out a number of specific ethical considerations were observed:

- Gatekeepers, parents, and children invited to take part were made aware of the planned research project(s).
- Gatekeepers, parents, and children were made aware that they were under no obligation to take part in the research.
- Participants were able to withdraw their data up to 28 days post data collection without giving a reason and without penalty.
- If participants elected to withdraw, then their data in its entirety was removed from the study, including deletion of all original materials.
- For children where consent was not given there were no implications for their engagement or participation in scheduled physical education classes.
- All children were eligible to participate within the study (measurement and games) however, any children with a medical condition / impairment that affects movement and / or physical activity were excluded from the data analysis.
- Both parent / guardian consent and child assent were required in order for a child to be eligible to participate in the research.
- Although parents / carers may have given consent for their child to take part in the study, the final decision to take part was ultimately the child's.
- Participants were given the opportunity to ask the researcher / research team questions about the project(s).
- All information was stored in line with the requirements of the General Data Protection Regulation (GDPR).
- All processed data was anonymised, stored on a password protected shared drive, accessible only by approved members of the research team to ensure confidentiality was maintained.
- Audio / video files were transferred to a secure password protected storage device, with all original footage deleted from camera storage devices.
- All original information and documents once processed were destroyed. Original copies of all research materials were disposed of / deleted in accordance with university guidelines on disposing of sensitive documentation.
- The risk of adverse or medical events during data collection were minimised by screening the participants for contraindications to exercise, completion of a child medical information form, and parental consent being granted.

- Data collection was completed on university grounds in facilities suitable for sports and physical activities under the supervision of school staff.
- Some data collection required physical exertion, however the nature of this was very typical of children's normal physical education classes and participants were well accustomed to the nature of activities undertaken.
- Staff first aiders were on site to deal with any adverse medical events or injuries in accordance with school policies and procedures.
- Risks to participants were mitigated for as a consequence of members of the research team being compliant with individual school requirements pertaining to external partners / visitors (based upon the organisation, this included presentation of DBS certificates, completion of equality training, safeguarding training, familiarity of safeguarding policy and the completion of site visits).
- All classes, activities, and data collection were designed to be learner-environment centred, remaining true to the pedagogical philosophy informed by physical literacy. Consequently, classes provided meaningful, fulfilling, engaging, and inclusive learning experiences for all children regardless of individual endowment.

3.4 Ethical Approval

All studies and data reported within this thesis received full ethical approval. Data collection, used in studies one-four including the initial baseline measures of anthropometric data; assessment of movement competency; perceived movement competence; working memory; and game play behaviours received full ethical approval from the Research Ethics Committee within York St John University (ETH2223-0212). Data collection to establish content validity through expert qualitative and quantitative review (study three) also received full ethical approval from the Research Ethics Committee within York St John University (RECEDU0072).

Chapter Four - Measuring Physical Literacy: A Fresh Approach

The main outcomes of this study have been published in: Wilkie, B., Foulkes, J., Rudd, J., Lewis, C., Woods, C., Sweeting, A., & Robinson, E. (2021). Measuring Physical Literacy: A Fresh Approach. In *Nonlinear Pedagogy and the Athletics Skills Model* (pp. 161-168). Routledge.

4.1 Thesis Study Map: Study One

Study	Objectives
Study One (Chapter Four) Measuring Physical Literacy: A Fresh Approach	Objectives: • Establish the feasibility of capturing children's behaviour and environmental interactions during games-play that would reveal their physical literacy. • Establish face validity of a novel approach to assessment, framed by an ecological dynamics conceptualization to capture and measure physical literacy. • Highlight that the current reductionist approach to the measurement of physical literacy is not appropriate, especially when attempting to capture the embodied dimension of physical literacy.
Study Two (Chapter Five) Assessing Physical Literacy, Conceptualised in an Ecological Dynamics Theoretical Rationale	Objectives: • Pilot an assessment of physical literacy conceptualised in an ecological dynamics theoretical rationale. • Demonstrate the underpinning ecological dynamics principles and conceptualisation applied to the measurement of physical literacy.
Study Three (Chapter Six) Examining the Validity, Reliability and Feasibility of Capturing Children's Physical Literacy through Games-Based Assessment in Physical Education	Objectives: • Establish the validity and reliability of the psychometric properties of the emergent games-based assessment tool following a systematic process including face and content validity, combined with inter- and intra-observer reliability.
Study Four (Chapter Seven) An Ecological Insight into the Revelation of Physical Literacy in Children during Small-Sided Games	Objectives: • Investigate how features of the physical literacy construct reveal themselves through children's behaviours using the emergent games-based assessment tool. • Establish key differentiating behaviours of higher- and lower-physical literacy children when playing small-sided games. • Promote the role of ecological dynamics when employed as a theoretical framework to investigate physical literacy.

The COVID-19 outbreak and subsequent lockdowns during early to mid-2020 resulted in schools initially discontinuing external partners from working with pupils before later closing altogether, forcing premature conclusion to data collection. The absence of a completed intervention and with no capacity to undertake post-intervention data collection the project in its original form was impossible to progress. This resulted in major revisions to the original project focus, a reimagining of the data collection, data analysis and the conceptual field of investigation. As a consequence, Study One (Chapter Four) reports on the feasibility of measuring physical literacy as it reveals itself more holistically in applied settings. Providing a basis upon which to build the wider investigation. Within Study One, I conceived and designed the methodology in agreement with the supervisory team. I was responsible for data collection (facilitating the small-sided games to be analysed) and analysis (post-event manual, electronic tagging). Writing and preparation of the tables and figures in this chapter was completed independently.

4.2 Introduction

As outlined in chapter two, the dilemma caused by continually shifting definitions of physical literacy has manifested itself in a somewhat perpetual departure away from an embodied understanding of movement. The original, and arguably most prominent, conceptualisation of physical literacy with a strong grounding in phenomenology was put forward by Whitehead (2001). It is captured in Whitehead's (2001, p. 131) assertion that:

> *A physically literate individual moves with poise, economy and confidence in a wide variety of physically challenging situations. The individual is perceptive in 'reading' all aspects of the physical environment, anticipating movement needs or possibilities and responding appropriately to these, with intelligence and imagination. Physical literacy requires a holistic engagement that encompasses physical capacities embedded in perception, experience, memory, anticipation and decision-making.*

Since this conceptualisation, six further definitions have been put forward, with Whitehead's most recent definition describing physical literacy as "the motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engaging in physical activity for life" (Whitehead, 2019, p.8). Over the last 20 years, definitions of physical literacy have tended to move away from the importance of individual-environment interactions and how they shape physical literacy journeys, towards a reductionist and separate conceptualisation of the four overlapping and equally weighted constructs (as described above) that we need to teach children (Edwards et al., 2018). This shift has inevitably changed how practitioners and researchers engage with the concept of physical literacy.

Clearly, there is motivation to measure physical literacy and use assessments to guide the creation of effective learning environments and inform practice (Tremblay & Lloyd, 2010; Corbin,

2016; Shearer et al., 2021). Globally common approaches to measuring physical literacy have been paradigmatically reductionist, tending to break down movements into discrete and quantifiable outcomes, often captured in de-contextualised settings that are far removed from performance contexts (Jurbala, 2015; Longmuir & Tremblay, 2016; Green et al., 2018; O'Sullivan et al., 2020). For example, in Canada, we continue to witness measurement of physical literacy focused on the quantification of separate physical, affective, and cognitive domains (Way et al., 2014; Longmuir et al., 2015); in Australia, approximated scores calculated from disconnected elements of physical, psychological, social, and cognitive skills are used (Sport Australia, 2019); and in the UK, checklists of set capabilities and achievements that every child should achieve are used (Sport England, 2016). Such approaches appear overly reductionistic, grounded in some idealistic ontology, limiting our capability to understand physical literacy in a more holistic way (Jurbala, 2015; Edwards et al., 2018; Green et al., 2018). For example, while tests have been developed to assess the physical, cognitive, affective and psychomotor domains of physical literacy (Lundvall, 2015; Corbin 2016), their validation has occurred as an independent measure, captured along different numerical scales (i.e., a physical test of balance may be captured along a continuous scale, while a motivational assessment tool may use a categorical scale). The disparity in measurements between tests makes it very challenging when attempting to reconcile these reductionistic assessments through summary scores – even when relativized. Importantly, this inadvertently leads researchers to adopt linear, or cause and effect, statistical models that further compound the inherent reductionism associated with the measurement of physical literacy. These approaches have a number of significant limitations for those who are looking at this concept from the point of view of ecological dynamics. An ecological dynamics perspective would suggest that any attempt to deconstruct physical literacy into component parts and thus remove it from play, physical activity, or the performance environment is unlikely to provide an understanding of a child's physical literacy. This is because these systems interact and self-organise through movement (Button et al., 2020; Rudd et al., 2020) and the context of play and physical activity is very different from the constraints acting on an individual in standardised assessment-based conditions. Thus, there is a clear need for an assessment tool that captures the holism of physical literacy i.e., the integration of all four key constructs equally, and a statistical methodology that accounts for its inherent non-linearity and individualised nature of the construct.

To evaluate physical literacy from an ecological dynamics approach it needs to be captured during play, or in performance environments. Team invasion games have been identified as highly dynamical environments, where informational constraints, such as the number and movements of defenders, the distance between teammates, changing match scores, and the duration of the game all enmesh to create unique and evolving problems as the game unfolds (Davids, Button & Bennett,

2008). Accordingly, setting out pre-determined 'plans' or tactical 'models of behaviour' rarely work, and trying to reduce the causes of behaviour down to one 'mechanism' discounts the non-linearity and dynamicity of a game (Ribeiro et al., 2019). Consequently, any invasion game that a child is playing consists of dynamic problems that they must learn to solve by learning to perceive *ways* to exploit emerging gaps and spaces matched to their current action capabilities. This means that to understand a child's physical literacy when embedded in a games-based approach, we need to observe a child's movement skill in context, within the game. This can enable us to understand what information sources children attune to (i.e., detect), the affordances this information specifies to them and how they utilise these affordances to achieve task outcome(s). Subsequently, such an approach to viewing physical literacy requires an ecological epistemology, appreciating the mutual relationship between a child and their environment. When viewed through an ecological dynamics lens, practitioners have the opportunity to collect new information and develop insight beyond what might otherwise be available through more traditional performance analysis tools. Therefore, the aims of this study are to establish the feasibility of capturing children's behaviour and environmental interactions during games-play, revealing qualities of physical literacy through a framework informed by ecological dynamics. In doing so, face validity will be confirmed, introducing the prospect of an alternative approach to assessment that better captures the embodied dimension of physical literacy.

L4.3 Methods

4.3i Development of observational instrument

The first step was to establish performance indicators and operational definitions of variables to be used in the observational tool. Due to this being the first observational tool that frames physical literacy assessment and evaluation through an ecological dynamics rationale, adapting an existing observational instrument as recommended by Brewer and Jones (2002), was not possible. Consequently, the development of a theoretical framework to inform the observational instrument was necessary. An initial literature review with the evaluation of offensive and defensive behaviour variables, framed within an ecological dynamics framework was undertaken. Potential performance indicators and their descriptions were introduced, discussed, trialled, and endorsed by academic and technical experts within the fields of pedagogy, performance analysis, and ecological dynamics. During a four-month period, subsequent modifications and refinements were made, before agreement was established. As a consequence of this process the ecological conceptualisation, measurement variables, and measurement item descriptions of the tool were finalised. Tables 4.1-4.3 outline measurements and definitions framed around the ecological conceptualisations of on-ball functionality and off-ball spatial-temporal interactions. The goal of the selected variables was to

collect information on a range of learner-environment interactions. Observations framed in this manner allow insights into the learner's ability to attune to information and the affordances presented. For example, successfully identifying passing and shooting opportunities, effectively finding space, closing down opposition players, and implementing strategic patterns of play allows a detailed picture of an individual's knowledge *of* the environment and the affordances that the child is perceiving to be captured.

Table 4.1 On ball functionality and technical interactions – measurements and definitions.

Interaction or behaviour	*Description*
Passing and shooting success	Categorises whether passes and shots were successful or unsuccessful. Where a successful pass is executed, there is further evaluation to identify whether the pass was into contested or uncontested space.
Passing Direction	Categorises passes as penetrating, forward, lateral, defensive, or backwards.
Pass Length	Categorises passes as short, medium, or long.
Interaction Network	Identifies which player distributes the ball, and to whom the intended recipient is.

Table 4.2 Off ball offensive spatial-temporal interactions – measurements and definitions.

Interaction or behaviour	*Description*
Movement into unoccupied space	Intentional movement to adopt a position currently unoccupied by opposition player(s) or teammate(s).
Movement into occupied space	Intentional movement to adopt a position that is occupied by a teammate(s).
Movement into contested space	Intentional movement to adopt a position that is occupied by opposition player(s).
Multiple offensive movements	Multiple intentional movements in response to changing game environment (e.g., having moved into unoccupied space that then becomes occupied resulting in the player adjusting their court/field position in recognition of being marked).
Movement results in becoming the target of a pass	Observed player becomes the intended target of a pass.
Network Interactions	Identifies whether observed player offers visual or verbal cues indicating their desire to be the target of the pass, is aware of the ball as evidenced by their scanning behaviours or is ignorant of the ball as evidenced by an absence of scanning behaviours directed to the ball.

Table 4.3 Off ball defensive spatial-temporal interactions – measurements and definitions.

Interaction or behaviour	*Description*
Closing down player in possession	Intentional movement towards opponent in possession of the ball resulting in being the first player to apply pressure to the opposition player in possession. Court or pitch position also recorded.

Overloading player in possession	Intentional movement towards opponent in possession of the ball resulting in two defensive players applying pressure to the player in possession. Court or pitch position also recorded.
Swarming player in possession	Intentional movement towards opponent in possession of the ball resulting in three or more defensive players applying pressure to the player in possession. Court or pitch position also recorded.
(Defensive) Movement into unoccupied space	Intentional movement to adopt a position currently unoccupied by opposition player(s) or teammate(s).
(Defensive) Movement into contested space	Intentional movement to adopt a position that is occupied by opposition player(s)
Multiple defensive movements	Multiple intentional movements in response to changing game environment (e.g., having moved to mark a player initially the defensive player moves again as the attacking player adjusts their position).
Blocks or interception	Intentional movement that results in the defensive player attempting to, or successfully influencing the ball's movement through a tip, block, or interception.

4.3ii Participants and settings

For the purposes of this study, 10 primary school children (Age: 8.70 ±0.46 yrs. Male *n*=4, Female *n*=6) were observed. Baseline assessment using previously validated assessment tools capturing knowledge *about* physical literacy was undertaken prior to emergent games-based observations framed within an ecological dynamics framework taking place. Children were placed into teams of mixed movement ability based on their functional movement skill performance captured through the Dragons challenge movement assessment (Stratton et al., 2015) (described in detail previously - see Chapter Three). Participants then engaged in a commonly played, small-sided, conditioned, physical education game (mat ball). The mat ball game was played in a gymnasium equipped for multisport activities, with a wooden, sprung floor. Playing area dimensions were 18m × 12m with a goal (a gym mat with a goalkeeper kneeling upon it) placed centrally at either end of the court. Games consisted of two, competitive, five-minute periods of play with a short break in the middle. Rules included: non-contact, no running with or dribbling of the ball, and scoring was only possible by shooting from within the opposition half. Games were video recorded (GoPro Hero 9) from an elevated court side position allowing post-event digital video-based tagging (Dartfish Pro) of the games to be completed.

4.3iii Measures and data collection

Post-event manual, electronic tagging was undertaken recording child-environment interactions during team games play. The coding panel created for analysis used the measurement variables, and measurement item descriptions developed and endorsed by academic and technical experts (Table 4.1-4.3). Discrete data (frequency counts) were coded, using recorded video playback with frame-by-frame capabilities (1080hp, 60Hz frame rate). This allowed for accurate documentation of each child's technical-tactical actions and behaviour. The scale of analysis was an individual child playing the game using event-based temporality for recorded observations. For the purposes of this study event-based temporality was defined as the observed behaviours and interactions occurring between receipt of the ball by a player from another player and the conclusion of the subsequent ball distribution as a temporal period. Coding typically took 30 – 40 minutes per player.

4.4 Results

Table 4.4 provides a summary of the key differences that emerged from the notational analysis of gameplay behaviours and interactions.

Table 4.4. Frequency of observed gameplay behaviours.

Interaction or behaviour		*H-PL children*	*L-PL children*	*Difference comparing H-PL to L-PL children*
Passing success		Very high	Very high	No difference
Shooting success		Moderate	Low	Increased success
Direction of pass	Attacking	Moderate	Very low	More frequent
	Lateral	Moderate	Moderate	No difference
	Backwards	Very low	Moderate	Less frequent
Length of pass	Short	Variable	very high	Greater range of passing demonstrated
	Medium		very low	
	Long		very low	
Passing network		Balanced	Seeks higher-physical literacy target	Seeks variable targets
Offensive movement	Unoccupied space	Moderate	Very low	Moves into unoccupied space more frequently
	Occupied space	Very low	Low	Avoids moving into space occupied by team mates
	Contested space	Low	Moderate	Avoids moving into space occupied by opposition players
	Multiple movements	Low	Very low	More frequently demonstrates multiple movements
Network interactions	Visual cue offered	High	Moderate	More frequently indicates availability to receive pass
	Verbal cue offered	Moderate	Very low	More frequently shouts to receive pass
	Ball awareness	Very high	High	More frequently demonstrates ball tracking
Defensive movement	Closing down	Moderate	Very low	More frequently first defender to closing down
	Overloading	Low	Moderate	Less frequent overloading
	Swarming	Very low	Moderate	Less frequent swarming
	Unoccupied space	Very low	Very low	No difference
	Contested space	Moderate	High	Less frequently entered contested space
	Multiple movements	Moderate	Very low	More frequently adjusted position
	Blocks / interception	Very low	Very low	No difference

Note: H-PL = High physical literacy learners; L-PL = Low physical literacy; Very high = ≥80% of observed behaviour; High = 60–79% of observed behaviour; Moderate = 40–59% of observed behaviour; Low = 20–39% of observed behaviour; Very low = ≤20% of observed behaviour.

4.5 Discussion

The categorical observational items used in the notional analysis developed for this study were generated through an iterative, democratic process whereby potential performance indicators were introduced, discussed, refined and endorsed by technical experts within the field. Consequently, the most relevant indicators were put forward for subsequent analysis which should provide information on a range of individual-environment interactions (e.g., functionality, technical interactions, and spatial temporal interactions). Through observation of interactions and behaviours it is feasible to gain insight to individual's ability to read the environment and affordances offered, demonstrate knowledge *of* the environment through attunement of their behaviours, generate complex networks to coordinate dynamic patterns of collective behaviour, and action option generation and selection. These interactions and behaviours are able to offer insight into how participants in this study with differing physical literacy profiles play conditioned games in a physical education setting.

A rich range of distinctive, thought-provoking, gameplay behaviours emerged from the analysis, highlighting what information in the environment children are self-regulating their action to. The tool proved sensitive enough to discern these subtler manifestations of this attunement and offered insights into the affordances that children were perceiving in the game. To supplement the summary data presented in Table 4.4, a range of indicative examples of observed games play are given to help illustrate the differences observed and how the behaviours may reveal children who are further advanced in their physical literacy journey. Data showed that children with higher-physical literacy and therefore deeper knowledge *of* the environment typically attempted more uncontested, attacking (penetrating or forward in direction) passes, over varied distances, compared to other players, regardless of the target player's physical literacy profile. From a physical literacy perspective, such behaviours and their success provide insight to movement qualities being demonstrated, in addition to the perception involved in reading the environment and attuning to appropriate affordances to enable 'good' decisions to be made when distributing the ball. Passing network data revealed children with higher-physical literacy also adopted greater diversity in passing and target identification than less physically literate individuals. Interestingly, the more physically literate players also demonstrated greater capacity to regulate their own court position based upon the player in possession of the ball. Such behaviours reflect the capacity of a physically literate individual to anticipate movement needs, respond appropriately with intelligence, and demonstrate physical capacities embedded in perception and decision making. Passos et al. (2011) have previously investigated adjacency matrixes to help identify networks within team sports. From an ecological perspective such information provides an indication of stronger / more powerful attractors and whether individual environment-systems are moderating their interactions based upon their physical

literacy. In highly dynamical environments such a team games, where informational constraints are in constant flux (Davids, Button & Bennett, 2008) it would be reasonable for attractors to become transient – emerging or decaying in relation to court position, distance from ball or defensive dyadic stability observed. Additionally, the adoption of more advanced court positions, further from the ball when the player in possession was of higher-physical literacy compared to reducing distance to the ball and demonstrating more overt visual and verbal signals of their availability as a target when possession was with less physically literate players were observed. Defensive spatial-temporal behaviours indicated that swarming of the player in possession was a frequent off ball interaction for all learners irrespective of their knowledge *of* the environment. Higher-physically literate children, whilst still demonstrating overload and swarming behaviours, however, did so with greater discretion. This demonstrated their ability to better regulate their behaviour so that swarming behaviours were more likely to be observed when they were in their own half, or in particular, when close to their own goal. Responding appropriately in this manner displays the physical literacy qualities of intelligence and sound decision making in reply to affordances and task-goals. Finally, higher-physical literacy children demonstrated a greater willingness to adjust court position or defensive role associated with defensive off ball spatial-temporal interactions. Higher-physical literacy children were more frequently recorded moving to an alternative court position in defence when they were the second or third player to close down opponents in possession of the ball. These secondary movements, as they sought to disrupt play with their newly adjusted defensive positioning led to more frequent blocks and interceptions being attempted. Davids et al. (2013) and Vilar et al. (2012) have investigated the role of ecological dynamics in analysing performance, discussing system stability and how attackers attempt to engage in a process of symmetry breaking to destabilise the organisational state of the game. Action adjustments and positional revisions demonstrate the capacity to respond effectively to novel environmental circumstances as advocated by Whitehead (2001).

As a fundamental characteristic of the physically literate learner, the capacity to anticipate and respond with intelligence and imagination to dynamic physical settings as has been demonstrated in this study through the insightful interactions with the environment observed. Physically literate individuals are better able to transfer knowledge to new contexts, effectively solve previously unencountered problems, and creatively offer versatile movement solutions to novel challenges (Ennis, 2015; Mandigo et al., 2009). An ecological dynamics framework would consider locomotive performance as dynamic functional movement solutions, founded upon the interface between different task, organism or environmental constraints (Button et al, 2020). As the phenomenon of interest and investigation in this study is the embedded, embodied behaviours of the learner within game environments it is beneficial to document data on 'more than' just the motor skill outcomes or

performance orientated characteristics synonymous with success. Adopting a philosophical research paradigm informed by physical literacy, combined with an analysis approach grounded in an ecological dynamics framework, affords the opportunity to gather information and develop insight based upon behaviours evident within the individual-environment system. Embodied knowledge in physical activity and knowing how to act in a given situation are examples of what Whitehead (2013a) labelled knowledge and understanding, and reading the environment and responding to the possibilities of movement.

4.5ii Limitations

Some of the limitations noted include potential confusion and subjectivity involved in accurately reporting behaviours, particularly where temporal events observed were prolonged, or incorporated numerous distinct behaviours; overly detailed micro-categorisation (of passing functionality for example) offered little further insight into behaviour and the revelation of physical literacy; and finally, numerous interactions not included in the initial list of behaviour categories were observed that had not been defined at a theoretical level, but which manifested during games play. Future research should look to develop clearer, unambiguous definitions for more complex interactions, reduce categorisation bloat where no beneficial insight is acquired from multiple micro-categorisations when a broader grouping of behaviour may suffice, and ensure all critical behaviours are acknowledged within the tool to provide the most comprehensive assessment possible. Finally, having established the feasibility of the tool there would be merit in more comprehensively accounting for the underpinning ecological dynamics principles and conceptualisation applied to the measurement of physical literacy in this manner.

4.6 Conclusions

Undertaking an assessment that measures gameplay interactions enables researchers and practitioners to gain further insight into how learners effectively attune to the affordances offered within games and team activities. This feasibility study provides a glimpse of the richer possible interpretations of physical literacy 'in action', that progresses understanding beyond what is offered through the isolated, reductionist examination of movement competence, confidence and knowledge and understanding. The processes undertaken in this study ensured the observational instrument outlined, enabling analysis of gameplay behaviour and environment interactions had categorical items that accurately represented the revelation of physical literacy through observed behaviour within small-sided games. Within the context of systematic observation, this would mean face validity can be assumed within the physical education environment. In terms of establishing the feasibility of an

observational instrument designed to capture embedded, embodied behaviours representative of the physical literacy construct the novel approach introduced in this study warrants further investigation. The opportunity to acquire such uniquely original insight could stimulate practitioners and researchers to renounce mass measurement and embrace a move towards the assessment of physical literacy through embodied learner-environment interactions in naturalistic settings.

Chapter Five - Assessing Physical Literacy, Conceptualised in an Ecological Dynamics Theoretical Rationale.

The main outcomes of this study have been published in: Wilkie, B., Foulkes, J., Woods, C. T., Sweeting, A., Lewis, C., Davids, K., & Rudd, J. (2022). A games-based assessment in ecological dynamics for measuring physical literacy. *Asian Journal of Sport and Exercise Psychology*, *2*(1), 50-58.

5.1 Thesis Study Map: Study Two

Study	Objectives
Study One (Chapter Four) Measuring Physical Literacy: A Fresh Approach	Objectives: • Establish the feasibility of capturing children's behaviour and environmental interactions during games-play that would reveal their physical literacy. • Establish face validity of a novel approach to assessment, framed by an ecological dynamics conceptualization to capture and measure physical literacy. • Highlight that the current reductionist approach to the measurement of physical literacy is not appropriate, especially when attempting to capture the embodied dimension of physical literacy. Key Findings: • Established the feasibility of assessing physical literacy through observations of children's games play through the development of an observational instrument and categorical items that accurately represented the revelation of physical literacy through observed behaviour within small-sided games. • Within the context of systematic observation, established face validity of the observational instrument. • Highlighted the insight offered by embodied learner-environment interactions in naturalistic settings.
Study Two (Chapter Five) Assessing Physical Literacy, Conceptualised in an Ecological Dynamics Theoretical Rationale	Objectives: • Pilot an assessment of physical literacy conceptualised in an ecological dynamics theoretical rationale. • Demonstrate the underpinning ecological dynamics principles and conceptualisation applied to the measurement of physical literacy.
Study Three (Chapter Six) Examining the Validity, Reliability and Feasibility of Capturing Children's Physical Literacy through Games-Based Assessment in Physical Education	Objectives: • Establish the validity and reliability of the psychometric properties of the emergent games-based assessment tool following a systematic process including face and content validity, combined with inter- and intra-observer reliability.

Study Four (Chapter Seven) An Ecological Insight into the Revelation of Physical Literacy in Children during Small-Sided Games	Objectives: • Investigate how features of the physical literacy construct reveal themselves through children's behaviours using the emergent games-based assessment tool. • Establish key differentiating behaviours of higher- and lower-physical literacy children when playing small-sided games. • Promote the role of ecological dynamics when employed as a theoretical framework to investigate physical literacy.

Within Study Two (Chapter Five) I conceived and designed the methodology and analysis in agreement with the supervisory team with the intention of progressing the thesis aims and objectives and addressing the previously identified limitations of Study One (Chapter Four). Study Two reports on how ideas and concepts taken from ecological dynamics might provide an alternative perspective on physical literacy assessment. This study pilots an assessment of physical literacy conceptualised in an ecological dynamics theoretical rationale. I was responsible for data collection and analysis, with writing and preparation of the tables and figures in this chapter completed independently.

5.2 Introduction

This chapter builds upon the feasibility study undertaken (Chapter Four) and considers how physical literacy can be assessed, leaning on an ecological dynamics conceptualisation to help us navigate the complexity of measuring something that is, in essence an embedded and embodied *process* (Rudd, 2021). Embodiment in the context of physical literacy, describes the potential individuals have to engage with their surrounds via movement (Whitehead, 2010). When movement learning is considered, embodiment means that perception and decision-making cannot be learnt independently from acting, as perceiving is already acting. Embedded cognition describes how individuals are shaped by, and can shape the (physical and socio-cultural) environments in which they reside (Araújo, Davids & Hristovski, 2006; Rudd, 2021). Linked to these notions, ecological dynamics has been acknowledged as contributing a well-developed empirical and theoretically informed perspective on how we comprehend movement skill, development and performance (Button et al., 2020). Central to this theory is the principle that movement is a self-organising phenomenon predicated on the interaction between an individual and their environment. Organism-environment interactions are the product of coupling socially shared affordances and task goal-directed activity to the information or environmental affordances present. Coupling environmental affordances and action in team games emerges as performers continuously interact with, and interpret perceived information provided by in-game events, objects, actors and the playing environment. On this basis, intentional action is

viewed dynamically, with functional behavioural solutions arising from the continuous interactions of individual, task and environmental constraints (Newell, 1986; Seifert et al., 2018).

The earliest documented use of the term physical literacy was to capture the movement quality of the indigenous peoples of America. It was surmised at the time that this was not taught but was embedded in the very fabric of their hunter-gatherer way of life and the way in which they navigate and 'wayfind' in their world (Maguire, 1884; Cairney et al., 2019; Woods et al., 2020b). Whitehead (2001, p131) in her influential reimagining of the concept, defined physical literacy as:

> *A physically literate individual moves with poise, economy and confidence in a wide variety of physically challenging situations. The individual is perceptive in 'reading' all aspects of the physical environment, anticipating movement needs or possibilities and responding appropriately to these, with intelligence and imagination. Physical literacy requires a holistic engagement that encompasses physical capacities embedded in perception, experience, memory, anticipation and decision-making.*

This aligns effectively with commonly expressed themes currently found within the literature, highlighting physical literacy involves the parallel consideration of movement competence, affective behaviours, knowledge, understanding, and the valuing of physical interactions with the environment (Whitehead 2013a; Edwards et al., 2017).

Globally, only 20% of children and adolescents aged 11-17 years are considered to be sufficiently active to the point in which health gains can be achieved (Guthold et al., 2020). In part, this is due to fact that many children and young people in contemporary societies are often deprived of the opportunities that earlier generations had to develop their physical literacy, and as result, have been described as being part of a 'movement-supressed' society, whereby individuals are not getting enough physical activity to maintain their health (Keegan et al., 2013). Physical educators, through the use of different pedagogical models (e.g., Teaching Games for Understanding and Sport Education) are, thus, often tasked with the challenge of reshaping children's experiences of physical education in an attempt to improve both movement competencies and personal disposition towards physical activities. Such learning experiences are normally followed by assessments, which López-Pastor et al. (2013) suggested remains one of the most problematic issues facing physical educators.

Whitehead's (2001) early definition of physical literacy specifies the concept as a combination of interlacing characteristics, derived from the affective, physical and cognitive domains. Since this early definition, it could be argued that the physical literacy construct has moved away from an emphasis on holism, with crucial attributes identified within the original definition regularly presented as discrete entities (Longmuir et al., 2015), or omitted entirely (Tompsett, Burkett and McKean, 2014). Traditional assessments of physical literacy tend to be reductionist, providing only knowledge *about* a child's performance within a specific physical literacy domain (physical, emotional and knowledge and understanding). Primarily this has manifested itself through the focus on fundamental movement

skills evaluation and the physical domain of physical literacy. This form of assessment typically breaks down movements into discrete and quantifiable outcomes – situated in de-contextualised settings (e.g., removed from game play contexts) where the skills will normally be performed (O'Sullivan et al., 2020). Although useful to a degree, such reductionism provides limited insight into how complex systems adapt their behaviours in response to task goals and performance constraints (Teques et al., 2017). It has been argued that such approaches are a weakness (Rudd 2021), as detaching the phenomenological and the motor has significant consequences, as reductionism in this fashion negates Whitehead's original ideas of the inseparability of the body and mind. The collected data will be understood to be both reliable and valid under scientific methodologies oft-rooted in the dualistic worldview of Descartes, and opportunities for comparison between individuals and groups emerge. However, physical literacy is not founded, nor does it prescribe to Cartesian science and any attempt to overlap such assessment methods means that the embodied and embedded experience is lost (Whitehead, 2013a; Rudd et al., 2021).

In re-casting the concept to include the specific philosophical paradigm of existentialism Whitehead (2001) embraced embodiment as a fundamental experiential principle central to the concept of physical literacy. In the context of physical literacy embodiment is used to describe the "potential individuals have to interact with the environment via our embodied dimension" (Whitehead, 2010, p202-203). Through exploring embedded, lived experience and meaning creation during interactions of a physical orientation there remains the opportunity to more perceptively align evaluation of physical literacy to the holistic nature of the concept. An ecological dynamics perspective on physical literacy offers a solution to this problem by prescribing less emphasis on knowledge *about* performances. Instead, for us to understand and measure physical literacy it is it essential to focus on children's knowledge *of* the performance environment. This viewpoint draws on Gibson's (1979) insights on the distinction between knowledge *of* and knowledge *about* the environment, whereby knowledge *about* the environment is conceived by verbal descriptions, expressing idealised ways of doing or being (Woods et al., 2021). By contrast, knowledge *of* the environment is articulated through perception, action and skilled intentionality (Button et al., 2020).

Building from the feasibility study completed (Chapter Four), the aim of this study was twofold: firstly, to propose an ecological dynamics conceptualisation of how physical literacy could be assessed – thereby preserving key information-movement couplings in representative contexts. Secondly, to use this theoretical rationale to design and pilot a games-based assessment tool of physical literacy. It is hoped that the preliminary insights gleaned here can support practitioners in the challenge to further explore how ideas of ecological dynamics could be harnessed to develop and assess physical literacy.

5.3 An ecological dynamics conceptualisation of physical literacy assessment

A central component of assessment informed by an ecological dynamics rationale is that it must faithfully preserve key person-environment relations. This is because ecological dynamics is based on the concept that perception is embedded in the environment and embodied in cognitions and actions (Araújo, Davids & Hristovski, 2006; Araújo et al., 2019). With a strong grounding in phenomenology, the definition of physical literacy proposed by Whitehead (2001 – noted earlier) acknowledges that the individual and the environment are inseparable, advocating the Monist dimension of being – viewing mind, body and environment as unitary. Assured interactions with the environment, intelligent, creative responses to stimuli and a mindfulness of embedded capability leading to fluent self-expression, are all key characteristics of the physically literate person (Whitehead, 2013a). Ecological dynamics aligns well with Whitehead's interpretation of physical literacy, associated with the ideas that perception for movement is direct, and an external focus of attention is important to successfully accomplish intended goals. As a feasible framework for investigating behaviours when observing physical activity, physical education and conditioned games, ecological dynamics recognises the flexibility of neurobiological systems and their capacity to effectively and continually (re)organise themselves to use continuously evolving environmental affordances and satisfy interacting constraints (Button et al., 2020). The continuous coupling of actions and perception forms the basis of adaptive flexibility in realising functional movement solutions (Vilar et al., 2012; Chow et al., 2016).

Typically, research and practice in the field of physical literacy has focussed primarily upon the 'physical' dimension of the concept, and to a lesser extent on the affective and cognitive domains (Edwards et al., 2017). Such compromises are at the expense of concentrating upon the wider, more holistic meaning and understanding of the philosophy that encompasses the embodied dimension of being. However, research has typically focused its scale of analysis on the organism *per se*, viewed detached from the environment in which they inhabit. Resulting in artificial, decontextualised motor skill assessment, decoupled from the multiple nested movements typically observed when performed in context (Ng & Button, 2018). The execution of a standing overhand throw to determine throwing proficiency for example (Test of Gross Motor Development, Ulrich, 2013), is divorced from the reality of games play. The presence of competing and cooperating players results in the execution of an open, rather than closed-skill task, where the throw must be functionally appropriate to the external constraints influencing behaviour. Analysis of team sports performance informed by an ecological dynamics framework has attempted to help explain this more embodied-embedded aspect, exploring the interactions that exist between athletes and their environment (Vilar et al., 2012; Davids et al., 2013a; Passos, 2020). Research has shown that, as a performer interacts with their environment, the prospect of action develops – meaning emerges, persists, and dissolves, continually shaped by

informational constraints. The movements of defenders, distances to teammates, opportunities for distribution or travelling with the ball all enmesh to generate dynamic performance challenges and problems for individuals (Wilkie et al., 2021). This dynamic process, implied in the perception of affordances (Gibson 1979; defined as *opportunities for action*, discussed later), allows us to draw upon contemporary propositions of ecological dynamics that view the learning process as one of *wayfinding* – navigating *through* dynamic performance landscapes (Woods et al., 2020a).

Assessment of physical literacy, thus, needs to account for a performer's adaptability to context. An adaptable performer is able to selectively respond to the affordance landscape, attending to features that invite the successful completion of a task (Button et al., 2020; Chow et al., 2020b; O'Sullivan et al., 2020). Concepts in ecological dynamics provide a framework from which to explain these complex interactions in performance and learning. Thus, the sections to come provide an exploration of some of the key pillars of an ecological dynamics rationale which could help design a novel games-based assessment tool of physical literacy.

5.4 Key pillars of an ecological dynamics approach to the design of a game-based assessment

The first step in developing an assessment tool was to enrich it with aspects of theory that could help researchers to understand the behaviours being observed. A significant assumption in adopting such an approach informed by ecological dynamics is that physically literate individuals would be more accomplished at recognising and taking advantage of (i.e., *attuning* to) information within their environment. What this information specifies is the affordances of one's surrounds, which performers can perceive and actualise to find their way through performance landscapes (i.e., use perception, cognition and action to achieve intended task goals). In doing so, the physically literate performer will functionally regulate their behaviours more appropriately than less literate individuals based upon task and environmental constraints. Building from earlier work considering the application of key ecological principles towards the manifestation of physical literacy in games play (Wilkie et al., 2021), performance indicators and their descriptions were retained, revised, refined or introduced, following discussion and endorsement by experts within the field. As a consequence of this process the ecological conceptualisation, measurement variables, variable descriptions, and recommended reporting was finalised (Table 5.1), framed around the key ecological principles of 1) Wayfinding, 2) Affordances and Attunement, 3) Intentionality, and 4) functional movement skills.

5.4ii Key pillars of an ecological dynamics approach to the design of a game-based assessment (Wayfinding)

Any physical education lesson, conditioned game or organised sports activity will entail dynamic problems that individuals must learn to navigate effectively. Wayfinding is a purposeful, intentional

and self-regulated journey through various performance landscapes, guided by the perception and actualisation of affordances within the environment (Woods et al, 2020b). As an individual finds their way through a performance landscape, what they develop is their knowledge *of* the surrounds (Gibson, 1966), established through direct and unmediated interaction with the environment (Woods et al., 2020a). This is contrasted to knowledge *about* one's environment, which is indirect and mediated – by second hand information – through words, pictures, symbols or photographs (Gibson, 1966). Thus, if wayfinding is to be a central pillar of an assessment tool of physical literacy, it needs to centralise a performer's knowledge *of* (not *about*), their environment – emphasising the embeddedness of the tool. Applied to a games-based context, wayfinding might reveal itself through the functionally effective solving of emergent, task-orientated movement challenges (Woods et al., 2020b). For example, successfully navigating through spaces emerging between opponents, finding ways of passing the ball to teammates in advantageous positions, or exploring ways of defending space when outnumbered by attackers, would be reflective of an individual's knowledge *of* the environment (Ribeiro et al., 2019). Opportunities will be matched with action capabilities, meaning that to understand a learner's physical literacy we need to observe movement skill performance while simultaneously capturing information on the environment, task and individual. Wayfinding provides an anthropological grounding for the tool, subsequently informing the approach as a whole. Consequently, an ecologically dynamic assessment of physical literacy should capture the various ways in which children are able to adapt to the changing constraints of a performance environment as they find their way through the various ebbs and flows of a game. Physically literate children should be able to demonstrate more effective adaptation to novel performance situations, allowing adept, efficient interactions with the environment.

5.4iii Key pillars of an ecological dynamics approach to the design of a game-based assessment (Affordances and Attunement)

Affordances are the action-relevant properties of the environment that can be exploited by performers (Gibson, 1979), while attunement describes the process of selection from relevant informational variables within the environment (Button et al, 2020). By integrating principles of affordances and attunement into the creation of the games-based assessment tool, it is possible to develop an ecological understanding of decision making. The notion of a symbiosis between an individual and the performance environment establishes the idea that individuals perceive the affordances of the environment in terms of their relevance and functionality (Davids et al., 2013a). Individual action capabilities influence perception of affordances, guiding performance, and helping establish an understanding of what individuals learn and know, and how they choose to act (Araújo, Davids & Hristovski, 2006). This significant development in conceptualisation since Gibson's (1979)

early insights foregrounds the more refined, nuanced exchanges taking place between individuals and the affordances that emerge. So, while some affordances act as strong attractors, soliciting attention, individuals can choose to accept or reject these invitations for action by moderating the extent to which the system relaxes to particular attractors (stable states of system organisation), simultaneously ignoring alternatives (Araújo, Davids & Hristovski, 2006).

From a physical literacy perspective, the affordance landscape and attunement to picking out key information variables relevant to each individual reflects embedded knowledge and understanding of the environment in related or familiar tasks, as well as the ability to effectively adapt movements as required by the circumstances in novel settings. Physically literate children should be able to demonstrate more intuitive reading of the environment and attunement to key affordances offered resulting in greater responsivity to ongoing opportunities for action. Informed by ecological dynamics, variables (described fully in Table 5.1) such as *contested and uncontested distribution; signalling for the ball; off-ball movements to break or establish dyadic stability*; and *effectively tracking play* provide insight into a child's attunement to a game's affordances.

5.4iv Key pillars of an ecological dynamics approach to the design of a game-based assessment (Intentionality)

Intentionality, from an ecological dynamics perspective, describes an individual's capacity to self-regulate functional behaviour in the absence of external input (Chow et al., 2020b). By integrating principles of intentionality into the creation of the games-based assessment tool, it is possible to describe the realisation of value and meaning during movement. Intentionality is not only limited to cognition, but extends to a child's perception, action, comprehension, planning, self-organisation, decision making and motile effectivities as these qualities collectively work in concert to adapt to the dynamic environment and task constraints present in games play. Expressed through self-regulation and performance, a child's development and success are represented by the dynamic explorations of the environment, as a means of information-gathering in the service of action (Rudd, 2021).

Player behaviours in team sports are constrained by local organisational tendencies, with cooperative and competing environment interactions emerging as players regulate relative positioning to exploit opportunities when invading or defending space (Riley et al., 2011; Vilar et al., 2012). In practice, this process involves players moving with poise, economy and confidence that matches individual capabilities and self-regulation skills (Rudd, O'Callaghan & Williams, 2019). A physically literate child will be well placed to demonstrate intentionality if they are able to adapt to the variable dynamic challenges that emerge in pursuit of achieving task and performance goals. Informed by ecological dynamics, variables (described fully in Table 5.1) such as *coadaptive network formation; moderation of defensive positioning to close down, overload or swarm the opposition;* and

effectively tracking play or players in offence and defence; provide insight into how children demonstrate intentionality in games environments.

5.4v Key pillars of an ecological dynamics approach to the design of a game-based assessment (Functional Movement Skills)

Functional Movement Skills refers to the qualities that allow individuals to negotiate their environment in the completion of intended task goals (Davids et al., 2012; Chow et al., 2020a). Rudd (2021) identifies functional movement skills as the only way practitioners can observe and appreciate all dimensions of a child's physical literacy. By integrating principles of functional movement skills into the creation of the games-based assessment tool it is possible to describe the mixture of adaptive behaviours an individual possesses and is capable of implementing. The adjustment in perspective from conceptualising 'fundamental' movement and changing explanations of its role in physical literacy to 'functional', challenges the prevalent reductionist operationalisation and interpretation of this domain typically observed. Consequently, shifting the orientation of athlete and practitioner towards interactions and functional relationships between the child-environment system (Renshaw & Chow, 2019). Action results in the continuous delivery of new affordances for opponents, teammates and the individual themselves. Effective interaction with this dynamic landscape of affordances requires holistic engagement that is adaptive and flexible to reflect the interactions between competing and cooperating players.

Observing functional movement behaviours during games allows practitioners to establish the prominence of certain attractors amongst available distribution targets, while also providing insight to favoured functional movement solutions in pursuit of intended goals. The physically literate child will be able to demonstrate a fuller repertoire of emergent behaviours in pursuit of achieving task and performance goals, where cognition, perception and action comprise the articulated functional movement. Informed by ecological dynamics, variables (described fully in Table 5.1) such as *heterogeneous or homogenous ball distribution*; and *range and directions of passing,* provide insight into how children reveal functional movement skills in games environments.

5.5 Methods

5.5i Bringing a theoretical framework into practice

To better understand an individual's physical literacy when embedded in a games-based approach, practitioners and researchers should observe the performer's movement skill in context. Such an approach would enable the appreciation of the information sources children attune to, the opportunities for action available, and how they might use such affordances to successfully negotiate

task outcomes (Wilkie et al., 2021). Such an approach to observing physical literacy necessitates an ecological epistemology, recognising the mutual relationship between a child and their environment. Table 5.1 introduces a theoretically informed framework for an emergent, game-based assessment grounded in ecological dynamics, identifying variables measured and their definitions.

Table 5.1. Theoretically informed framework for an emergent game-based assessment tool.

Ecological Conceptualisation	*Measurement Variable*	*Description of measurement variable*	*Recommended reporting*
Offensive Functionality (Distribution behaviours)	Attempted Passes	Number of attempted passes made by each child.	Total number of observed pass attempts
	Passing success	Behaviour results in successful distribution of ball to teammate.	Percentage of successful passes from total attempted passes
	Uncontested passes	Number of times distribution was to an unmarked teammate resulting in an unchallenged successful reception.	Percentage of unchallenged passes from total successful distributions
	Targeted player	Identifies the distribution target's physical literacy.	Percentage of distributions to higher and lower-physical literacy targets
Invitations for Action (Length and direction of pass)	Hand off	Distribution of ball involves handing the ball to a teammate – there is no flight phase involved in the distribution action.	Percentage of total successful passes that were hand offs, short, medium or long passes
	Short pass	Distribution involves observed flight of ball between teammates of <1.5m.	
	Medium pass	Distribution involves observed flight of ball between teammates of 1.5m – 4.5m.	
	Long pass	Distribution involves observed flight of ball between teammates of >4.5m.	
	Penetrating pass	Distribution is of a penetrative (between 10 and 2 on a clock face), lateral (right lateral between 2 and 4, and left lateral between 8 and 10 on a clock face) or rearwards (between 4 and 8 on a clock face) orientation where 12 on the clock face indicates the direction of opposition goal).	Percentage of total successful passes that were penetrating, lateral or rearwards in direction
	Lateral pass		
	Rearwards pass		
Offensive Intentionality	Single off ball movement	Child undertakes one off ball locomotive action resulting in horizontal displacement of more than one step during offensive possession period.	Percentage of total offensive off ball periods where observed child completes a single locomotive action

	Multiple off ball movements	Child undertakes two or more off ball locomotive actions during offensive possession period.	Percentage of total offensive off ball periods where observed child completes more than one locomotive action
Offensive Spatial Temporal Interactions (in relation to eliminating dyadic system stability)	Remains stationary	Child remains stationary during offensive possession period.	Percentage of total offensive off ball periods where observed child does not move
	Moves into space	Child moves into space (no opposition player within 1.5m).	Percentage of total offensive off ball periods where observed child moves into an unoccupied court position
	Moves into contested space	Child moves in an area occupied by opposition player (one of more opposition players within 1.5m).	Percentage of total offensive off ball periods where observed child moves into an occupied court position
	Effectively tracks play	Head and body orientation of child allows for effective scanning behaviour - following play, observing the ball, and positions of competing and cooperating players.	Percentage of total offensive off ball periods where observed child tracks play
	Proximity to ball on offence	Offensive positioning results in the child being 'close to the ball' (<1.5m away from player in possession), 'near the ball' (1.5m – 4.5m away from player in possession), or 'distant to the ball' (>4.5m away from player in possession).	Percentage of total offensive off ball periods where observed child is close, near or distant to the player in possession.
Coadaptive Network formation to achieve task goals	Calls or signals for ball	Child provides a visual or verbal indication that they are wanting to be the target of a pass	Percentage of total offensive off ball periods where observed child calls for ball
	Target for pass	Child is the target of distribution from a teammate	Percentage of total offensive off ball periods where observed child becomes the target of teammate's distribution
	Attractor recognition ratio	The ratio of signals for the ball to the number of times the child becomes the target for distribution	Calculated ratio of calls for ball and becoming the target of distribution
Defensive Intentionality	Single movement	Child undertakes one off ball locomotive action resulting in horizontal displacement of more than one step during defensive possession period.	Percentage of total defensive off ball periods where observed child completes a single locomotive action
	Multiple Movements	Child undertakes two or more off ball locomotive actions during defensive possession period.	Percentage of total defensive off ball periods where observed child completes more than one locomotive action

Defensive Spatial Temporal Interactions (in relation to forming or retaining dyadic system stability)	Closes down ball	Child moves towards the player with the ball and affects ease of opposition player's subsequent actions.	Percentage of total defensive off ball periods where observed child moves closes down or swarms the ball.
	Swarms ball	Child moves towards the player with the ball and affects ease of opposition player's subsequent actions but is not the first person to close down the ball.	
	Marks opposition player	Child purposefully moves towards and subsequently occupies contested space attempting to mirror the movements of opposition player without the ball.	Percentage of total defensive off ball periods where observed child moves into contested court position
	No marking	Child moves into unoccupied space (no opposition player within 1.5m).	Percentage of total defensive off ball periods where observed child moves into an unoccupied court position.
	Effectively tracks play	Head and body orientation of child allows for effective scanning behaviour - following play, observing the ball, and positions of competing and cooperating players.	Percentage of total defensive off ball periods where observed child tracks play
	Proximity to ball on Defence	Defensive positioning results in the child being 'close to the ball' (<1.5m away from player in possession), 'near the ball' (1.5m – 4.5m away from player in possession), or 'distant to the ball' (>4.5m away from player in possession).	Percentage of total defensive off ball periods where observed child is close, near or distant to the player in possession
Defensive Functionality (Interactions with ball)	No attempted object interaction	Child makes no attempt to effect ball flight during distribution or shooting actions.	Percentage of total defensive off ball periods where observed child interacts with the ball
	Unsuccessful block or interception	Child unsuccessfully attempts to effect ball flight during distribution or shooting actions.	
	Successful block or interception	Child successfully effects ball flight through contacting the ball during opposition possession.	

5.5ii Participants and settings

For the purposes of this study, a smaller, indicative sample of participant behaviour is included to provide insight to the potential the emergent game-based assessment tool has as a novel approach to games-based physical literacy assessment. With this in mind, the analysis presented is a representative, convenience sample taken from a larger research project, resulting in 10 primary school children (Age: 10.48 ±0.25 yrs.) being selected. Baseline assessment using previously validated assessment tools capturing knowledge *about* physical literacy was undertaken prior to the emergent games-based assessment being performed. A composite physical literacy score for each child was obtained through the evaluation of Working Memory (McClelland et al., 2014), Game Play Perception (Miller et al., 2019), and an assessment of fundamental movement skills using the Dragon Challenge (Stratton et al., 2015). To determine similarities between individual participants, a *kmeans* cluster approach was utilised (R Core Team 2019) to detect and organise data into a number of groups via the elbow method. This analysis enabled subsequent grouping of individuals with similar levels of physical literacy into higher- and lower-physical literacy categories. This categorisation informed the creation of balanced (mixed physical literacy) teams and was used for the purpose of identifying performers during the gameplay observations and analysis.

5.5iii Measures and data collection

In the analysed games, children were placed into mixed gender teams of five, consisting of individuals who had differing levels of physical literacy. Children then played a game of mat ball, which is a small-sided invasion game where the object is to score more points than the opposition. A point is scored by successfully distributing the ball to a teammate positioned in the scoring zone (a 2m x 1m gym mat with a player kneeling upon it). Games consisted of two competitive, five-minute periods of play with a short break between periods. Rules included: no physical contact, no running with or dribbling of the ball, and scoring was only possible by shooting from within the opposition half. The court dimensions were 18m x 12m with the gym mat placed centrally at either end of the court. Games were video recorded (GoPro Hero 9) from an elevated court side position allowing digital video-based tagging (Dartfish Pro) of the games to be completed.

Post-event manual, electronic tagging was undertaken using the emergent game-based assessment instrument capturing child-environment interactions during team games play. A coding panel was created within Dartfish for analysis using the theoretically informed framework highlighted in the emergent games-based analysis tool (Table 5.1). Discrete data (frequency counts) was coded, using recorded video playback with frame-by-frame capabilities (1080hp, 60Hz frame rate). This

allowed for accurate documentation of player action and behaviour. The scale of analysis was an individual child playing the game using event-based temporality for recorded observations. This approach defined the observed behaviours and interactions occurring between receipt of the ball by a player from another player and the conclusion of the subsequent distribution of the ball to another player as a temporal period. Coding typically took 40 – 50 minutes per player, resulting in an average of 899 data entry points being recorded per individual child during the game.

Video tagging using the emergent games-based assessment tool, enabled a descriptive analysis to be undertaken, resulting in 98 temporal periods of play being recorded during the game (means per player: 11 'On Ball' periods, 39 'Offensive Off Ball' periods, and 48 'Defensive Off Ball' periods) over the duration of the game. Table 5.2. Provides a summary of the descriptive analysis undertaken examining the behaviours of higher-physical literacy learners (H-PL) and lower-physical literacy learners (L-PL) during the game.

5.6 Results

Table 5.2. Emergent game-based assessment tool of players behaviours during mat ball.

Ecological Conceptualisation	*Decisions 'expressed as actions'*	*L-PL learners*	*H-PL learners*	*Difference comparing H-PL to L-PL learners*
Offensive Functionality (Distribution behaviours)	Attempted Passes	29	47	More passes attempted
	Passing success	79.3%	78.7%	No difference
	Uncontested pass	86.9%	91.2%	More frequently passed to unmarked teammate
	Targeting L-PL player	31%	59.6%	H-PL demonstrated a more balanced distribution strategy. L-PL players typically demonstrate more mono-stable action couplings
	Targeting H-PL player	69%	40.4%	
Invitations for Action (Length and direction of pass)	Hand off	0%	8.5%	Technical interactions from H-PL players are more varied in the movement solution demonstrated
	Short	62%	51%	
	Medium	37.9%	36.2%	
	Long	0%	4.2%	
	Penetrating	41.4	44.7	H-PL players make penetrating and backward passes more frequently than L-PL players
	Lateral	44.8%	34.7%	
	Backwards	13.8%	19.1%	
Offensive Intentionality	Single movement	85.3%	90.4%	Less frequently demonstrates multiple movements
	Multiple Movements	14.8%	9.6%	
Offensive Spatial Temporal Interactions (in relation to eliminating dyadic system stability)	Remains stationary	34.6%	17.8%	Less likely to remain stationary during offensive periods
	Moves into space	43.6%	60.5%	Moves into unoccupied space more frequently potentially disturbing dyadic system stability
	Moves into contested space	21.8%	21.7%	No difference
	Effectively tracks play	91.6%	96.2%	More frequently demonstrates tracking of ball and critical play characteristics
	Close to ball (<1.5m away)	39.7%	31.8%	Less frequently close to teammates in possession
	Near to ball (1.5-4.5m way)	37.8%	51%	More frequently near to teammates in possession
	Distant to ball (>4.5m away)	22.4%	17.2%	Less frequently distant to teammates in possession
	Calls or signals for ball	57.7%	34.4%	Less frequently indicates availability to receive pass
	Target for pass	22.4%	24.2%	Marginally more frequently targeted

Coadaptive Network formation to achieve task goals	Attractor recognition ratio	2.57:1	1.42:1	More frequently acknowledged as a viable attractor (recipient of pass) when signalling for the ball
Defensive Intentionality	Single movement	89.7	82.5	Less likely to make only one locomotive action on defence
	Multiple Movements	10.3	17.4	More frequently adjusted position on defence
Defensive Spatial Temporal Interactions (in relation to forming or retaining dyadic system stability)	Closes down ball	24.6	29.6%	H-PL players More frequently observed trying to create dyadic system stability on defence by closing down opposition in and out of possession
	Swarms ball	11.8	15.9%	
	Marks opposition player (takes up contested space)	16.9	21.1%	
	No marking (takes up unoccupied space)	58.5	50.3%	
	Effectively tracks play	91.6%	96.2%	More frequently demonstrates tracking of ball and critical play characteristics
	Close to ball (<1.5m away)	33.3%	40.7%	More frequently close to the opposition player in possession
	Near to ball (1.5-4.5m way)	39%	39.2%	No difference
	Distant to ball (>4.5m away)	27.7%	20.1%	Less frequently distant to the opposition player in possession
Defensive Functionality (Interactions with ball)	No attempted object interaction	88.7%	75.1%	Less frequent
	Unsuccessful block or interception	9.2%	21.7%	More frequently attempted to block or intercept the ball
	Successful block or interception	2.1%	3.2%	Marginally more frequent

5.7 Discussion

The aim of this study was to conceptualise an ecological dynamics-inspired, game-based assessment tool to gain an embedded understanding of a child's physical literacy. Following this, a pilot was undertaken demonstrating how such a tool could capture emergent child-environment interactions and how this information might be used to help practitioners design programmes to support each child's ongoing development. This pilot study has provided initial evidence that an ecological dynamics informed games-based assessment has the potential to provide richer understanding of children's physical literacy.

The emergent gameplay behaviours forming the analysis highlight what information sources in the environment children are self-regulating their action to. Previous research has discussed how perception is embodied and embedded and how by directly studying behaviour or actions, it can reveal the performer's exploration, problem solving or reasoning (Araújo, Davids & Hristovski, 2006; Araújo et al., 2019). This tool helps guide a practitioner to focus on the ecological information that is being picked up by the child. For example, through the use of the emergent game-based assessment tool, a practitioner is able to discern a child's responsiveness to affordances in the game.

Data from this pilot showed that passing success rates were almost identical between higher- and lower-physical literacy children (79.3% vs 78.7%). On its own, this information provides some motivation to explore a wider, more holistic evaluation of performance that encompasses the child-environment interactions taking place as players attempt to effectively wayfind in pursuit of shared task goals. As a more readily accepted traditional performance measure, passing completion rates provide little insight to the 'how' and 'why' of observed performance. The rudimentary, but commonly held association between fundamental movement skills equating to physical literacy (Almond, 2013c), leads to a much narrower realisation of the concept than for example Whitehead (2019) advocates. By framing the problem more holistically, drawing on individual movement skills and knowledge *of* the environment we are able to gain insight to how physical literacy better accounts for the qualities required for meaningful, embodied engagement in performance settings (Bailey, 2020a; Durden-Myers, Meloche & Dhillon, 2020). Passos et al. (2011; 2020), for example, used an Adjacency Matrix to establish the networks formed through emergent coadaptive ball distribution behaviours in team sports, helping develop understanding of interpersonal interactions within social neurobiological systems. A similar approach was adopted in the emergent game-based assessment tool. A review of offensive performance functionality in this study reveals higher-physical literacy children adopted a more varied offensive functionality compared to lower-physical literacy children, who more typically demonstrated mono-stable action couplings. Higher-physical literacy children were observed to make more uncontested (91.2% vs 86.9%), penetrating passes (44.7% vs 41.4%), over mixed distances,

compared to their lower-physical literacy counterparts. Lower-physical literacy children typically sought out higher-physical literacy team mates for passes (69% vs 40.4%), attempting only short and medium range passes, predominantly in a lateral (44.8% vs 34.7%), rather than forward (41.4% vs 44.7%) direction. The additional richness offered as a consequence of reviewing passing functionality in this manner, aligns well with the philosophical and ontological basis of physical literacy. Whereby, the interface between abilities, opportunities and circumstances, enmesh to affect an individual's navigation of their environment (Bailey, 2020b; Whitehead, 2019).

Higher-physical literacy children also demonstrated greater capacity to regulate their court position in relation to attempts to eliminate dyadic system stability between themselves and defenders. This performance feature resulted in higher-physical literacy children more frequently finding space on the court (60.5% vs 43.6%), a willingness to remain in motion (82.2% vs 65.4%), and in their capacity to effectively track play (96.2% vs 91.6%) and seek out the affordances offered within the games environment. Davids et al. (2013a) and Vilar et al. (2012) have highlighted how attackers engage in a process of symmetry breaking to destabilise attacker-defender stability and the organisational state of the game, while defenders try to maintain a stable dyadic system. Higher-physical literacy players were able to demonstrate greater appreciation of making themselves available in regard to positioning themselves relative to the player in possession of the ball, by occupying space near (51% vs 37.8%), rather than right next to or distant to, the player in possession. Whitehead's (2001; 2010) original and more recent articulation of the core components of physical literacy identified the ability to read the situation and react appropriately through movement as key facets of becoming physically literate. The capacity to respond effectively to the formation and dissolution of attacker-defender stability was a feature of higher-physical literacy children's gameplay. Attractor recognition ratios (defined as the ratio of signals for the ball to the number of times the child becomes the target for distribution) were much better in higher-physical literacy children who appeared more discerning in when they signaled for the ball compared to lower-physical literacy children, who signaled almost twice as often, yet became the target of distribution less frequently (1.42:1 vs 2.57:1). Observing invitations for action and functional behaviours in passing behaviour allows practitioners to establish dominant attractors in terms of other players that systems typically relax to as targets for distribution, while also providing insight to the functionally successful movement skills adopted. Such observations provide insight to the transient, emerging, or decaying attractor states that reveal themselves through the game providing an understanding of how learners are evidencing confidence in their decision making as some functional movements might actually emerge as being repellers through child-environment interactions.

The emergent game-based assessment tool also provides rich insight into defensive intentionality and spatial-temporal behaviours. Analysis highlighted that higher-physical literacy children demonstrated behaviours typically considered favourable in defensive gameplay situations. By being generally closer to the ball at all times (40.7% vs 33.3%), closing down or swarming the ball following distribution (45.4% vs 36.4%), and by marking players off the ball more frequently (21.1% vs 16.9%) than lower-physical literacy children, they were more readily able to form or preserve desirable defensive dyadic system stability. These observed attempts to maintain the organisational state of the game represent embedded moments of engagement incorporating physical capacities, perception and decision making. These behaviours demonstrated by higher-physical literacy children were combined with greater willingness to change court position or defensive role during periods out of possession, in response to the affordances offered by the environment. Adaptation in games and sports contexts acknowledges the recurring reorganisation of the team, conceptualised as a complex system, to satisfy the ecological constraints of competition (Button et al., 2020). Although all players demonstrated similar capacity to track play when defending, the data suggests greater attunement to key affordances by higher-physical literacy children as a consequence of more frequently-reported attempts (21.7% vs 9.2%) and successes (3.2% vs 2.1%) blocking or intercepting passes. The evaluation of defensive spatial temporal interactions and functionality provided insight to children's wayfinding success and the ability to not only effectively read the situation, but to also anticipate the likelihood of certain actions manifesting themselves. This capacity to read, anticipate and react effectively through movement is something highlighted by Whitehead (2001; 2010), Jurbala (2015) and Shearer et al. (2018) as being characteristic of the physically literate individual. Button et al. (2020) indicates that an individual must perceive enough of their environment to achieve such task goals, while selecting only the most relevant information to facilitate successful intentional behaviour. The embedded functional capabilities of the performer manifest themselves in the continuous interactions between child and environment, allowing observations to be picked out that readily differentiate higher- and lower-physical literacy child-environment interactions when playing games.

5.7ii Limitations

Through an ecological dynamics rationale, physical literacy assessment has been explored in ways yet to be taken up in research and practice. This approach, however, is not without limitation that requires some brief mention. The analysis presented, was purposefully explorative, focussing on a smaller sample size for the initial presentation of data. A more substantive project recruiting children from across Key Stage groups should be considered. This would allow for a more robust statistical analysis to be undertaken, greater fidelity and increased confidence in the generalisability of findings. Video

tagging can be time consuming, due to the scale of analysis being at the individual-environment interaction level and perhaps it is unreasonable to expect a 'full' analysis to be completed by teachers in school settings. Further research is needed to explore the potential to employ the tool to evaluate discrete gameplay qualities such as 'attacking behaviours', 'defensive behaviours', or 'spatial awareness' by selectively employing measurement variables from the games-based assessment tool. A more streamlined evaluation could be undertaken, aligned to specific teaching intervention objectives and the design of learning episodes aimed at developing principles of attack and defence, or tactics and strategies to overcome opponents for example. Future research should also look to build on the game-based analysis tool's potential to navigate unexplored research territory in terms of dyadic system stability, networking and cognitive ecology in children's games.

As part of the iterative process of establishing the Key Pillars from ecological dynamics that provided a framework for assessment, it is acknowledged that not all elements of the physically literacy construct have been equally accommodated. For example, the affective domain of physical literacy and the ecological principle of affective learning design is an important core concept that was beyond the scope of this particular study. But, considering how enjoyment, frustration, motivation, and confidence might manifest themselves during game play is a potential area of future investigation. Finally, there is the scope to build upon the Key pillars of an ecological dynamics approach identified in this study and apply them to alternative sporting environments. The desire, in this first instance was to create a tool that could be deployed more broadly across the National Curriculum for Physical Education, and as a consequence there was an orientation towards the modified, small-sided games typical of this environment.

5.8 Conclusion

Undertaking an assessment that measures gameplay interactions in the manner outlined enables researchers and practitioners insight into how children learn to perceive affordances within games-based environments. This analysis outlined a rationale for why an approach informed by ecological dynamics might offer a novel contribution to understanding and evaluating physical literacy. In particular, the sample data provides a flavour of the potentially rich interpretations possible when there is a willingness to move beyond reductionist, decontextualised assessment strategies and embrace a more holistic, embedded evaluation of physical literacy during performance. This is the first tool, of which we are aware, that frames physical literacy assessment and evaluation through an ecological dynamics rationale, evaluating emergent gameplay behaviours where decisions are expressed as actions. Tapping into children's knowledge *of* the environment – manifest through the perception of affordances, their intentionality, and how they functionally move to effectively wayfind

through the challenges they are presented with – provides uniquely novel insight into how physical literacy reveals itself through embodied organism-environment interactions in naturalistic settings.

Chapter Six - Examining the Validity, Reliability and Feasibility of capturing Children's Physical Literacy through Games-Based Assessment in Physical Education

The main outcomes of this study have been published in: Wilkie, B., Jordan, A., Foulkes, J., Woods, C., Davids, K., & Rudd, J. Examining the Validity, Reliability and Feasibility of capturing children's Physical Literacy through Games-Based Assessment in Physical Education. *Frontiers in Sports and Active Living*, *5*, 203.

6.1 Thesis Study Map: Study Three

Study	Objectives
Study One (Chapter Four) Measuring Physical Literacy: A Fresh Approach	Objectives: • Establish the feasibility of capturing children's behaviour and environmental interactions during games-play that would reveal their physical literacy. • Establish face validity of a novel approach to assessment, framed by an ecological dynamics conceptualization to capture and measure physical literacy. • Highlight that the current reductionist approach to the measurement of physical literacy is not appropriate, especially when attempting to capture the embodied dimension of physical literacy. Key Findings: • Established the feasibility of assessing physical literacy through observations of children's games play through the development of an observational instrument and categorical items that accurately represented the revelation of physical literacy through observed behaviour within small-sided games. • Within the context of systematic observation, established face validity of the observational instrument. • Highlighted the insight offered by embodied learner-environment interactions in naturalistic settings.
Study Two (Chapter Five) Assessing Physical Literacy, Conceptualised in an Ecological Dynamics Theoretical Rationale	Objectives: • Pilot an assessment of physical literacy conceptualised in an ecological dynamics theoretical rationale. • Demonstrate the underpinning ecological dynamics principles and conceptualisation applied to the measurement of physical literacy. Key Findings: • Rationalised key pillars of an ecological dynamics approach underpinning the design of a game-based assessment for physical literacy. • This study provided initial evidence that an ecological dynamics informed games-based assessment has the potential to provide richer understandings of children's physical literacy.

	• Explorative analysis outlined a rationale for why an approach informed by ecological dynamics might offer a novel contribution to understanding and evaluating physical literacy.
Study Three (Chapter Six) Examining the Validity, Reliability and Feasibility of Capturing Children's Physical Literacy through Games-Based Assessment in Physical Education	Objectives: • Establish the validity and reliability of the psychometric properties of the emergent games-based assessment tool following a systematic process including face and content validity, combined with inter- and intra-observer reliability.
Study Four (Chapter Seven) An Ecological Insight into the Revelation of Physical Literacy in Children during Small-Sided Games	Objectives: • Investigate how features of the physical literacy construct reveal themselves through children's behaviours using the emergent games-based assessment tool. • Establish key differentiating behaviours of higher- and lower-physical literacy children when playing small-sided games. • Promote the role of ecological dynamics when employed as a theoretical framework to investigate physical literacy.

Within Study Three (Chapter Six) I conceived and designed the research approach, methodology and analysis in agreement with the supervisory team with the intention of establishing the validity and reliability of emergent games-based assessment. Study Three reports on the outcomes of the multistage process followed during the design and validation of the observational instrument. I was responsible for data collection and data analysis required at each stage of the process. Writing and preparation of the tables and figures in this chapter was completed independently.

6.2 Introduction

Observational instruments and methodologies are important to the study and wider development of physical education as a subject. Observational tools help to inform and guide the practice of teachers in their quest to design effective learning environments for children and youth. The last twenty years has seen significant investment in the development and application of systematic observational tools, enabling the identification of key teacher and child behaviours for effective learning and development during physical education and sport lessons (Arias & Castejón, 2012; Cushion et al., 2012; Roberts & Fairclough, 2012; Kinnerk et al., 2018; Eddy et al., 2020). The purpose of systematic observation in pedagogy resides in efforts to improve the quality and value of educational intervention, supported by theoretically guided research that provides deep insights into professional behaviours and practices and why they should be encouraged or discouraged. Furthermore, systematic observations in physical education and sport provide authentic points of reference (demonstrated in context / in the practice

environment), allowing for pragmatic understanding of what is typically considered to be an esoteric process to be developed (Potrac et al., 2000). Overtime, these tools over time have replaced, or at least augmented other more traditional forms of evaluation (diagnostic 'eyeballing', subjective / anecdotal notetaking, completion of rating scales and checklists), in physical education assessments (López-Pastor et al., 2013).

Physical literacy has rapidly permeated the practice and policy discourse among physical educators (Aspen Institute, 2015; Edwards et al., 2017). Commonly expressed themes within academic literature highlight that physical literacy involves the equal consideration of movement competence, affective behaviours, knowledge, understanding, and the valuing of physical interactions with the environment (Edwards et al., 2017). Although the importance of accurate assessment of physical literacy has been established (Lundvall, 2015), there is need to develop tools that are both valid and capture the spirit of the whole construct successfully (Corbin, 2016). Developing a framework for the assessment of a multifaceted phenomenon such as physical literacy is acknowledged as being difficult (Dudley, 2015), and there remains tension between Whitehead's (2001; 2010; 2019) characterisations of physical literacy, and the manner in which it is typically assessed. Traditional assessments of physical literacy have been criticised, identifying that they are predisposed towards remaining reductionist in nature, product focussed, and tend to overly privilege movement competency components of the wider construct (Ng & Button, 2018; O'Sullivan et al., 2020). Recording the features of physical literacy that are not directly observable, such as the affective qualities of motivation or confidence, and the cognitive features of knowledge or reading the environment, is arguably more complex (Dudley, 2015). In their major systematic review investigating measurement of physical literacy Edwards et al. (2017) identified only three percent of the studies reviewed, combined all domains of physical literacy in their measurement of the construct. They went on to highlight the necessity to 'assess beyond the constructs of physical proficiencies' (p.660), calling for the adoption of a more holistic perspective. Although many existing instruments propose to provide a measure of physical literacy, the majority involve the evaluation of the cognitive, affective and psychomotor domains in isolation, often in decontextualized settings (Longmuir et al., 2015; Tyler et al., 2018). Separating the discrete domains of physical literacy during evaluation contradicts the holistic philosophical foundations of the construct (Green et al., 2018). The disconnected performance of movement fails to effectively evaluate a child's capacity to alter, adapt, and combine movement skills according to performance needs. Flexibility and adaptation in movement, to reflect emerging environmental demands are important traits to advance competence and progress physical literacy (Tyler et al., 2018). Previously, Wilkie et al. (2022), developed a games-based assessment tool utilising an ecological dynamics framework providing a rationale that the cognitive, affective and psychomotor

domains were observed through game play movement and captured using the emergent game-based assessment tool. This is the first tool available in the academic literature that frames physical literacy assessment and evaluation through a 'games environment' providing representative design (Brunswik, 1955) as well as better alignment to Whitehead's (2001) original definition of physical literacy. There is however, more robust psychometric evaluation needed to explore the validity and reliability of the emergent games-based assessment tool before it should be used in education or intervention.

Brewer and Jones (2002) have previously noted that information related to validity and reliability of observational instruments was often inadequate and difficult to acquire. The development and subsequent validity and reliability evaluations of observational tools have increased more recently, both in terms of scope of application and the recognition of the process of assessing the psychometric properties of the tools developed. Numerous studies have emerged with the objective of validating observational instruments for performance in sports including, Climbing (Taylor et al., 2020), Football (Larkin, O'Connor & Williams, 2016; Fernandes et al., 2019; Ju et al., 2022), Tennis (Torres-Luque, 2018), Rugby Union (Villarejo et al., 2014), and Volleyball (Palao, Manzanares & Ortega, 2015). Similarly in pedagogy, validation of observational instruments such as the Games Performance Assessment Instrument (Oslin, Mitchell & Griffin, 1998), which assesses skills, movements and cognitive decisions, Performance Assessment in Team Sports (Gréhaigne, Godbout & Bouthier, 1997), assessing motor and tactical skills, and observing teaching physical education games, (Roberts & Fairclough, 2012), assessing lesson context and teacher interaction during physical education classes has been undertaken. Assessing the validity of an observational instrument is typically achieved through independent verification from experts on a topic and refers to the extent to which the methods employed adequately assesses what they claim to measure (Thomas et al., 2022). Reliability describes the consistency within the employed analytical procedures across time or observers (Lacy & Williams, 2018), typically achieved utilising some combination of test, retest protocol. Therefore, the aims of this study are to build upon the theoretical model proposed by Wilkie et al. (2022) that led to the development of the emergent games-based assessment tool, by establishing the validity and reliability of the psychometric properties of the assessment tool following a systematic process including face and content validity, combined with inter- and intra-observer reliability.

6.3 Methods - Development and validation of the Emergent Games-based Assessment Tool

To establish the validity and reliability of the emergent game-based assessment a multistage development process as outlined by Brewer and Jones (2002), and recently adopted by Palao,

Manzanares and Ortega, (2015), Larkin, O'Connor and Williams (2016), Torres-Luque et al. (2018), and Fernandes et al. (2019) was implemented. This process included the following stages: 1) review of the literature and consultation with experts in the field leading to designing the observational instrument and a category system establishing face validity; 2) pilot observation study; 3) expert qualitative and quantitative review to establish content validity; 4) observation training; and 5), establishing intra- and inter-observer reliability.

6.3i Stage 1: Design of the observational instrument and establishing face validity

The first step involved establishing performance indicators and operational definitions of variables to be used in the tool. The initial literature review commenced with an evaluation of offensive and defensive behaviour variables from the team games literature, framed within an ecological dynamics framework. Due to this being the first observational tool we are aware of that frames physical literacy assessment and evaluation through an ecological dynamics rationale, adapting an existing observational instrument as recommended by Brewer and Jones (2002), was not possible. Consequently, the development of a theoretical framework to inform the observational instrument was necessary. This conceptual framework involved identifying key pillars of an ecological dynamics approach for the design of a game-based assessment. For this purpose, key ecological principles towards revealing physical literacy in games play were established. Building from this, a category system and their descriptions were introduced, discussed, trialled, and endorsed by academic and technical experts within the field (Wilkie et al., 2022). The intent was to make the category system within the instrument capable of capturing the actions that allow specification of key performance variables such as ball distribution, possession, turn-over, spatial-temporal interactions and tactical movements within small-sided games typical of physical education settings to be recorded. This enabled ecological conceptualisations, measurement variables, and variable descriptions, to be finalised, framed around the key ecological principles of 1) Wayfinding; 2) Affordances and Attunement; 3) Intentionality; and 4) Functional Movement Skills. This process ensured the games-based assessment tool had categorical items that accurately represented the revelation of physical literacy through observed behaviours within small-sided games, which, within the context of systematic observation would mean face validity can be assumed within a physical education environment.

6.3ii Stage 2: Pilot observation study

Before the validation study, an initial pilot feasibility test was carried out to evaluate the emergent games-based assessment tool, with the objective of making modifications, if necessary. The original

category system design was comprised of three ecological conceptualisations of behaviours, 18 measurement variables and 42 categorial observation items. The category system for the emergent game-based assessment tool was developed into an electronic coding module allowing digital video-based tagging (Dartfish Pro) to be completed. Feasibility pilot testing with 10-minutes of physical education games footage was completed (see Chapter Four for detail). This approach ensured all technical and tactical behaviours were identified within the observational instrument. During this process, numerous scenarios not included in the initial list of behaviour categories were identified, and following subsequent meetings with academic and technical experts these further categories were defined and added to the coding instrument. The feasibility testing resulted in adding behaviours that previously had not been defined at a theoretical level, but which manifested during games play (e.g., a 'hand-off' as a distribution category within offensive functionality, moving without obvious purpose within offensive and defensive intentionality). Similarly, at this stage of the design and validation process the reported frequencies across behaviour categories was reviewed, with the intent to use the data to demarcate, define, and confirm behaviour categories (e.g., within invitation for action, forward and penetrating pass direction categories were grouped to capture all 'forward' distribution behaviours). At this point the observational manual was created in which the nine ecological conceptualisations of behaviours, 20 measurement variables and 61 categorial observation items (revised from the initial pilot) were named and defined. The outcomes related to the design of the observational instrument after the first two stages (development of the category system and pilot study) have been defined and described in detail previously (Wilkie et al., 2022; Chapter Five). The processes reported in Stage 1 and 2 ensured the emergent games-based assessment tool had categorical items that accurately represented the revelation of physical literacy through observed performance behaviours within small-sided games, which, within the context of systematic observation would mean face validity can be assumed within the physical education environment.

6.3iii Stage 3: Expert qualitative and quantitative review to establish content validity

The content validity of an observational instrument scrutinises the relevance of the categories to the contextual content area under investigation. Consequently, a systematic observation instrument devised to record children's behaviours in small-sided games can be considered to have content validity if it thoroughly captures, or adequately samples the principal array of behaviours demonstrated by individuals with different physical literacy profiles within physical education environments. Brewer and Jones (2002) identify that observed behaviours should be treated equally without privileging any particular behaviour, ensuring there are no behaviours that are incorrectly defined or neglected from the category system. Possessing a complete picture of the technical and

tactical behaviours and interactions within children's small-sided games to reveal physical literacy will allow the emergent games-based assessment tool to have content validity, as it will mean the instrument effectively samples or fully captures the archetypal behaviours demonstrated by the individuals and the phenomenon under investigation.

In this study, evaluation of content validity ensured the emergent games-based assessment tool was representative of games play and effectively able to report on individuals as they navigated their environment / the technical and tactical elements of the games. To establish content validity, a qualitative and quantitative evaluation of the modified emergent games-based assessment tool was provided by expert practitioners (teachers and academics). The inclusion criteria established for forming the expert panel were: 1) post graduate qualifications in pedagogy or Sports Science; 2) to be active practitioners or researchers in the field of pedagogy, physical education, or Sports Science; 3) to hold senior leadership or academic positions within their educational institutions (e.g., head of Physical Education); 4) have a minimum of 10 years' experience within their field of expertise; and 5) to be able to demonstrate knowledge transfer within their field of expertise (publications, mentoring, or the delivery of professional development and training courses). Following similar approaches adopted within other sport observational instrument design and validation studies (Villarejo et al., 2014; Larkin, O'Connor & Williams, 2016; Torres-Luque et al., 2018), the expert panel were required to provide opinions and feedback on: 1) degree of suitability in the definitions of behaviour variables used in the instrument (Adequacy); 2) the relevance of these behaviours in revealing physical literacy (Pertinence); 3) suitability of including the behaviour or variable as part of the observational instrument (Inclusion); and 4) the necessity to include behaviours otherwise not considered within the framework of the observational tool. The quantitative evaluation consisted of scoring 1 to 10 the adequacy and pertinence of behavioural variables measured in the observational tool and in the qualitative section, acknowledging the appropriateness of inclusion of the behaviour measured by responding "Yes" or "No". By gathering the opinions of a range of experts it is possible to establish that all elements of the game's environment, and the behaviours observed are appropriately considered when developing the instrument. The qualitative and quantitative evaluation data to establish validity was later calculated through Aiken's *V* coefficient (Aiken, 1980; Penfield & Giacobbi, 2004), to define criteria for acceptance, modification or elimination of items. Items of the emergent game-based assessment tool were evaluated firstly for pertinence and if deemed pertinent they were then evaluated for adequacy (definition).

6.3iv Stage 4: Observer training

Following the finalisation of the modified coding instrument an observer training programme was delivered. Rigorous observer training has been identified as particularly valuable in establishing the reliability and objectivity of an observation instrument (Brewer & Jones, 2002). To this end, a multistage process of observer training, as outlined by van der Mars (1989) was employed over a period of several weeks. The observer training was administered in a similar manner to that reported by Cushion et al. (2012), Villarejo et al. (2014), and Torres-Luque (2018). For this study two observers received training comprising of three, two-hour sessions, held over multiple days. The observers held post graduate qualifications in Physical Education and Sport Science, were active practitioners and researchers in the field of pedagogy and physical education, with over 10 years' experience within their field of expertise. Training focussed on: 1) orientation to the overall purpose of the instrument; 2) familiarisation of the categories; 3) using the coding timeline appropriately within Dartfish Pro; 4) embryonic coding of excerpts from physical education classes and games-play; and 5) the digital coding of one small-sided, physical education game utilising the full emergent games-based assessment categorical instrument. The early stages of the training programme comprised of an introduction to the overarching purpose of the instrument, learning the behavioural classifications, and becoming familiar with the application of the temporal event-based nature of the observations within the coding timeline. The later phases included trialling the coding process with particular behaviours (e.g., single and multiple on / off-ball movement events), so that any misclassifications could be discussed and coding revised. Additional behaviours and extended passages of games-play were introduced as observers demonstrated consistency in classifying observations. Finally, a single small-sided physical education game utilising the full emergent games-based assessment categorical instrument was coded. Embryonic and whole game electronic coding during stages 4 and 5 used recorded video playback of physical education games with frame-by-frame playback capabilities (1080hp, 60Hz frame rate). Throughout the training process, observers working with myself reviewed and clarified any erroneous or unclassified behaviours to confirm understanding and interpretation of the instrument.

6.3v Stage 5: Establishing observer reliability

To measure observer reliability, procedures outlined by Brewer and Jones (2002) were followed. Observer reliability demonstrates the consistency or repeatability of an instrument for categorising behaviour. Therefore, to ensure the emergent games-based assessment tool is able to inform practice and contribute meaningfully to assessment and evaluation within a physical education environment, both intra- and inter-observer agreement should be established. Doing so safeguards against

variability within the results which may otherwise have ramifications upon the accurate interpretation of observed behaviours. Objectivity of the categorical system was evaluated to ensure that different observers could achieve a measure of agreement in their evaluations while observing the same behaviours. Inter-observer reliability was examined by reviewing the consistency between different observers when observing identical performances. Intra-observer reliability was explored by reviewing the measure of agreement between scores, when identical trials were evaluated by the same observer on two separate occasions. The intra- and inter-observer reliability was established using a 90-clip movie-test, similar to approaches adopted by Cushion et al. (2012). The movie-test consisted of at least three examples of each ecological conceptualisation and all potential measurement items from the emergent games-based assessment. Movie-test clips were purposefully selected with varying degrees of complexity demonstrated across the behaviours (e.g., single vs multiple off-ball movements and shorter vs longer temporal events). To ensure a comprehensive representation of the child-environment interactions possible, the game-play behaviours chosen for the movie-test included footage from three different primary schools, and comprised of mixed gender (3 Male, 3 Female), Key Stage two (aged 7-11 years), mixed physical literacy children. The physical literacy of children was calculated through a composite score of Working Memory (McClelland et al., 2014), Game Play Perception (Miller et al., 2019), and an assessment of fundamental movement skills using the Dragon Challenge (Stratton et al., 2015). To determine similarities between individual participants, a *kmeans* cluster approach was utilised (R Core Team 2019) to detect and organise data into a number of groups via the elbow method. This analysis enabled the grouping of individuals with similar levels of physical literacy into higher- and lower-physical literacy categories. All movie-test clips were taken from a fixed, elevated, court side position. This perspective allowed for all participants, and features of the playing area to be captured within the field of view. The movie-test recordings were provided to the observers as an electronic video file (1080hp, 60Hz frame rate), with frame-by-frame playback options. Overall, 30 in-possession, 30 offensive off-ball, and 30 defensive off-ball events comprised the movie-test. A 90-clip movie-test was considered optimal as it provided acceptable variety in behaviours and enabled observers to complete the trial in a reasonable timeframe (90-120 min). The two trained observers conducted the electronic coding over a 14-day period, with a minimum of 7 days between the original and retest.

6.3vi Statistical analysis

All statistical analyses were performed in Microsoft® Excel® for Microsoft 365 (version 2301). The content validity of the quantitative evaluation of both pertinence and adequacy (definition) by the expert practitioners was determined by using Aiken's *V* coefficients (Aiken, 1980). Aiken's *V* ascertains

the magnitude to which experts deem items in a tool to represent and measure each construct (Penfield & Giacobbi, 2004). Aiken's *V* (1980) was calculated using the formula:

$$v = \sum s \,/\, n(c - 1)$$

Where the 's' was the score given by the expert practitioners minus the lowest value, 'c' is the highest value and 'n' was the number of expert practitioners. The Aiken's *V* coefficient ranges from 0-1, where 0 indicates lowest response from all experts ("not pertinent" or "poorly defined"), whereas 1 indicates highest response ("highly pertinent" or "very well defined") from all experts (Penfield & Giacobbi, 2004). The central limit theorem and confidence levels were applied to the Aiken's *V* to set criteria for acceptance, modification or elimination of each item in the emergent games-based assessment tool. This process has been described in detail previously (García-Ceberino et al., 2020). In this study, an item was accepted if Aiken's *V* for pertinence was ≥0.78 (95% confidence level) and eliminated if Aiken's *V* was ≤0.77. Of the remaining items deemed pertinent, the adequacy (definition) of the items was modified if Aiken's *V* was ≤0.77 and eligible for modification between 0.78 and 0.86 (95-99% confidence level).

Cohen's Kappa (κ) was used to measure the inter-rater reliability (between the observer responses) and intra-rater reliability (between original and retest responses) of the observers using emergent games-based assessment tool. Cohen's κ was the preferred measure of reliability with categorical data, since it accounts for the likelihood of agreement by chance (Cohen, 1960) and was calculated using the formula:

$$\kappa = \frac{Po - Pe}{1 - Pe}$$

Where Po is the proportion of agreement, Pe is the proportion of agreement due to chance. Cohen's κ were interpreted as; ≤ 0 as no agreement, 0.01–0.20 as none to slight, 0.21–0.40 as fair, 0.41– 0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1.00 as almost perfect agreement (Cohen, 1960).

6.4 Results

Expert qualitative and quantitative review to establish content validity was provided by 15 expert practitioners (7 teachers and 8 academics) with an average of 12.86 years' experience in their respective fields. All experts held post graduate qualifications in pedagogy or Sports Science, leadership or senior academic positions within their educational institutions, and were able to demonstrate knowledge transfer within their field of expertise. Aiken's *V* from the quantitative evaluation is shown in Table 6.1 drawing upon ecological conceptualisations defined in Wilkie et al. (2022) to frame measurement categories.

Table 6.1. Content validity in the aspects of pertinence and adequacy (definition)

Measurement Category linked to Ecological Conceptualisation	Measurement item	*Pertinence*			*Adequacy*		
			95% CI			95% CI	
		V	Low.	Upp.	*V*	Low.	Upp.
Passing (Offensive functionality)	Attempted passes	0.83	0.76	0.88	0.87	0.81	0.92
	Passing success	0.95	0.90	0.97	0.74[b]	0.77	0.89
Receiving (Offensive functionality)	Undisputed reception	0.87	0.81	0.92	0.86	0.69	0.83
	Disputed reception	0.89	0.83	0.93	0.74[b]	0.66	0.81
	Passing targets physical literacy	0.60[a]	0.52	0.68	-	-	-
Distribution technique (Offensive functionality)	Overhead pass	0.91	0.85	0.95	0.90	0.84	0.94
	Shoulder pass	0.88	0.82	0.92	0.84	0.77	0.89
	Chest pass	0.87	0.81	0.92	0.88	0.82	0.92
	Underarm pass	0.87	0.81	0.92	0.84	0.77	0.89
Distribution distance (Invitation for action)	Hand off	0.72[a]	0.64	0.79	-	-	-
	Short pass	0.85	0.78	0.90	0.86	0.79	0.91
	Medium pass	0.84	0.78	0.89	0.86	0.79	0.91
	Long pass	0.84	0.77	0.89	0.86	0.79	0.91
Distribution direction (Offensive invitation for action)	Penetrating pass	0.82	0.75	0.88	0.83	0.76	0.88
	Lateral pass	0.82	0.75	0.88	0.85	0.78	0.90
	Rearward pass	0.84	0.77	0.89	0.84	0.78	0.89
Offensive off-ball movement (Offensive intentionality)	Remains stationary on offence	0.79	0.72	0.85	0.71[b]	0.62	0.78
	Single offensive off-ball movement	0.77[a]	0.70	0.83	-	-	-
	Multiple offensive movements	0.82	0.75	0.88	0.68[b]	0.60	0.75
Use of space (Offensive spatial temporal interactions)	Finds space effectively	0.90	0.85	0.94	0.73[b]	0.65	0.79
	Moves into occupied space	0.82	0.75	0.88	0.83	0.76	0.88
	Moves into contested space	0.85	0.78	0.90	0.84	0.77	0.89
	Offensive Support	0.79	0.72	0.85	0.70[b]	0.62	0.77
Offensive awareness and interactions (Coadaptive networks)	Effectively tracks play on offence	0.86	0.79	0.91	0.81	0.74	0.86
Defensive off-ball movement (Defensive intentionality)	Remains stationary on defence	0.81	0.74	0.87	0.76[b]	0.68	0.83
	Single defensive off-ball movement	0.73[a]	0.65	0.79	-	-	-
	Multiple defensive movements	0.78	0.70	0.84	0.72[b]	0.64	0.79
Defender-attacker dyad (Defensive spatial temporal interactions)	Movement towards ball	0.90	0.84	0.94	0.81	0.74	0.87
	Swarms the ball	0.86	0.79	0.91	0.79	0.72	0.85
	Defensive marking	0.88	0.82	0.92	0.80	0.73	0.86
	No marking	0.74[a]	0.66	0.81	-	-	-
	Defensive pressure	0.79	0.71	0.84	0.73[b]	0.65	0.79

Defensive awareness (Coadaptive networks)	Effectively tracks play on defence	0.81	0.74	0.87	0.81	0.74	0.87
Interactions with ball (Defensive Functionality)	Defensive Intervention	0.90	0.84	0.94	0.84	0.77	0.89

Note: *V* = Aiken's *V*; Low. = lower limit; Upp. = upper limit; CI = confidence interval; [a] eliminated (*V* ≤0.77 in pertinence); [b] modified (*V* ≤0.77 in adequacy).

Expert review resulted in 5 measurement items being eliminated from the tool. Additionally, 9 of the remaining variables reported values lower than 0.78 in the aspects of Adequacy (definition). These item descriptions were revised and improved following the recommendations of the experts. Table 6.2 presents the qualitative evaluations issued by experts and the actions taken to improve the definitions used in the emergent game-based assessment tool.

Table 6.2. Qualitative expert evaluations issued and actions taken

Measurement Variable and Qualitative Evaluation	Action
Passing Success E2: "pass contributed positively towards the team's outcome" E3: "Receiving success to couple with the passing data" E8: "Rate of success (comparing successful passes with attempted passes)"	A clearer definition was determined for passing success. *"Successful distribution and reception of ball, contributing effectively to achieving game objectives"*
Contested Reception E9: This can be very subjective measure, what is duress.	Item title and definition revised offering a clearer articulation of variable. *"Distribution was to a marked teammate resulting in a contested, but successful reception".*
Remains stationary (on offence and defence) E1: "Movement rather than displacement to simplify definition" E9: "Consideration of a vertical component" E13: "Remaining stationary and taking steps are not the same"	The concepts of horizontal and vertical displacement were included and language was revised to assist clarity / understanding. *"No horizontal (e.g., stepping) or vertical (e.g., jumping) movements observed"*
Multiple (offensive and defensive) movements E1: "Change of direction or significant change in velocity" E9: "A player runs in one direction but then changes direction during the run without stopping vs runs in one direction, stops/slows down and then changes direction" E14: "Whether the movement was done as one action, or multiple adjustments"	The concepts of changes in direction and changes in velocity were included to clarify the definition. *"Player demonstrates multiple significant changes of direction or changes in speed"*
Finds space effectively E2: "People can often find space, but it can often be too far away from the ball to receive a pass". E9: "What (do) you describe as enough space"	Item title and definition was revised. Distance from opposition players was specified to avoid subjectivity and acknowledgement of player location within the game's area relevant to task goals was added.

E15: "Recognition of invitation to move"	*"Moves to, or occupies space (no other player within 1.5m) appropriate to achieving game objectives"*
Offensive Support E1: "Proximity to player in possession during offence" E9: "Definition relating to how many steps away a player would be from the player in possession might be better."	Item title was revised and a clearer definition was determined incorporating specified distances to avoid subjectivity. *"Proximity to team mate in possession of the ball during offence (Close: within 1.5m of player with ball; Nearby: 1.5m – 4.5m away from player with ball; Distant: more than 4.5m of player with ball)"*
Defensive Pressure E1: "Appropriateness of defensive positioning"	Item title was revised and a clearer definition was determined representative of tactical intentionality incorporating specified distances to avoid subjectivity. *"Proximity to opposing player in possession of the ball during defence (Tight: within 1.5m of player with ball and able to easily affect behaviours of the player in possession reflective of task goals; Loose: 1.5m – 4.5m away from player with ball and able to influence gameplay behaviours reflective of task goals; Distant: more than 4.5m away from player with ball exerting no or moderate effect on player in possession)"*

Aiken's *V* from the quantitative evaluation by the expert panel reported all variables not eliminated had an Aiken's *V* value >0.78 and were consequently considered relevant for inclusion (Penfield & Giacobbi, 2004). Consequently, the modified instrument (Table 6.3) included 15 measurement variables (6 related to on-ball offensive behaviours, 4 related to defensive off-ball behaviours, and 4 related to offensive off-ball behaviours during games play) and 44 categorical observational items for observation. All retained measurement variables scored highly (87%-100%) in expert review for suitability of including the behaviour as part of the final observational instrument.

Table 6.3. Emergent game-based assessment tool for the evaluation of physical literacy through an ecological dynamics framework

Ecological Conceptualisation of behaviour	*Measurement Variable*	*Categorical Observation Item and description*
Offensive functionality	Attempted passes	Total number of observed pass attempts
	Passing	**Successful** - Distribution and reception of ball, contributing effectively to achieving game objectives. **Unsuccessful** - Failed distribution or reception of ball. **Successful shot** - 'On' target. **Unsuccessful shot** - 'Off' target. **Intercepted** - Interrupted progress, or course, of ball before arrival.
	Receiving	**Undisputed** - Distribution was to an unmarked teammate resulting in a successful reception. **Disputed** - Distribution was to a marked teammate resulting in a contested, but successful reception.
	Distribution technique	**Overhead Pass** - Throwing the ball with both hands - starting from behind the head and releasing the ball over or in front of the head. **Shoulder Pass** - Ball is held high (above the shoulder), the supporting hand is removed to propel the ball with a single hand releasing over or in front of the shoulder. **Chest Pass** - Using both hands, starting from their chest, arms are extended out propelling the ball forwards. **Underarm Pass** - One or two-handed pass that is initiated from below the waist.
Offensive invitation for action	Distribution distance	**Short pass** - Distribution involves ball travelling <1.5m between teammates. **Medium pass** - Distribution involves ball travelling 1.5m – 4.5m between teammates. **Long pass** - Distribution involves ball travelling >4.5m between teammates.
	Distribution direction	**Penetrating pass** - Distribution is of a penetrative orientation (between 10 and 2 on a clock face where 12 on the clock face indicates the direction of opposition goal). **Lateral pass** - Distribution is of a lateral orientation (right lateral between 2 and 4, and left lateral between 8 and 10 on a clock face, where 12 on the clock face indicates the direction of opposition goal). **Rearwards pass** - Distribution is of a rearward orientation (between 4 and 8 on a clock face, where 12 on the clock face indicates the direction of opposition goal).
Offensive intentionality	Offensive off-ball movement	**Remains stationary on offence** - No horizontal (e.g., stepping) or vertical (e.g., jumping) movements observed. **Multiple off-ball movements** - Player demonstrates multiple significant changes of direction or changes in speed.
Offensive spatial temporal interactions	Use of space	**Finds space effectively** - Moves to, or occupies space (no other player within 1.5m) appropriate to achieving game objectives. **Moves into occupied space** - Movement to an area occupied by a teammate (one or more cooperating players within 1.5m).

		Moves into contested space - Movement to an area occupied by opposition player (one of more competing players within 1.5m).
	Offensive support	Proximity to team mate in possession of the ball during offence. **Close** - Within 1.5m of player with ball. **Nearby** - 1.5m – 4.5m away from player with ball. **Distant** – More than 4.5m away from player with ball.
Offensive coadaptive networks	Offensive awareness and interactions	**Effectively tracks play** - Head and body orientation allows for effective scanning behaviour (following play, observing the ball, and positions of competing and cooperating players). **Does not track play** - Head and body orientation do not allow for effective scanning behaviour (following play, observing the ball, and positions of competing and cooperating players). **Calls or signals for ball** - Visual or verbal cue provided, indicating availability as distribution target.
Defensive intentionality	Defensive off-ball movement	**Remains stationary on defence** - No horizontal (e.g., stepping) or vertical (e.g., jumping) movements observed **Multiple off-ball movements** - Player demonstrates multiple significant changes of direction or changes in speed
Defensive spatial temporal interactions	Defender-attacker dyad	**Moves towards the ball** - Movement towards ball reducing ease (space and time) of player's subsequent actions. **Overloads the ball** - Movement towards the player with the ball affecting ease of opposition player's subsequent actions (second defender to close down the ball). **Swarms the ball** - Movement towards the player with the ball affecting ease of opposition player's subsequent actions (third defender to close down the ball). **Defensive marking** - Purposeful movement towards and subsequently occupying contested space attempting to mirror the movements of opposition player(s) without the ball. **Unpurposeful movement** – Movement is neither towards the ball or opposition player.
	Defensive pressure	Proximity to opposing player in possession of the ball during defence. **Tight** - Within 1.5m of player with ball and able to easily affect behaviours of the player in possession reflective of task goals. **Loose** - 1.5m – 4.5m away from player with ball and able to influence gameplay behaviours reflective of task goals. **Distant** - More than 4.5m away from player with ball exerting no or moderate effect on player in possession.
Defensive coadaptive networks	Defensive awareness and interactions	**Effectively tracks play** - Head and body orientation allows for effective scanning behaviour (following play, observing the ball, and positions of competing and cooperating players). **Does not track play** - Head and body orientation do not allow for effective scanning behaviour (following play, observing the ball, and positions of competing and cooperating players).
Defensive functionality	Defensive intervention	**Successful block or interception** - Player cuts out a pass or shot effecting progress, or course of ball through contact. **Attempted block or interception** - Player attempts to cut out a pass or shot. **No defensive intervention** - No attempt to effect progress, or course of ball through contact is made.

Movie-test coding typically took 90-120 minutes per test-retest coding exercise, resulting in 780 data entry points being recorded per observer during the movie-test. Cohen's κ following inter-observer and test-retest quantitative evaluation is shown in Table 6.4 drawing upon ecological conceptualisations defined in Wilkie et al. (2022) to frame measurement categories.

Table 6.4. Cohen's κ inter- and intra-observer agreement following training

Measurement Category linked to Ecological Conceptualisation	Inter-observer reliability		Test-retest reliability	
	K	Strength of agreement	*K*	Strength of agreement
On-ball behaviours				
Attempted passes - Offensive functionality	1	Perfect	0.952	Almost Perfect
Passing - Offensive functionality	0.768	Substantial	0.701	Substantial
Receiving - Offensive functionality	0.724	Substantial	0.817	Almost Perfect
Distribution technique - Offensive functionality	0.944	Almost Perfect	1	Perfect
Distribution distance - Invitation for action	0.634	Substantial	0.841	Almost Perfect
Distribution direction - Invitation for action	0.941	Almost Perfect	0.942	Almost Perfect
Offensive off-ball behaviours				
Offensive off-ball movement - Offensive intentionality	0.590	Moderate	0.624	Substantial
(Initial) Use of space - Spatial temporal interactions	0.463	Moderate	0.602	Substantial
(Secondary) Use of space - Spatial temporal interactions	0.331	Fair	0.552	Moderate
(Initial) Offensive support - Spatial temporal interactions	0.650	Substantial	0.649	Substantial
(Secondary) Offensive support - Spatial temporal interactions	0.650	Substantial	0.874	Almost Perfect
Offensive awareness and interactions (Tracking play) - Coadaptive networks	0.634	Substantial	1	Perfect
Offensive awareness and interactions (Calls for ball) - Coadaptive networks	0.714	Substantial	0.682	Substantial
Target for pass - Coadaptive networks	0.911	Almost Perfect	0.911	Almost Perfect
Offensive positioning	0.918	Almost Perfect	0.799	Substantial
Defensive off-ball behaviours				
Defensive off-ball movement - Defensive intentionality	0.684	Substantial	0.832	Almost Perfect
(Initial) Defender-attacker dyad - Spatial Temporal Interactions (initial movement)	0.417	Moderate	0.603	Substantial
(Secondary) Defender-attacker dyad - Spatial Temporal Interactions (secondary movement)	0.389	Fair	0.652	Substantial
(Initial) Defensive pressure - Spatial Temporal Interactions	0.586	Moderate	0.802	Almost Perfect

(Secondary) Defensive pressure - Spatial Temporal Interactions	0.827	Almost Perfect	0.722	Substantial
Defensive awareness and interactions - Coadaptive networks	0.682	Substantial	0.661	Substantial
Defensive intervention - Defensive Functionality	0.732	Substantial	0.773	Substantial
Defensive positioning	0.770	Substantial	0.821	Almost Perfect

Note: κ = Cohen's Kappa coefficient values

The kappa values for inter- and intra-observer reliability ranged from 0.331 to 1.00 and 0.552 to 1.00, generally reporting substantial strength of agreement during inter-observer analysis and substantial to almost perfect strength of agreement during intra-observer analysis. Specifically, slight agreement was not noted for any criterion. Fair agreement was noted in spatial temporal interactions during attacking and defensive categories. Substantial, almost perfect, and perfect strength of agreement was reported for 85% of the measurement categories.

6.5 Discussion

The study exemplified the multiple phases necessary to create, validate, and test the confidence of a games-based behavioural observational instrument that frames physical literacy assessment and evaluation through an ecological dynamics rationale. The intention of the study was to construct a scale for the assessment of physical literacy that remains more faithful to the philosophically complex and holistic nature of the concept, rather than conforming to the more linear and reductionist thinking prevalent in the physical literacy measurement field (Edwards et al., 2018; Barnett et al., 2019). Content validity and reliability in this study have been demonstrated at a statistical level, establishing that the emergent games-based assessment tool is able to measure the dynamic interactions observed between child and environment in small-sided modified games.

The present study implemented a multiphase approach to validation following a systematic process adapted from Brewer and Jones (2002). This validation process implemented comparable approaches to those previously adopted in research on the development of novel observation instruments in sport (Palao, Manzanares & Ortega, 2015; Larkin, O'Connor & Williams, 2016; Torres-Luque et al., 2018; Fernandes et al., 2019). The systematic approach to establishing validity and reliability of the assessment tool commenced with a review of the literature and the development of a category system, with associated descriptions endorsed by academic and technical experts within the field (Stage 1). The tool was refined during piloting resulting in additional behaviours that previously had not been defined at a theoretical level, but which manifested during games play to be added, with frequency data used to demarcate and confirm revised behaviour categories (Stage 2).

6.5i Expert Contributions

A panel of experts was responsible for the validation of the revised instrument, reviewing the adequacy, pertinence, and inclusion of the observational measurement items (Stage 3). The number of experts that participated in the current study was greater than the number in similar studies validating observational instruments in sport (e.g., Larkin, O'Connor & Williams et al., 2016; Gamonales et al., 2018; Fernandes et al., 2019; García-Ceberino et al., 2020). The statistical values needed to ensure content validity was achieved by the emergent game-based assessment tool exceeded minimal levels (0.70) recommended by the literature (Penfield & Giacobbi, 2004), providing a more conservative level of acceptance for all measurement items. In this study, responses from the expert panel revealed that the majority of variables had an Aiken's *V* greater than 0.78, and were consequently considered relevant (Penfield & Giacobbi, 2004). There were, however, some items of the emergent game-based assessment tool that reported Aiken's *V* values lower than 0.78 in aspects of Pertinence. These items were subsequently removed from the assessment tool. This process resulted in retaining the nine previously defined ecological conceptualisations of behaviour from the pilot, reducing the measurement variables by five to a total of 15, and reducing the categorical observational items by 17 to a total of 44 in the final modified version of the assessment tool. Additionally numerous items of the emergent game-based assessment tool reported values lower than 0.78 in the aspects of Adequacy (definition). Where these items were still deemed pertinent the descriptions were revised and refined following the qualitative commentary and recommendations of the experts. This process resulted in revising definitions of nine observational items (see Table 6.2). The revised item descriptions were mostly related to offensive and defensive intentionality, defining movements of individuals as they attempted to maintain a secure dyadic (1v1) system or disrupt attacker-defender stability. These actions are typically complex and require players to often execute several actions, sequenced together to achieve movement goals (Vilar et al., 2012; Davids et al., 2013). Ju et al. (2022) identified the value of capturing these more complex interactions as they add greater transparency and insight to the overall evaluation. The other item descriptions revised at this stage related to spatial temporal interactions, which, while offering valid, reliable insight (Dogramaci, Watsford & Murphy, 2011), have been identified as requiring appropriate observer training to ensure accurate representation of the behaviours (Palao, Manzanares & Ortega, 2015). The complexity of the actions described necessitates the adoption of an unambiguous description to assist observer interpretation and accurate data collection. The revisions undertaken remained cognisant of this need throughout.

6.5ii Instrument Objectivity

The level of intra- and inter-observer agreement reported (Stage 5) confirms that after familiarisation with the coding instrument and the completion of the observer training programme the instrument can be considered reliable. All aspects of the emergent game-based assessment tool reported 'fair-perfect' strength of agreement for reliability, with 83% of behaviours reporting 'substantial' or better scores. The scale of analysis used in the emergent games-based assessment (captured at an individual-environment interaction level), capturing key affordances that a child attunes to and how they are functionally playing the game, results in a complex observational process being undertaken. Since van der Mars (1989) indicated agreement levels can be dependent upon the phenomenon under investigation and the complexity of instrument employed it is reasonable to expect variance between simpler and more complex environment interactions. Recurrent patterns of error or weaker agreement levels were noted in events where multiple behaviours emerged simultaneously, prolonged temporal events were observed, or spatial temporal evaluations were difficult to define with confidence. 'Fair-moderate' strength of agreement was reported, for example, in spatial temporal interactions on both offence and defence, suggesting some reliability in the reporting of these behaviours. Consequently, these aspects of the emergent game-based assessment tool should be used with caution. Alternatively, there may need to be further consideration given to the observer training programme, with a greater focus on these elements to assure more reliable assessment and data reporting. The test-retest data for both offensive and defensive spatial temporal interactions returned improved (moderate-substantial) strength of agreement, indicating more consistent use and interpretation of the categorial observation items when employed by individual observers during the re-test. García-Ceberino et al. (2020) and Ju et al. (2022), have similarly reported variables establishing defensive and offensive behaviours in relation to defending and exploiting space as the least identifiable actions when quantifying performance. By comparison, shorter, single behaviour, limited locomotion examples, with easily defined spatial temporal interactions (e.g., offensive functionality) reported greater strength of agreement during the process of establishing observer reliability.

6.5iii Limitations

Some of the limitations noted are not dissimilar to those previously reported in other studies of observational research tools and include issues such as analysis complexity due to detailed categorisation (Dogramaci, Watsford & Murphy, 2011), the labour-intensive nature of coding (Fernandes et al., 2019), potential confusion and subjectivity in accurately reporting behaviours (O'Connor & Joffe, 2020) and the unpredictability of an individual's environmental interactions and the potential for player congestion (Dogramaci, Watsford & Murphy, 2011). Nonetheless, this study evidences that the emergent game-based assessment tool has the potential to be highly effective

following familiarisation and training. Future research should look to establish effectiveness and feasibility of use by practitioners in physical education settings.

6.6 Conclusion

This study found the ecological emergent games-based assessment tool to be valid and reliable, providing both educators and researchers with a useful mechanism to assess physical literacy during small-sided games. The emergent games-based assessment values the holistic and multidimensional orientation of the physical literacy construct and has the potential to chart growth over time, support assessment, and enable educators to better understand children's knowledge *of* the environment and how physical literacy reveals itself through embedded actions. Such insight could develop deeper understandings of the physical literacy construct, in addition to supporting a fulfilling physical literacy journey.

Chapter Seven - An Ecological Insight into the Revelation of Physical Literacy in Children during Small-Sided Games

7.1 Thesis Study Map: Study Four

Study	Objectives
Study One (Chapter Four) Measuring Physical Literacy: A Fresh Approach	Objectives: • Establish the feasibility of capturing children's behaviour and environmental interactions during games-play that would reveal their physical literacy. • Establish face validity of a novel approach to assessment, framed by an ecological dynamics conceptualization to capture and measure physical literacy. • Highlight that the current reductionist approach to the measurement of physical literacy is not appropriate, especially when attempting to capture the embodied dimension of physical literacy. Key Findings: • Established the feasibility of assessing physical literacy through observations of children's games play through the development of an observational instrument and categorical items that accurately represented the revelation of physical literacy through observed behaviour within small-sided games. • Within the context of systematic observation, established face validity of the observational instrument. • Highlighted the insight offered by embodied learner-environment interactions in naturalistic settings.
Study Two (Chapter Five) Assessing Physical Literacy, Conceptualised in an Ecological Dynamics Theoretical Rationale	Objectives: • Pilot an assessment of physical literacy conceptualised in an ecological dynamics theoretical rationale. • Demonstrate the underpinning ecological dynamics principles and conceptualisation applied to the measurement of physical literacy. Key Findings: • Rationalised key pillars of an ecological dynamics approach underpinning the design of a game-based assessment for physical literacy. • This study provided initial evidence that an ecological dynamics informed games-based assessment has the potential to provide richer understandings of children's physical literacy. • Explorative analysis outlined a rationale for why an approach informed by ecological dynamics might offer a novel contribution to understanding and evaluating physical literacy.
Study Three (Chapter Six) Examining the Validity, Reliability and Feasibility of Capturing Children's	Objectives: • Establish the validity and reliability of the psychometric properties of the emergent games-based assessment tool

Physical Literacy through Games-Based Assessment in Physical Education	following a systematic process including face and content validity, combined with inter- and intra-observer reliability. Key Findings: • Content validity and reliability were demonstrated at a statistical level, establishing that the emergent games-based assessment tool is able to measure the dynamic interactions observed between child and environment in physical education games play
Study Four (Chapter Seven) An Ecological Insight into the Revelation of Physical Literacy in Children during Small-Sided Games	Objectives: • Investigate how features of the physical literacy construct reveal themselves through children's behaviours using the emergent games-based assessment tool. • Establish key differentiating behaviours of higher- and lower-physical literacy children when playing small-sided games. • Promote the role of ecological dynamics when employed as a theoretical framework to investigate physical literacy.

Within Study Four (Chapter Seven), I conceived and designed the methodology and analysis in agreement with the supervisory team with the intention of progressing the thesis aims and objectives. This study built upon the work of previous chapters and focused on the role of ecological dynamics when employed as a theoretical framework to investigate how features of the physical literacy construct reveal themselves through children's behaviours in a game setting. I was responsible for data collection and analysis, with writing and preparation of the tables and figures in this chapter completed independently.

7.2 Introduction

Physical literacy has become a prominent feature of the discourse related to physical education policy and practice (Capel & Whitehead, 2013; Whitehead, 2013a; Jurbala, 2015; Roberts, Newcombe & Davids, 2019; Young, O'Connor & Alfrey, 2019). Alongside the increased prominence of physical literacy, there has also emerged the need to produce assessment approaches that allow valid and reliable measures of the construct to be obtained. It has been suggested that appropriate measurement and evaluation of physical literacy in youth populations has the possibility to facilitate the development of physical literacy in children, in addition to improving the standards, refining expectations, and developing the profile of physical education as a subject area (Tremblay & Lloyd, 2010; Corbin, 2016). The last twenty years has seen considerable investment in the development and application of systematic observational tools within physical education (Arias & Castejón, 2012; Roberts & Fairclough, 2012), and physical literacy more specifically (Longmuir et al., 2015, 2018). The purpose of systematic observation in broader pedagogy resides in efforts to improve the quality and value of educational intervention, providing insights into professional practice and behaviours (Wilkie

et al., 2023b). Within physical education, systematic observations afford authentic (demonstrated in context) assessment and evaluation opportunities, granting valuable insight into what is typically considered to be an esoteric process to be developed (Potrac et al., 2000).

The multidimensional nature of physical literacy, with its origins embedded in phenomenology and existentialism has resulted in friction within the academic literature on how, and if physical literacy can be assessed, with consequences for operationalising evaluation in practice (Lundvall, 2015; Edwards et al., 2018; Whitehead, Durden-Myers & Pot, 2018; Cairney et al., 2019a; Rudd, 2021). Previous attempts to evaluate physical literacy have resulted in typically reductionist approaches being employed (Jurbala, 2015; Longmuir & Tremblay, 2016; Edwards et al., 2017). Barnett et al. (2019) acknowledged that most evaluation strategies utilised can be considered to simultaneously capture key aspects of physical literacy, while concurrently not adequately representing the entirety of the construct. Currently, few approaches advocate the implementation of a more composite approach able to provide detailed insight into multiple areas of the concept simultaneously (Edwards et al., 2017). Edwards et al. (2018) and Green et al. (2018) have both encouraged the development of creative, nonconventional approaches to the evaluation of physical literacy that better reflect the holistic nature of the construct. Previously, Wilkie et al. (2022, Chapter Five), developed a games-based assessment tool utilising an ecological dynamics framework, providing a rationale that features of the cognitive, affective and psychomotor domains can be captured through game play movements and behaviour. Consequently, this study will focus on the role of ecological dynamics when employed as a theoretical framework to investigate how features of the physical literacy construct reveal themselves through children's behaviours in a games setting.

An ecological dynamics framework emphasises the critical relationship that exists between the learner, and their environment, identifying it as a basis for practice design and a key theoretical principle by which to understand the learning process (Davids et al., 2013b; Roberts, Newcombe & Davids, 2019). Adopting an individual-environment scale for the assessment of physical literacy remains more faithful to the philosophically complex and holistic nature of the concept, rather than conforming to the more linear and reductionist thinking currently prevalent in the field (Wilkie et al., 2023b). The over-emphasis on movement technique, evaluating how closely children conform to optimal movement templates, within isolated tasks, performed in closed environments is not purposefully attempting to be dualistic, but is motivated by the perceived necessity for standardisation and the desire to make reliable comparisons across time and individuals. Decontextualised ideas and expressions of throwing, catching, balance, and locomotion, detached from the consideration of context (e.g., environment, person, task, perception, and interpretation) or the affect upon the ecological system that they are part of, is a worthless objectification of an

individual's embodied relationship with the world, and arguably a poor representation of their physical literacy (Green et al., 2018). Whitehead's (2001) conceptualisation of physical literacy instead addresses the value of developing one's capacities for movement across a range of activity settings. Consequently, the focus is on self-realisation of an individual's potential and exploiting their ability to express themselves through physical activity (O'Sullivan et al., 2020; Rudd et al., 2020). These ideas are reinforced by the importance Whitehead (2010) places on individual endowment. The result is that from a Whiteheadian perspective movement must be viewed in relation to the unique potential possessed by each individual within their environment and the opportunities such a context offers.

Jurbala (2015) indicates that advances in the study of physical literacy will result from examining the interactions between the composite elements of the construct. Observing children engaged in problem solving and decision making (as an artefact of behaviour) is an indicator of how well they are constructing knowledge across numerous learning domains (Roberts, Newcombe & Davids, 2019). Shaped by environment and task constraints, decisions on whether, when, and how to act, are critical intersections between the different facets of physical literacy. Such perspectives can be captured effectively through ecological approaches that value the reciprocity that has evolved between individual-environment systems (Gibson, 1979; Travassos et al., 2012; Seifert & Davids, 2017). Ecological dynamics provides an appropriate platform through which experience, interpretation, value, meaning, and self-regulation of behaviours in movement contexts can be established (O'Sullivan et al., 2020; Rudd et al., 2020). An ecological dynamics rationale for explaining skilled behaviour in physical activity contexts is predicated upon an individual's ability to successfully negotiate the performance setting through the emergence of functionally adaptable movement solutions (Araújo et al., 2020; Woods et al., 2020b). Within such a framework, observed behaviour is recognised as a self-organising phenomenon that emerges as a consequence of the invitations for action presented by the environment and how these affordances are perceived and exploited (Hristovski et al., 2012; Woods et al., 2020b). A significant assumption in adopting approaches for charting physical literacy, informed by an ecological dynamics framework, is that physically literate individuals would be more accomplished at recognising and taking advantage of (i.e., *attuning* to) such information. In doing so, the physically literate performer will functionally regulate their behaviours more appropriately than less literate individuals based upon task and environmental constraints.

The adoption and promotion of physical literacy seemingly indicates a growing focus on holistic and inclusive approaches to understanding and promoting physical activity, health and well-being (Roetert, Ellenbecker & Kriellaars, 2018). Whilst it is becoming increasingly apparent that physical literacy is becoming embedded into UK physical education programmes (Sport England, 2016; Youth Sport Trust, 2022), what is less evident is how practitioners might be advised to operationalise

the provision and evaluation of pedagogies to support children's physical literacy journey. Globally, the typical approach to evaluation of physical literacy has been paradigmatically reductionist. For example, measurement of physical literacy focused on the quantification of separate physical, affective, and cognitive domains (Canadian approach); approximated scores, calculated from disconnected elements of physical, psychological, social, and cognitive skills (Australian approach); and checklists of set capabilities and achievements that every child should achieve (UK and Swedish approach). In an attempt to address such shortcomings, previous work has outlined how assessment of physical literacy, conceptualised in an ecological dynamics theoretical rationale might be undertaken (Wilkie et al., 2022; 2023b). Content validity and reliability have been demonstrated at a statistical level, establishing that the emergent games play assessment tool is able to measure the dynamic interactions observed between a child and the environment in small-sided, modified games (Wilkie et al., 2023b). The assessment tool reported high levels of validity for all measurement variables ($V \geq 0.78$), and 'substantial' to 'perfect' agreement for observer reliability. Based upon key pillars of ecological dynamics (Wayfinding, Affordances and Attunement, Intentionality, and Functional Movement Skills) that align to features of the physical literacy construct, the emergent games-based assessment tool, has nine ecological conceptualisations of behaviour, 15 measurement variables, and 44 categorical observational items (See Chapter Six for specific details). The emergent games-based assessment remains more faithful to the philosophically complex and holistic nature of the physical literacy concept, avoiding decontextualised, reductionist approaches to assessment (Wilkie et al., 2023b). Instead, embedding assessment opportunities in activities typical of primary physical education lessons. Tyler et al. (2018) argued that measures of physical competence in primary school children should evaluate fundamental, combined and complex movement skills in authentic settings in a time efficient manner. Such proposals align with the emerging trend to adopt more ecological, embedded, qualitative assessment approaches in school settings (Bannon et al., 2013; Durden-Myers & Whitehead, 2018; Green et al., 2018). The emergent games-based assessment tool appropriately accommodates both the interactions between cooperating and competing players and important performance constraints such as ball and goal location, ensuring a more authentic and representative assessment environment. By otherwise neglecting key features of the performance setting, other, more reductionist approaches are not able to faithfully simulate the dynamical nature of many sporting activities and contexts, which may in turn significantly affect the functionality of evaluations undertaken and their relevance in reflecting learning and knowledge *of* the environment. Vilar et al. (2012) have highlighted that assessment approaches that fail to yield relevant, authentic sources of information for individuals to perceive and exploit in regulating their subsequent behaviour can result in the assembly of poorer functional performance behaviours. Consequently, the aim of this

study is to evaluate how physical literacy reveals itself through the individual-environment interactions observed during small-sided games using the emergent games-based assessment tool in children.

7.3 Methods

7.3i Participants and settings

Key Stage two, year four, five, and six children from three different primary schools located in the Northwest of England were recruited through existing educational networks (*n*=54; Age: 10 ±0.9yrs; Height: 1.38 ±0.08m; Mass: 36.41 ±9.7kg). Baseline assessments using previously validated assessment tools that capture key, individual, constructs of physical literacy were undertaken prior to the completion of the emergent games-based assessment. A composite physical literacy score for each child was obtained through the evaluation of Working Memory (McClelland et al., 2014), Game Play Perception (Miller et al., 2019), and an assessment of fundamental movement skills using the Dragon Challenge (Stratton et al., 2015) (for more detail see Chapter 3.1). To determine similarities between individual participants, a *kmeans* cluster approach was utilised (R Core Team 2019) to detect and organise data into a number of groups via the elbow method. This analysis enabled subsequent grouping of individuals with similar levels of physical literacy into higher- and lower-physical literacy categories. This categorisation informed the creation of balanced, mixed physical literacy teams consisting of five players (two higher-physical literacy, two lower-physical literacy, and a single neutral player per team) and was used for the purpose of identifying performers during the game-based assessment.

Numerous key principles when designing evaluation tests based on concepts that reside within ecological dynamics have been proposed within the literature. The inclusion of critical perceptual variables that individuals typically use to control their actions during performance aligns to the creation of representative design (Chow et al., 2011; Pinder et al., 2011; Davids et al., 2013b). Representative design is predicated on the availability of equivalent affordances existing in assessment environments, that would otherwise be found in performance contexts. These proposals are grounded in compelling empirical evidence that indicates that different patterns of movement coordination manifest as a consequence of manipulated informational task constraints (Pinder et al., 2009; Dicks, Button & Davids, 2010). Due to the significance of performer-environment mutuality from an ecological dynamics perspective it is important to attend to the following principles in representative assessment design 1) employment of noisy evaluation tasks, 2) ensuring tasks are predicated on information-based control of action, 3) making certain continuous, context-dependent decision and action opportunities are presented, 4) ensuring representative affordances are present

in the test environment, and 5) recognising and accommodating individual difference (Davids et al., 2013). A modified, small-sided (5 v 5) invasion game (for more detail see Chapter 3.1) was chosen for the purposes of games play assessment as it provided a representative design aligned to the principles outlined by Davids et al. (2013).

Opportunities for combinations of motor and perceptual-cognitive skills to emerge within a technical-tactical performance setting were provided by the game environment. The reduced number of players (five per team) enabled individuals to play a more meaningful role in the game as each child had greater opportunities to contact the ball, resulting in more on-ball decisions and actions being taken (Köklü et al., 2012). Additionally, player's knowledge *of* the environment is more readily revealed due to the constant exposure to offensive and defensive dyadic formation opportunities (Dellal et al., 2011). Cooperating and competing players, shifting task objectives, transition between offensive and defensive behaviours, and implementation of strategic principles of play resulted in a dynamic, affordance rich, representative, testing environment being provided. Such an environment makes available critical perceptual variables that performers characteristically attune to when regulating their actions during goal-orientated behaviour. Additionally, these qualities made the game specific to the physical education curriculum requirements for Key Stage two children who are expected to be able to run, jump, throw and catch in isolation and combination, and apply basic principles for attacking and defending in modified games (Department for Education, 2013). Consequently, an affordance rich, dynamic games play environment was considered highly appropriate as a vehicle to capture and reveal physical literacy when aligned to a framework informed by ecological dynamics.

7.3ii Measures and data collection

In the analysed small-sided, modified games, children were placed into mixed gender, balanced physical literacy teams of five. Children then played a 10-minute game of mat ball with each five-minute half separated by a short break (for more detail see Chapter 3.1). Participants wore coloured, numbered bibs, to allow participant identification for the purposes of analysis and to allow cooperating and competing players to be identified during the gameplay. Games were video recorded (GoPro Hero 9) from a fixed, elevated, court side position. This perspective allowed for all participants, and features of the playing area to be captured within the field of view.

The emergent game-based assessment tool (Wilkie et al., 2023b) was developed into an electronic coding module within Dartfish Pro allowing post-event, manual, electronic digital video-based tagging to be completed. Discrete data was coded, using recorded video playback with frame-by-frame capabilities (1080hp, 60Hz frame rate). Observational analysis of children's games play

followed the guidelines provided by Wilkie et al. (2023b). The scale of analysis was an individual child playing the game, using event-based temporality for recorded observations. This approach defined the observed behaviours and interactions occurring between receipt of the ball by a player from another player and the conclusion of the subsequent distribution of the ball to another player as a temporal period. Coding for a single 10-minute game typically took 40 – 50 minutes per player. Once coded, frequency data was converted into percentages for purposes of analysis and reporting. Gutierrez and Garcia-Lopez (2012) similarly used percentages of offensive actions to analyse behaviour in invasion games using event-based temporality.

7.3iii Statistical Analysis

Descriptive statistics for higher- and lower-physical literacy groups (means and standard deviations) were calculated for each variable. The Shapiro-Wilk test for the assumption of normality was employed for all variables. Where normality of data was assumed independent samples t-test were subsequently employed to analyse for differences between higher-physical literacy and lower-physical literacy groups. Where normality of data was not assumed a Mann-Whitney U test was alternatively employed to analyse data (Weir & Vincent, 2020). Following this initial analysis, to produce descriptions of the size of observed effects, independent of the possibly misleading influences of sample size, Cohen's *d* was used to calculate effect size as outlined in Fritz, Morris, and Richler (2012). Thresholds for effect size were set at <0.2, trivial; 0.2-0.6, small; 0.6-1.2, moderate; 1.2-2.0, large; 2-4, very large; and >4 extremely large (Hopkins, 2002).

7.4 Results

Electronic, digital video-based tagging, using the emergent games-based assessment tool, resulted in a mean of 112.2 ± 25.7 temporal events per participant being reported upon during games. Means per player of 10.5 ± 6.6 'On-ball' events, 45.8 ± 14.3 'Offensive off-ball' events, and 55.9 ± 17.4 'Defensive off-ball' events were recorded. Table 7.1 presents the data for on-ball behaviours during games play, highlighting similarities and differences in between higher- and lower-physical literacy groups.

Table 7.1. Comparison of on-ball behaviours during small-sided games play

Measurement Category	Measurement item	H-PL	L-PL	*p*	*ES*
Offensive functionality	Number of possessions	13.24 (±6.32)	9.63 (±6.22)	0.113	0.576
	Time in possession (s)	2.4 (±1.36)	3.5 (±2.35)	**0.009****	0.573
	Pass (%)	84.59 (±13.90)	84.39 (±20.30)	0.960	0.011
	Shot (%)	15.41 (±13.90)	15.61 (±20.23)	0.620	0.012
	Successful distribution (%)	79.39 (±10.94)	76.44 (±20.14)	0.599	0.182
	Unsuccessful distribution (%)	12.42 (±11.16)	13.87 (±13.07)	0.765	0.019

	Intercepted distribution (%)	8.19 (±9.68)	9.69 (±15.08)	0.574	0.118
	Overhead distribution (%)	18.69 (±32.16)	26.95 (±28.64)	0.100	0.271
	Shoulder distribution (%)	18.84 (±27.30)	6.08 (±17.08)	0.139	0.560
	Chest distribution (%)	55.53 (±37.32)	48.55 (±25.64)	0.219	0.218
	Underarm distribution (%)	6.93 (±11.68)	18.41 (±26.10)	0.702	0.568
Offensive invitation for action	Penetrating distribution (%)	63.47 (±17.14)	39.92 (±20.41)	**0.006****	1.249
	Lateral distribution (%)	30.99 (±15.98)	44.2 (±16.37)	0.156	0.817
	Rearwards distribution (%)	5.53 (±5.09)	15.87 (±17.06)	0.080	0.821
	Short distribution (%)	38.0 (±17.96)	48.64 (±23.56)	0.392	0.508
	Medium distribution (%)	42.31 (±18.42)	42.24 (±21.24)	0.661	0.004
	Long distribution (%)	19.69 (±18.92)	9.12 (±16.83)	0.132	0.590

Note: H-PL = Higher-physical literacy; L-PL Lower-physical literacy; *p ≤0.05; **p <0.01; *ES* = effect size

Analysis of on-ball behaviours identified significant differences between higher- and lower-physical literacy children in some features of invitations for action and functionality. Specifically, results indicate that higher-physical literacy children distributed the ball following reception significantly more quickly than lower-physical literacy children (p=0.009, *ES*=0.573) and executed penetrating passes as movement actions more frequently (p=0.006, *ES*=1.249). Table 7.2 presents the statistical analysis of offensive off-ball behaviours during games play, highlighting similarities and differences in between higher- and lower-physical literacy groups.

Table 7.2. Comparison of offensive off-ball behaviours during small-sided games play

Measurement Category	Measurement item	H-PL	L-PL	*p*	*ES*
Offensive intentionality	Moves in attack (%)	75.96 (±18.78)	72.06 (±16.69)	0.114	0.220
	Remains Stationary in attack (%)	24.04 (±18.78)	27.93 (±16.69)	0.114	0.219
	Single movement (%)	61.69 (±14.07)	62.74 (±19.30)	0.761	0.062
	Multiple movement (%)	14.28 (±8.11)	9.32 (±7.02)	**0.013***	0.654
Offensive spatial temporal interactions	Finds space effectively	72.24 (±17.84)	61.22 (±17.29)	**0.041***	0.627
	Moves into occupied space (%)	7.83 (±6.91)	9.14 (±7.52)	0.981	0.181
	Moves into contested space (%)	19.92 (±12.09)	29.64 (±14.96)	**0.018***	0.715
	Close offensive support (%)	22.74 (±18.18)	29 (±17.61)	0.671	0.349
	Nearby offensive support (%)	47.26 (±14.20)	43.2 (±13.67)	0.331	0.291
	Distant offensive support (%)	30 (±19.82)	27.8 (±19.01)	0.659	0.113
	Occupies area near to own goal (%)	15.1 (±23.56)	18.97 (±18.53)	0.248	0.183
	Occupies defensive-midcourt area (%)	27.98 (±13.75)	27.27 (±12.80)	0.448	0.053
	Occupies attacking mid-court area (%)	39.29 (±16.10)	33.61 (±15.95)	0.261	0.354
	Occupies area near to opposition goal (%)	17.62 (±12.57)	20.27 (±22.90)	0.465	0.143
	Effectively tracks play (%)	96.55 (±4.79)	93.2 (±6.04)	0.146	0.615

Offensive coadaptive networks	Network interaction (%)	45.38 (±19.81)	44.45 (±21.24)	0.529	0.045
	Targeted with pass (%)	22.99 (±15.24)	21.04 (±13.15)	0.568	0.137
	Call:Pass ratio	2.26 (±1.17)	2.49 (±1.32)	0.990	0.184

Note: H-PL = Higher-physical literacy; L-PL Lower-physical literacy; *p ≤0.05; **p <0.01; *ES* = effect size

Analysis of offensive off-ball behaviours identified significant differences existed between higher- and lower-physical literacy children in some features of intentionality and offensive spatial temporal interactions. Higher-physical literacy children specifically displayed significantly greater proportion of multiple movements during attacking periods of play (p=0.013, *ES*=0.654) and demonstrated significantly greater capacity to find space when their team had possession of the ball (p=0.041, *ES*=0.627). Conversely, lower-physical literacy children exhibited significantly more movements into contested spaces while their team was in possession of the ball (p=0.018, *ES*=0.715). Table 7.3 presents the statistical analysis of defensive off-ball behaviours during games play, highlighting similarities and differences in between higher- and lower-physical literacy groups.

Table 7.3. Comparison of defensive off-ball behaviours during small-sided games play

Measurement Category	Measurement item	H-PL	L-PL	*p*	*ES*
Defensive intentionality	Moves in defence (%)	88.49 (±10.19)	84.35 (±12.32)	**0.038***	0.366
	Remains Stationary in defence (%)	11.5 (±10.19)	15.64 (±12.32)	**0.046***	0.366
	Single movement (%)	75.07 (±9.92)	73.67 (±10.74)	0.061	0.135
	Multiple movement (%)	13.42 (±9.71)	10.68 (±8.01)	0.338	0.308
Defensive spatial temporal interactions	Towards ball (1st defender) (%)	14.13 (±11.29)	15.65 (±11.82)	0.743	0.132
	Overloads ball (2nd defender) (%)	9.7 (±11.06)	10.4 (±7.51)	0.827	0.074
	Defensive marking (%)	28.33 (±12.87)	19 (±7.16)	**0.026***	0.896
	Unpurposeful movement (%)	47.85 (±12.73)	54.95 (±15.74)	**0.025***	0.496
	Tight defensive pressure (%)	32.55 (±22.62)	32.24 (±18.35)	0.560	0.015
	Loose defensive pressure (%)	38.89 (±12.08)	41.34 (±11.87)	0.942	0.205
	Distant defensive pressure (%)	28.56 (±22.87)	26.42 (±18.67)	0.395	0.103
Defensive coadaptive networks	Effectively tracks play (%)	91.68 (±4.46)	86.74 (±6.45)	**0.010****	0.891
	Attempted block (%)	18.4 (±7.94)	10.96 (±8.98)	**0.008****	0.878
	Successful block (%)	32.67 (±17.93)	25.99 (±32.87)	**0.008****	0.252
Defensive spatial temporal interactions	Occupies area near to own goal (%)	31.6 (±28.89)	31.26 (±25.53)	0.423	0.012
	Occupies defensive-midcourt area (%)	39.09 (±13.75)	34.59 (±16.24)	0.166	0.299
	Occupies attacking mid-court area (%)	22.76 (±15.68)	25.36 (±14.56)	0.504	0.172

	Occupies area near to opposition goal (%)	6.5 (±6.45)	8.79 (±17.43)	0.339	0.174

Note: H-PL = Higher-physical literacy; L-PL Lower-physical literacy; *$p \leq 0.05$; **$p < 0.01$; *ES* = effect size

Analysis of defensive off-ball behaviours revealed significant differences existed between higher- and lower-physical literacy children in some categories of intentionality, spatial temporal interactions, coadaptive networks, and functionality. Higher-physical literacy children demonstrated significantly greater instances of movement (p=0.038, *ES*=0.366), marking behaviours (p=0.026, *ES*=0.896), attempted blocks (p=0.008, *ES*=0.878), successful blocks (p=0.008, *ES*=0.252), and defensive awareness through tracking play (p=0.01, *ES*=0.891). Whilst lower-physical literacy children demonstrated significantly more cases of remaining stationary (p=0.046, *ES*=0.366) and engaging in unpurposeful movement (p=0.025, *ES*=0.496) while their team was out of possession.

7.5 Discussion

The aim of this study was to gain an embedded understanding of how a child's physical literacy might reveal itself through an assessment framework situated in ecological dynamics. To better understand an individual's physical literacy when embedded in activity, practitioners and researchers should observe behaviour in context. Such approaches would enable insight to be developed regarding the information sources children attune to, the opportunities for action available, and how such affordances might be exploited to successfully negotiate task objectives (Wilkie et al., 2021). A particular characteristic of team games is the flow of interactions observed between performers, with or without the ball (Mateus, 2005). Consequently, a games-based approach to assessment provides opportunities to develop functional, perception-action couplings informed by an individual's physical literacy in relation to achieving task-goals. A significant assumption in adopting approaches for charting physical literacy, informed by an ecological dynamics framework, is that physically literate individuals would be more accomplished at recognising and taking advantage of such information. Consequently, physically literate performers will functionally regulate their behaviours more appropriately than less literate individuals. Research highlights that success in sport originates from improved functionality of performers in their environment, whereby they are able to realise stable, successful, performance outcomes regardless of context (Araújo & Davids, 2011; Davids et al., 2013b). This study has provided evidence that a games-based assessment informed by ecological dynamics successfully differentiates higher- and lower-physical literacy children's behaviour, providing fresh insight to understanding children's physical literacy.

7.5i Offensive functionality and invitations for action

Data from this study identified no significant differences between pass frequency, shooting frequency, passing success, shooting success, and interceptions when comparing higher- and lower-physical literacy children's on-ball behaviours. Further analysis of distribution technique also identified no significant differences between the functional movement solutions exhibited by both groups during games. As a more readily accepted traditional performance measure, evaluations of passing distribution success provides little insight to the 'how' and 'why' of observed performance. Commonly held associations between movement competencies equating to physical literacy levels, results in a more limited realisation of the concept than Whitehead (2019) advocates. In isolation these non-significant findings highlight the necessity to explore embedded movement behaviours more widely, capturing a more holistic evaluation of individual-environment interactions. In responding to affordances offered by the performance environment, data demonstrated similarities in distribution distances and direction between groups. By establishing that no significant differences exist in passing distances it is possible to infer that physical literacy qualities such as the confidence and motivation (i.e., intentionality) to perform such movements are not differentiating factors in observed behaviour between higher- and lower-physical literacy children. Expertise in throwing has previously been identified as poor, in age matched children when engaged in decontextualised expressions of movement proficiency (Behan et al., 2019; Lawson et al., 2021). Whereas data from the present study indicates predominantly successful passing distribution across both groups (77.45%). An approach underpinned by ecological dynamics is less concerned by the technical quality or proficiency of such movements and concerns itself instead, with functionally appropriate movement solutions that support the achievement of task-goals. From this perspective, even when factoring in the additional complexity presented by a dynamic performance environment, functional performance of both higher- and lower-physical literacy children could be considered positive in relation to object control skills. Distribution technique flexibility allows performers to more readily solve emergent problems in an efficient, creative manner, as numerous movement solutions and environment interactions are available to overcome challenges faced. Both higher- and lower-physical literacy groups evidenced varied distribution techniques supporting the notion that their motor competencies in this performance environment were comparable. While not a differentiating factor in the physical literacy of children playing the small-sided game used in this study, the data supports the notion of both higher- and lower-physical literacy groups 'responding appropriately' (Whitehead, 2001) to the environment.

Significant differences, with large effect size, were identified between the number of penetrating passes and shots (p=0.006, ES=1.249) attempted by higher-physical literacy children in comparison to lower-physical literacy children (63.47% vs 39.92%). Distribution laterally and

rearwards demonstrated no significant differences, with a moderate effect size between the groups, though lower-physical literacy children did display more frequent lateral (44.2% vs 30.99%) and rearward (15.87% vs 5.53%) distribution. Combined with distribution success, the data starts to expose noteworthy self-regulation tendencies of the participants in this study. Gibson (1966) identifies that knowledge *of* the environment guides individuals through the (re)organisation of actions as a consequence of processes of self-regulation in response to available, subsequently exploited affordances. Knowledge *of* the environment, is articulated through perception, action and skilled intentionality (Button et al., 2020). Both higher- and lower-physical literacy performers are demonstrating effective knowledge *of* their environment through processes of regulating their behaviour to meet task-objectives scaled against personal endowment. By displaying reduced penetrative passes, alternatively employing lateral and rearward distribution, lower-physical literacy children are still aligning their behaviour to shared task goals. Moderating behaviour so as not to jeopardize collective team goals through engaging in game play strategies regarded higher risk, provides excellent insight into embodied knowledge and how lower-physical literacy performers are able to respond to physically challenging situations with intelligence. Typically, learners are observed to migrate to behaviour and forms of the game they feel most comfortable and confident with (Roberts, Newcombe & Davids, 2019). In demonstrating significantly greater penetrating distribution higher-literacy performers are equally demonstrating self-regulation of behaviour allied to their personal endowment. From this perspective it could be proposed that the physical literacy of the performer is explicitly constraining functional behaviour. The synergism between the different domains of the physical literacy construct results in higher-physical literacy performer's having all, or some pertinent combination of motivation, confidence, motor competence, and embodied knowledge to subsequently demonstrate penetrating distribution strategies more often.

Time in possession (p=0.009, ES=0.573) was the other significant difference, with moderate effect size observed during on-ball behaviour of higher- and lower-physical literacy children (2.4s vs 3.5s). Expert performers typically do not deliberate between possible movement solutions available, rather, they typically execute the first satisfactory action considered, which leads to rapid decision making and action implementation (Araújo et al., 2019). Results indicate that higher-physical literacy performers are processing perceived affordances and then expediently actioning decisions with no compromise in performance outcome or success, compared to lower-physical literacy performers. Performance constraints have been shown to be dynamic, evolving, and deteriorating characteristics of the performance setting (Guerin & Kunkle, 2004; Hristovski et al., 2006; Renshaw et al., 2010). Within game environments affordances and their perception and interpretation exert attraction in various ways, emphasising the individual-environment reciprocity present (Chow et al., 2006; Vilar et

al., 2012; Button et al., 2020). From an ecological perspective these ideas may explain how lower-physical literacy individuals perceive the ball as a critical emergent constraint that consumes their focus to the detriment of the wider environment. The strength of attraction to this singular feature of the performance setting results in these performers being exclusively focused on catching and securing a pass. They commit little attention to the whereabouts or availability of cooperating players as distribution targets. Consequently, having secured possession lower-physical literacy performers will only then engage in scanning behaviours to support ball distribution. Conversely, a physically literate individual is 'perceptive at reading *all* aspects of the physical environment' (Whitehead, 2001). This results in their quicker distribution of the ball, which may be explained by their ability to perceive multiple key features or their performance setting, attuning to numerous critical affordances simultaneously (e.g., an incoming pass and the positioning of teammates). Demonstrating this embodied knowledge, through being well attuned to the performance environment allows for the possibility to switch quickly from one action to another (Rietveld, 2012). Such behaviour would better position higher-physical literacy performers to quickly distribute the ball as they are able to rapidly determine suitable subsequent movement solutions having received the ball. The value offered by reviewing passing functionality and invitations for action as outlined here is that it aligns more effectively with the philosophical and ontological basis of physical literacy. Whereby, the interface between abilities, opportunities and circumstances, enmesh to affect an individual's successful negotiation of the performance environment (Whitehead, 2019; Baily, 2020b).

7.5ii Offensive intentionality and spatial temporal interactions

Results identified significant differences, with moderate effect size, in the number of times higher-physical literacy children were able to find space (p=0.041, *ES*=0.627), occupying areas with no competing players proximal to their location. Higher-physical literacy children also exhibited significantly more, with moderate effect size instances, of moving multiple times (p=0.013, *ES*=0.654) during single offensive temporal periods. Lower-physical literacy children displayed significantly greater likelihood, with moderate effect size, of moving into contested areas (p=0.018, *ES*=0.715), with one or more competing players already occupying the location the performer moves to. Further analysis of the offensive off-ball behaviours revealed no significant differences, with trivial-small effect sizes, in the frequency with which children engaged in a singular locomotive action, remained stationary, moved to a position already occupied by a teammate, demonstrated network interactions, were targeted with a pass, or the frequency with which performers occupied different playing areas during attacking phases of the game.

Behaviour within games settings is constrained by an individual's position in the playing area, their relative position to competing and cooperating players, particular game phases (i.e., attacking or defending), and implementation of strategic plans (Araújo & Davids, 2016). These constraints on performance interact to shape the emergence of stability (i.e., secure dyadic 1v1 systems), variability (i.e., disruption of dyadic stability and loss of system coordination), and the materialisation of new, continuous attacker-defender interactions (Vilar et al., 2012). Interactions with competing and cooperating players has a significant impact on self-regulating tendencies, as behaviours and the affordances they subsequently offer are constrained by other performers in the environment (Passos, Araújo & Davids, 2016). The existence of collaboration and coadaptation in this manner is deemed crucial in the facilitation of the physical literacy journey (Roberts, Newcombe & Davids, 2019). No significant differences were identified in the offensive support offered by higher- and lower-physical literacy players (close support: 22.74% vs 29%; nearby support: 47.26% vs 43.2%; distant support: 30% vs 27.8%), with positions 1.5m–4.5m away from the player in possession (nearby support) being the most frequently observed by all participants (44.2%). Such on-court positioning corresponds well to the observed offensive invitations for action that reported short and medium length passes to be most commonly adopted (82.92% of all distribution). Consequently, both higher- and lower-physical literacy groups could be considered to be positioning themselves effectively in order to support their team achieving game objectives. Results also indicated no significant differences between higher- and lower-physical literacy children in the number of network interactions observed (45.38% vs 44.45%), or the frequency with which performers were picked out as distribution targets (22.99% vs 21.04%). By showing an equal desire to become the target for distribution both groups are demonstrating comparable inclinations to be part of the game, reflecting performer's motivation and engagement with the task, regardless of the validity of being a legitimate distribution target.

Higher-physical literacy performers demonstrated significantly greater capacity to regulate their movements in relation to attempts to eliminate dyadic system stability between themselves and defenders. Higher-physical literacy children demonstrated more frequent utilisation of multiple movements during attacking periods of play (14.28% vs 9.32%) and were able to find space more effectively (72.24% vs 61.22%). The data also highlighted how higher-physical literacy performers were significantly less likely to move into contested space, occupied by one or more competing players compared to lower-physical literacy performers (19.92% vs 29.64%). Davids et al. (2013) and Vilar et al. (2012) have highlighted how attacking players engage in processes of symmetry breaking, to destabilise attacker-defender stability and the organisational state of the game, while defending players try to maintain a stable dyadic system, aligned to performance objectives. Seeking out, and exploiting the availability of uncontested space, represents typically complex actions that require

performers to often undertake a sequence of several actions to achieve their objectives (Vilar et al., 2012; Davids et al. 2013). These findings illustrate how higher-physical literacy performers harnessed movement variability in an effort to destabilise dyadic systems and gain ascendency in attacking phases of the game. While the data supports the notion that lower-physical literacy performers recognised the merits of moving and being active in attack (moved in 72.06% of attacking events) they were not able to as effectively anticipate movement needs and respond appropriately (i.e., find space) compared to higher-physical literacy performers. Whitehead's (2001; 2010) original and more recent articulation of the key components of physical literacy identified the ability to read the situation and react appropriately through movement as central facets of becoming physically literate. This was evidenced by higher-physical literacy performer's demonstrating greater capacity to affect attacker-defender dyad stability, resulting in the favourable dissolution of attacking game phase symmetry.

7.5iii Defensive intentionality, spatial temporal interactions, coadaptive networks, and functionality

Results identified significant differences, with small-moderate effect size in the number of times higher-physical literacy children moved in defence (p=0.038, *ES*=0.366), marked opposition players (p=0.026, *ES*=0.896), effectively tracked play (p=0.010, *ES*=0.891), attempted blocks (p=0.008, *ES*=0.878), and successfully performed interceptions (p=0.008, *ES*=0.252) during defensive events. Additionally, results highlighted significant differences in the percentage of times lower-physical literacy children chose to remain stationary (p=0.046, *ES*=0.366) and engaged in unpurposeful movement (p=0.025, *ES*=0.496). Supplementary examination of defensive behaviours revealed no significant differences, with trivial-small effect sizes, in single and multiple movements, closing down the player in possession of the ball, swarming the player in possession of the ball, defensive pressure, and the frequency with which performers occupied different playing areas during defensive phases of the game.

In team games, attacking and defending players have been characterised as coadapting elements of complex self-regulating systems, where ongoing individual-environment interactions regulate behaviours (Araújo, Davids & Hristovski 2006; Davids et al., 2013a; Passos, Araújo & Davids, 2016). Roberts, Newcombe and Davids (2019) have highlighted the benefits of children developing an understanding of how movements, decisions, and interactions with, and in response to others is impactful for the development of physical literacy. Coadaptive interactions during invasions games have been shown to result in the emergence of unprompted pattern forming dynamics between cooperating and competing players (Passos et al., 2008). This investigation established that higher-physical literacy children were significantly more likely to move during defensive phases of the game (88.49% vs 84.35%), exhibiting significantly more defensive marking behaviours (28.33% vs 19%),

involving purposeful movements towards and subsequently occupying contested space, mirroring the movements of opposition players without the ball. Attempts to form, or preserve defensive dyadic system stability helps favourably maintain the organisational state of the game, representing pertinent combinations of motivation, motor competence, and embodied knowledge by the performer. Contrasting this more desirable game play behaviour, lower-physical literacy children demonstrated significantly more examples of unpurposeful movement (54.95% vs 47.85%) and instances where they elected to remain stationary (15.64% vs 11.5%). Insights to performer knowledge *of* the environment are revealed through the combination of these behaviours, as it differentiates desirable and undesirable traits in the achievement of socially shared performance-task goals. In small-sided games it is much easier to destabilise global systems as all performer subgroups must be active to maintain equilibrium (Davids et al., 2013a). Due to the inherent instability characteristics of these types of games it becomes exponentially more important that all component parts of the global system function in a unified manner. Performers with greater knowledge *of* the environment are more likely to exhibit desirable traits orientated towards satisfying shared performance-task goals. Small-sided games are useful as they expose performers to representative affordances allowing embedded knowledge and understanding to be developed (Davids, Chow & Shuttleworth, 2005). Findings from the present study plainly expose behaviours that would otherwise compromise shared performance-task goals, as even singular individual-environment interactions can be impactful to the broader performance environment.

Although all higher- and lower-physical literacy players demonstrated similar capacity to effectively track play when engaged in attacking phases of the game (96.55% vs 93.2%), results indicated significant differences between higher- and lower-physical literacy performer behaviours associated with tracking play when defending (91.68% vs 87.74%). Influenced by constituents of the affective domain of physical literacy it is feasible that the opportunities for fulfilling, meaningful interactions with the ball are more likely to be derived through offensive phases of play. Consequently, from an ecological perspective the trend to track play more frequently during offensive phases of the game may be explained due to some affordances acting as strong attractors, soliciting the attention of performers (Araújo, Davids & Hristovski, 2006). Under dynamic performance conditions when defending, other attractors (i.e., positions and movements of competing players, proximity to the goal, and defensive pressure being applied) may emerge to exert their attraction in the dynamics of the system more readily (Button et al., 2020). Such individual-environment interactions may explain why attention is drawn away from the ball. It is reasonable to assume the more effective awareness of play during defensive phases of the game demonstrated by higher-physical literacy performers influences wider individual-environment interactions. Button et al. (2020) has previously suggested that

individuals must perceive enough of their environment to achieve task goals, while selecting only the most relevant information to facilitate successful intentional behaviour. Higher-physical literacy children demonstrated significantly more attempted blocks (18.4% vs 10.96%) than lower-physical literacy children. Additionally, higher-physical literacy children were significantly more successful at executing blocks or interceptions, effecting ball progress, through contact when they made an attempt at a block (32.09% vs 25.99%). From an ecological dynamics perspective, decisions to act reflect a performer choosing to attune to particular affordances in the environment (Seifert & Davids, 2017; Roberts, Newcombe and Davids, 2019). The decision about 'whether' to act, is as significant as the action itself due to the mutuality of the individual-environment relationship that exists (Heft, 2003). By exhibiting more successful attempts to block or intercept the ball higher-physical literacy performers are evidencing better attunement to perceived affordances, more effectively information-gathering in the service of action (Rudd, 2021). Through their greater demonstrations of effectively tracking play and implementing movement behaviours that meaningfully affect the performance environment (i.e., turnover of possession), higher-physical literacy performers are demonstrating some pertinent combination of physical literacy characteristics aligned to the cognitive, affective, and motor competence domains. The analysis and findings reported, highlighting key behavioural differences between higher- and lower-physical literacy children in their defensive intentionality, spatial temporal interactions, coadaptive networks and functionality provides insight to performer's wayfinding success. Numerous examples from game-play behaviour evidence higher-physical literacy children's ability to not only read the performance environment effectively, but to also anticipate the likelihood of certain actions manifesting themselves as a consequence of the individual-environment reciprocity. This capacity to read, anticipate and react effectively through movement is something Whitehead (2001; 2010), Jurbala (2015), and Shearer et al. (2018) highlight as being key features of a physically literate individual.

Analysis of defensive behaviour highlighted numerous desirable features of games-play that were shared by higher- and lower-physical literacy children. No significant differences were identified in the defensive pressure presented by higher- and lower-physical literacy groups (tight defensive pressure: 32.55% vs 32.24%; loose defensive pressure: 38.89% vs 41.34%; distant defensive pressure: 28.56% vs 26.42%), with positions 1.5m–4.5m away from the player in possession being the most frequently observed across all children (39.95%). Such defensive spatial temporal positioning corresponds well to the observed offensive invitations for action that reported short and medium length passes to be most common. Additionally, both higher- and lower-physical literacy groups demonstrated similar spatial temporal behaviour in the frequency with which they moved towards the ball (14.13% vs 15.65%) and overloaded opponents in possession (9.7% vs 10.4%). Previous

research in similar small-sided, send-receive invasion games, has illustrated the constraining effects upon performer-movement behaviour of positioning relative to competing players and the location of the ball (Travassos et al., 2011; Davids et al., 2013a; Coutinho et al., 2016). By being generally closer to the ball and exhibiting similar defensive pressure both higher- and lower-physical literacy groups could be considered to be well placed to effectively contribute towards achieving game objectives through actions that generate favourable competitive circumstances (Araújo & Davids, 2016).

The embedded functional capabilities of the performer reveal themselves in the continuous interactions between child and environment. The emergent games-based assessment effectively highlights the ecological properties of the performance environment, helping to generate an understanding of the individual-environment interactions taking place and key affordances that are being perceived and acted upon. While the analysis clearly highlights examples differentiating behaviour of higher- and lower-physical literacy children, it also establishes many features of decision making and action are the same. All children demonstrated characteristics of a physically literate individual as defined by Whitehead (2001). These however need to be viewed on a continuum whereby certain individuals more frequently articulated examples of their physical literacy through their reading of the environment, decision making, movement responses, and movement outcomes. The fact that many of the behaviours were similarly represented regardless of the physical literacy of the performer perhaps reflects the notion of the 'journey' these individuals are on, and the 'moment' we chose to capture the manifestation of their physical literacy. The analysis demonstrates what might be considered more accomplished wayfinding by higher-physical literacy children as they demonstrated greater appreciation of the nuanced aspects of the performance environment, which in turn aided their ability to actively self-regulate during the observed activity. Wayfinding behaviour reveals itself through the ability to engage with the environment by deciphering dynamic problems, searching for and detecting information, exploiting affordances, and (re)organising task-orientated actions all based upon an individual's intentionality and the presented environmental constraints (Hristovski et al., 2012; Woods et al., 2020b).

Through these results it is possible to construct an understanding of how children at contrasting stages of their physical literacy journey interact with their performance environment differently. Analysis allowed observations to be picked out that readily differentiated higher- and lower-physical literacy child-environment interactions when playing games. Higher-physical literacy children performed more penetrating passes, distributing the ball more quickly when in possession. When not in possession, higher-physical literacy children exhibited multiple off-ball movements more often and were able to find space more frequently during attacking phases of the game. In defence, higher-physical literacy children moved more often, more effectively tracked play, marked opponents

without the ball more frequently, attempted more blocks and interceptions, and successfully intercepted distribution more often. Conversely, lower-physical literacy performers were observed to be stationary more often when defending and were not able to as effectively regulate their movement in support of attacking play, more frequently moving into contested rather than open space when out of possession.

7.5iv Limitations

Through an ecological dynamics rationale, this study explored the assessment of physical literacy in ways yet to be taken up in research and practice. Consequently, conclusions are by necessity conjectural, with a paucity of equivalent work to draw comparisons to. Some additional limitations noted in this study are similar to those previously reported in other research utilising observational research tools. These include issues such as analysis complexity due to detailed categorisation (Dogramaci, Watsford & Murphy, 2011) and the time-intensive nature of coding (Fernandes et al., 2019). Nonetheless, as an approach that is more philosophically aligned to the holistic, embodied conceptualisation of physical literacy originally presented by Whitehead (2001), a games-based assessment highlights the rich insight possible where there is a willingness to move beyond reductionist, decontextualised evaluation strategies. Future research should look to establish effectiveness and feasibility of use by teachers in school settings. For example, games-based assessments could be undertaken in an ipsative manner supporting assessment *for* learning, or alternatively, could be used to complement assessment *of* learning within the wider context of the National Curriculum. Finally, employing key ecological principles towards the revelation of physical literacy in other physical activity settings might enable the physical literacy journey to be charted more ubiquitously than the inauthentic representations of the construct often presented.

7.6 Conclusions

This study highlighted how an approach informed by ecological dynamics might offer a novel contribution to understanding and evaluating physical literacy. Physical literacy requires a holistic appreciation of physical capacities embedded in perception, experience, memory and decision making (Whitehead, 2001). This investigation highlights the value to be gained through understanding physical literacy at the level of the individual-environment system, where the reciprocal relationship between performer and their activity setting constrains the emergence of movement. Such an explanation of locomotor coordination is valuable to the reconceptualization of physical literacy assessment because it explains how movement is embedded in the environment, allowing the simultaneous revelation of pertinent features of the physical literacy construct to be revealed through

individual-environment interactions. To this end, behaviours as defined in this assessment tool that differentiate children's physical literacy included, time taken to distribute the ball, employing penetrating distribution strategies, a disposition to move multiple times during attacking phases of play, the ability to find space and avoid competing players, effective tracking of play when defending, engaging in marking actions, attempting blocks, and successfully executing interceptions. Responding with intelligence and imagination is revealed through the progressive attunement of an individual's perceptual system toward the discovery of context appropriate affordances. Wayfinding through representative performance tasks provides opportunities for sense making and embodied knowledge to develop as performers navigate their environment via goal-directed behaviour. Economical, proficient (functional), movement is the consequence of self-regulatory behaviour allowing individuals to operate within the boundaries of their personal endowment. By framing the problem more holistically, drawing on individual movement skills and knowledge *of* the environment we have been able to gain insight into how physical literacy better accounts for the qualities required for meaningful, embodied engagement in performance settings.

Chapter Eight - Synopsis

8.1 Thesis Study Map: Synopsis

Study	Objectives
Study One (Chapter Four) Measuring Physical Literacy: A Fresh Approach	Objectives: • Establish the feasibility of capturing children's behaviour and environmental interactions during games-play that would reveal their physical literacy. • Establish face validity of a novel approach to assessment, framed by an ecological dynamics conceptualization to capture and measure physical literacy. • Highlight that the current reductionist approach to the measurement of physical literacy is not appropriate, especially when attempting to capture the embodied dimension of physical literacy. Key Findings: • Established the feasibility of assessing physical literacy through observations of children's games play through the development of an observational instrument and categorical items that accurately represented the revelation of physical literacy through observed behaviour within small-sided games. • Within the context of systematic observation, established face validity of the observational instrument. • Highlighted the insight offered by embodied learner-environment interactions in naturalistic settings.
Study Two (Chapter Five) Assessing Physical Literacy, Conceptualised in an Ecological Dynamics Theoretical Rationale	Objectives: • Pilot an assessment of physical literacy conceptualised in an ecological dynamics theoretical rationale. • Demonstrate the underpinning ecological dynamics principles and conceptualisation applied to the measurement of physical literacy. Key Findings: • Rationalised key pillars of an ecological dynamics approach underpinning the design of a game-based assessment for physical literacy. • This study provided initial evidence that an ecological dynamics informed games-based assessment has the potential to provide richer understandings of children's physical literacy. • Explorative analysis outlined a rationale for why an approach informed by ecological dynamics might offer a novel contribution to understanding and evaluating physical literacy.
Study Three (Chapter Six) Examining the Validity, Reliability and Feasibility of Capturing Children's Physical Literacy through	Objectives: • Establish the validity and reliability of the psychometric properties of the emergent games-based assessment tool following a systematic process including face and content validity, combined with inter- and intra-observer reliability.

Games-Based Assessment in Physical Education	Key Findings: • Content validity and reliability were demonstrated at a statistical level, establishing that the emergent games-based assessment tool is able to measure the dynamic interactions observed between child and environment in physical education games play
Study Four (Chapter Seven) An Ecological Insight into the Revelation of Physical Literacy in Children during Small-Sided Games	Objectives: • Investigate how features of the physical literacy construct reveal themselves through children's behaviours using the emergent games-based assessment tool. • Establish key differentiating behaviours of higher- and lower-physical literacy children when playing small-sided games. • Promote the role of ecological dynamics when employed as a theoretical framework to investigate physical literacy. Key Findings: • Behaviour that differentiated children's physical literacy included time taken to distribute the ball, employing penetrating distribution strategies, a disposition to move multiple times during attacking phases of play, the ability to find space and avoid competing players, effective tracking of play when defending, engaging in marking actions, attempting blocks, and successfully executing interceptions. • This study provided evidence that a games-based assessment informed by ecological dynamics successfully differentiates higher- and lower-physical literacy children's behaviour, offering a novel contribution to understanding and evaluating physical literacy.

8.2 Introduction

The COVID-19 outbreak and subsequent lockdowns during early to mid-2020 resulted in major revisions to the original project focus, a reimagining of the data collection, data analysis and the conceptual field of investigation. As a consequence, this thesis sought to explore a novel assessment strategy to chart physical literacy in school-aged children (aged 7-12 years). The objectives of the thesis were to a) establish how ecological dynamics can be used to provide a theoretical framework to inform observational instrument design in physical education; b) to design and validate an observational instrument for assessing physical literacy that remains more faithful to the philosophically complex and holistic nature of the concept; and c) examine the relationship between game-based behaviours and primary school children's physical literacy. This chapter will summarise the constituent key findings from the thesis and consider the insights, applications, professional growth, and recommendations for future research that can be informed by these findings.

8.3 Thesis findings and outcomes

Physical literacy is typically described as a multidimensional concept, although the literature review undertaken within this thesis has demonstrated a paucity of measures and evaluations that attempt to capture the complete scope of physical literacy's domains, or acknowledge it as an integrated construct. By employing an ecological dynamics conceptualisation of physical literacy it has allowed progress towards an improved solution to capture and chart the physical literacy journey, by utilising an assessment which more effectively captures physical literacy as intended, i.e., a holistic demonstration of embodied interactions within the physical environment. The emergent games-based assessment is the first assessment of its type which frames physical literacy assessment and evaluation through an ecological dynamics rationale. The games-based assessment has been able to provide information on children's knowledge *of* the environment. Revealed through their perception of affordances, their intentionality, and how they functionally move to effectively wayfind through performance environments providing novel insights into how physical literacy manifests itself through embodied individual-environment interactions. Study One (Chapter Four) established the feasibility of an observational instrument designed to capture embedded behaviours representative of the physical literacy construct. This study provided a glimpse of the richer possible interpretations of physical literacy 'in action'. Progressing understanding beyond what is offered through the isolated, reductionist examination of movement competence, confidence, and knowledge and understanding. Face validity and the development of categorical items that accurately represented the revelation of physical literacy through observed behaviour within small-sided games were also established. Through exploratory analysis of interactions and behaviours, it appeared feasible to gain insight to individual's ability to read the environment and affordances offered, demonstrate knowledge *of* the environment through attunement of their behaviours, generate complex networks to coordinate dynamic patterns of collective behaviour, and demonstrate action option generation and selection.

Study Two (Chapter Five) produced findings on how ecological dynamics can be employed as a theoretical framework to investigate how features of the physical literacy construct reveal themselves through children's behaviours in a small-sided game. This study outlined the key pillars of an ecological dynamics approach to the design of a game-based assessment, establishing how principles from ecological dynamics may be integrated into the assessment of physical literacy. Data collection involved observing primary school children playing a small-sided, team, invasion game in physical education classes. Digital video-based coding of children's behaviours using the emergent game-based assessment tool was completed allowing descriptive analysis to be undertaken. Pilot data from this study provided insight to the potential rich interpretations possible through the adoption of an assessment founded in an ecological dynamics rationale. Results were readily able to differentiate

between higher- and lower-physical literacy learners' behaviour when playing small-sided games. Greater knowledge *of* the performance environment was observed in children with higher-physical literacy, noted through a greater capacity to favourably regulate their relative positioning between competing and cooperating players, adopting more varied offensive functionality, and exhibiting greater attunement to key affordances.

The intention of Study Three (Chapter Six) was to design and validate an observational instrument for assessing physical literacy that remains more faithful to the philosophically complex and holistic nature of the concept. Framed by ecological dynamics, the emergent games-based assessment tool enables capture of children's interactions with their environment, providing insight on the manifestation of physical literacy within physical education games. Following a multistage process, content validity and reliability were demonstrated at a statistical level. Establishing the emergent games-based assessment tool allows for the measurement of the dynamic interactions observed between the child and environment in small-sided games. Based upon key pillars of ecological dynamics that align to features of the physical literacy construct, the modified emergent games-based assessment tool, has nine ecological conceptualisations of behaviour, 15 measurement variables, and 44 categorical observational items. The emergent games-based assessment has the potential to provide practitioners and researchers with a useful mechanism to assess children's physical literacy during gameplay.

Study Four (Chapter Seven) built upon earlier work conceptualising and validating an ecological dynamics informed assessment of physical literacy, investigating how physical literacy reveals itself through individual-environment interactions in physical education games. The study utilised data from 54 primary school children who were observed playing a small-sided, modified, team invasion game. Significant differences were identified between higher- and lower-physical literacy children's game play behaviours during analysis. Higher-physical literacy children performed more penetrating passes and distributed the ball more quickly when in possession. Out of possession, higher-physical literacy children exhibited multiple off-ball movements more often and were able to find space more frequently during attacking phases of the game. In defence, higher-physical literacy children moved more often, more effectively tracked play, marked opponents without the ball more frequently, attempted more blocks and interceptions, and successfully intercepted distribution more often. Lower-physical literacy performers were observed to be stationary more often when defending and were not able to as effectively regulate their movement in support of attacking play, frequently moving into contested space when out of possession. This study provided evidence that a games-based assessment informed by ecological dynamics successfully captured and differentiated higher- and lower-physical literacy children's behaviour, providing fresh insight to understanding children's

physical literacy. This work while still in its infancy, effectively demonstrated how physical literacy can be assessed and charted using an ecologically informed scale of analysis. Consequently, presenting opportunities for further research and the potential to help inform future practice.

8.4 Unique benefits and applications of the emergent games-based assessment tool

From a physical literacy perspective there is still much of the currently published work that remains focussed upon the definition of the concept or the operationalisation and pedagogies to support the physical literacy journey. The academic and vocational fields continue to wrestle with the concept and in particular the wholesome adoption of the construct. Similarly, ecological dynamics can also perhaps still be considered to be emerging, in terms of links to pedagogies and applications in youth populations compared to high performance, coaching environments. There have been more recent attempts made to align ecological dynamics to primary physical education settings and the physical literacy construct (Rudd et al. 2020; Rudd, 2021), but even these are still somewhat embryonic in nature. The value offered by reviewing physical literacy through the observational framework outlined in this thesis is that it aligns more effectively with the philosophical and ontological basis of physical literacy, whereby the interface between abilities, opportunities and circumstances, enmesh to affect an individual's successful negotiation of their performance environment (Whitehead, 2019; Baily, 2020b). Consequently, categorical observational criteria employed in this framework typically reveal information pertinent to several, or all domains of the construct, rather than aligning to singular, discrete elements of physical literacy. There is an emerging rationale for research to look beyond established measures of physical proficiencies, or decontextualised, reductionist measures of the affective and cognitive domains and be creative in the development of nonconventional approaches to the evaluation of physical literacy (Edwards et al., 2018; Green et al., 2018). Separating the discrete domains of the physical literacy construct to evaluate physical literacy contradicts the holistic philosophical foundations to the concept (Edwards et a., 2017). Barnett et al. (2019) acknowledged that existing physical literacy assessments utilised are typically considered to simultaneously reflect important elements of physical literacy, while concurrently not adequately representing the entirety of the construct. Only through embracing the metaphysical language of phenomenologists and the related implications for operationalising the concept in assessment settings, is it possible to avoid diluting the concept, or doing physical literacy as a whole, considerable disservice (Jurbala, 2015; Shearer et al., 2018; Bailey, 2020). Social and environmental interactions are pivotal to the phenomenological and existential philosophical underpinnings of the concept (Whitehead, 2007), with embracing the embodied nature of the concept viewed as central to facilitating holistic development (Roberts, Newcombe & Davids, 2019). With specific reference to existentialism, it is

consequently important that learning and performance environments enable problem solving during movement regulation in representative settings (Whitehead, 2019). The emergent game-based assessment tool developed in this thesis embraces the multidimensional nature of physical literacy, providing insight beyond the singular domains of the concept. Opportunities to meaningfully interact with the environment are crucial to the phenomenological and existential foundations of the construct, with richer experiences facilitating the opportunity to understand and fulfil an individual's potential (Whitehead, 2007; Edwards et al., 2017).

Analysing emergent behaviours within physical education and games play, where decisions are expressed as actions allows for a more holistic, embedded evaluation of physical literacy to be undertaken in more authentic settings. Knowing through movement is articulated through perception, action and skilled intentionality, helping establish an understanding of how individuals choose to act in a specific circumstance. Knowledgeable performers should be able to respond appropriately, using intelligence and imagination to interact with events, objects and others in the environment. The emergent game-based assessment tool captures cognition that is embedded and embodied, as a consequence of perceiving affordances related to temporal, spatial and amplitude features of the surrounding environment to achieve success in designated tasks (Button et al., 2020). Successfully navigating through emerging openings between opponents, creatively distributing the ball to teammates in advantageous positions, or defending when outnumbered by attackers, would all be reflective of an individual's knowledge of the environment manifesting itself (Ribeiro et al., 2019). This evidence-based conceptualisation aligns with insights of Turvey and Carello (1981), from the perspective of ecological realism, who argued that cognition may be considered as the coordination of intentional interactions with the environment. Consequently, children are able to demonstrate knowledge of their environment through processes of regulating their behaviour to meet task-objectives scaled against personal endowment. Informed by ecological dynamics, categorical observational items (described fully in Table 6.3) enabling insight into: the intuitive reading of the environment that informs subsequent desirable behaviour; contested and uncontested distribution; signalling for the ball when legitimately a good target for distribution; off-ball movements to break or establish dyadic stability; and the effective tracking of play or players in offence and defence would provide insight to how the cognitive domain of the physical literacy construct is captured through embedded, embodied behaviour.

Insight to the affective domain of physical literacy is revealed through embedded games play behaviour in small-sided games. In particular the qualities of motivation and confidence that are persistently highlighted throughout Whitehead's definitions of the construct (Whitehead, 2001, 2010, 2013, 2019), can be captured through the observational tool developed. Observing how individual

behaviours in sports activity and performance are constrained by self-organisation tendencies provides excellent insight to individual motivation and confidence (Davids, Button & Bennett, 2008; Araújo & Davids, 2009; Chow et al., 2011). As cooperative and competing environment interaction opportunities arise players regulate relative positioning, and action, to exploit emergent opportunities in pursuit of achieving task and performance goals in a satisfying manner (Hristovski et al., 2012; Woods et al., 2020b). Consequently, physically literate children will demonstrate the affective qualities of motivation and confidence, aligned to the physical literacy construct through pertinent combinations of emergent behaviour as they respond to the shifting affordances presented by the performance environment. Informed by ecological dynamics, categorical observational items (described fully in Table 6.3) enabling insight into: coadaptive network formation; moderation of defensive positioning to close down, overload or swarm the opposition; effectively tracking play or players in offence and defence; and overt demonstrations of a child's willingness and desire to be involved in the game through calling for the ball all provide insight into individuals' motivation when playing in games environments. Categorical observational items capturing heterogeneous distribution strategies (distances and direction); inclination to adopt higher risk strategies in attempts to progress the ball; and persistence in the face of adversity (where previous action(s) have resulted in failure) would provide insight to children's confidence in games environments. The acknowledgement of such behaviour when considered through a framework informed by ecological dynamics provides an alternative mechanism to evidence the affective qualities of motivation and confidence through embedded, embodied behaviour (Hristovski et al., 2012; Chow et al., 2020b; Button et al., 2021; Rudd, 2021).

An ecological dynamics framework considers locomotive performance and the articulation of embedded movement competencies as dynamic functional movement solutions, which are based upon the interface that exists between task, organism and environmental constraints (Button et al, 2020). As physical literacy is concerned with the embedded, embodied behaviours of the individual within their environment it becomes beneficial to garner insight that goes beyond simply reporting on motor skill outcome or performance orientated characteristics synonymous with success. Insight to the motor competence domain of physical literacy in children can be obtained through observing their demonstrated functional movement behaviours in pursuit of achieving task and performance goals. Functional Movement refers to the qualities that allow individuals to negotiate their environment in the completion of intended task goals (Davids et al., 2012; Chow et al., 2020a), acknowledging the continuous coupling of actions and perception, which forms the basis of adaptive flexibility in realising effective, appropriate movement with reference to circumstances (Vilar et al., 2012; Chow et al., 2016). Informed by ecological dynamics, categorical observational items (described fully in Table 6.3)

enabling insight into: heterogeneous or homogenous ball distribution; range and directions of distribution, distribution technique flexibility; accuracy of distribution; successful reception of passes; and defensive intervention through blocking and intercepting the ball would provide insight to individual motor competencies within the psychomotor domain of the physical literacy construct during small-sided games. The emergent game-based assessment tool, by adhering to the complex and holistic nature of the concept, is able to simultaneously provide insight to numerous domains of the construct.

Additionally, the feasibility of primary school physical education teachers, who are already balancing a burdensome work schedule, being able to undertake appropriate assessments for whole classes remains unclear (Shearer et al., 2021). Essiet et al. (2021) nonetheless suggested that comprehensive evaluation of physical literacy is possible within the constraints of the professional teaching role. Embedding physical literacy assessment, for example using the emergent game-based assessment tool as part of normal physical education curricula, may mitigate against issues such as additional time, equipment, and resource requirements. Such an approach would align to the emerging trend to adopt more ecological, embedded, qualitative assessment approaches in school settings (Bannon, 2013; Durden-Myers et al., 2018; Green et al., 2018). Embedding assessment into a game's context has the potential to promote children's satisfaction and enjoyment of the assessment process, avoiding otherwise potentially negative memories and experiences of physical education (Shearer et al., 2021). Goss et al. (2022) state that assessment should be an integrated feature of the physical literacy journey, through which evaluation of the construct itself should be a developmental opportunity. The emergent games-based assessment has the potential to chart growth over time, supporting assessment *of*, and *for*, learning in physical education to become a realistic possibility, due to how easily it can be embedded into existing practice employing games as part of the curriculum. Charting progress allows for the consideration of physical literacy at an individual level, recognising it is unique to the person, their endowment, and organism constraints (Whitehead & Almond, 2013; Green et al., 2018). Monitoring progress in physical literacy is encouraged, as it can assist practitioners in the development of effective pedagogies (Shearer et al., 2021). Assessment *for* learning in this manner is conducted principally to support and promote students' learning, creating a virtuous circle of teaching and student progression that informs future steps in curriculum delivery. By comparison, assessment *of* learning enables the evaluation of the effectiveness of a learning process, typically associated with accountability, certification, or intervention evaluation. Linked to the Key Stage two National Curriculum for physical education (Department for Education, 2013), the emergent games-based assessment provides opportunities for assessment *of*, and *for*, learning. The National Curriculum identifies movement skills in isolation and in combination, the application of basic

principles of attacking and defending, and the ability to compare current performance to past performance, recognising their own success as foci for development (Department for Education, 2013). The emergent games-based assessment can support practitioner evaluation of physical literacy in a formative, ipsative manner supporting assessment *for* learning, or alternatively in a broader, summative fashion, supporting assessment *of* learning, within the wider framework of the National Curriculum.

8.5 Limitations and recommendations for future research

In addition to the specific limitations identified in each of the study chapters within the thesis, there are numerous overarching limitations to the body of research that should be acknowledged. As the first assessment tool of its type, framing physical literacy assessment and evaluation through an ecological dynamics rationale, it is apparent that further empirical research is needed to fully explore the potential such an approach has to contribute to the field of interest. This thesis reported similar limitations to those experienced by other studies that have employed observational tools with regard to the time-intensive nature of coding (Fernandes et al., 2019), analysis complexity (Dogramaci, Watsford & Murphy, 2011), and the potential confusion and subjectivity that arises in accurately reporting behaviour in performance settings (O'Connor & Joffe, 2020). Beyond the logistical barriers associated with detailed observational analysis, making accessible the multifaceted, potentially complex concepts associated with an ecological dynamics approach to assessment is a further barrier to address. Demystifying ecological ideas and concepts for practitioners through interpretation of the language and pragmatic operationalisation of concepts is critical to the wider adoption of approaches outlined in this study. As a guiding theoretical framework that offers a mechanism to explain human behaviour the studies in this thesis have started to highlight behaviours that differentiate higher- and lower-physical literacy children. As a consequence, a more streamlined assessment could be completed with a focus on discrete gameplay qualities that readily differentiate children such as their ability to find and exploit space in small-sided games. Assessment feasibility emerged as an important theme within the review of literature undertaken. Consequently, future research should look to establish the effectiveness and feasibility of practitioners employing the emergent games-based assessment in physical education settings across a broader age range and demographic. Finally, there is scope to consider the application of key ecological principles towards the manifestation of physical literacy in other physical activity and performance settings.

8.6 Professional growth and impact

The research process and findings presented, alongside the immersion within the academic field of study have had numerous consequences for my own research and practice. Academically, my knowledge and understanding of philosophy, physical literacy and ecological dynamics has increased exponentially over the period of study. My formative academic (student) years preceded the physical literacy 'movement' and the inception of ecological dynamics as a mechanism to explain skilled movement behaviour as emergent properties of individual-environment interactions. As a young(er) coach and teacher I would have found great solace in these concepts and how they inform practice and understanding. Instead, I was raised on more traditional, prescriptive teaching approaches, whereby classes were experienced as 'physical education as sport techniques' (Kirk, 2010). Then, later, tutored in the delivery of rigid, more formulaic teacher-centred practice that discouraged adaptability and exploration. I am fortunate then, to have had the opportunity to comprehensively reimagine my understanding of pedagogy and skill acquisition and the role of the practitioner in facilitating a fulfilling, meaningful learning experience. While perhaps beyond the remit of her specific intent, Lundvall (2015) warned that adopting physical literacy as a framework to inform practice and physical education is full of challenges. The broader consequence and challenge of the doctoral programme for me, has been to construct, or perhaps reconstruct my professional identity as an academic practitioner working in higher education.

How to effectively embed ideas and principles from my research into my professional practice has also been a significant challenge. At no point in the history of our subject area have we had the capacity to evaluate applied practice, to offer novel, innovative proposals on how to take the profession forwards, or to maximise the opportunities for learning and development in our classes. However, attempts to introduce 'modern' teaching approaches or ideas have always been challenged by those who favour the status quo, as a consequence pedagogy in practice has remained largely resistant to new ideas (Chow et al. 2016). Stimulating and subsequently supporting the transition of future practitioners' roles from one of ensuring compliance of learners towards reliable execution of technical models of performance, to, appreciating the learner-environment ecosystem and the promotion of emergent movement behaviours to functionally achieve performance objectives has been a significant endeavour. Embedded across my undergraduate teaching there are now opportunities where ideas and concepts pertinent to this thesis are introduced to students in their modules, maturing theoretical and practical knowledge and understanding of the concepts of physical literacy and how principles of ecological dynamics may be employed to inform practice. The changes in teaching syllabus, while (ultimately) enriching have also proved to be 'disorienting' for students as they experience conflict between what is known and familiar compared to unknown or alien. McKenzie (2007) acknowledges the discomfort experienced by practitioners in the face of new

approaches to practice, but maintains expansion and innovation appears necessary if the insights from a growing body of research are to be integrated into practice. Beyond curriculum delivery I have also supervised numerous undergraduate and postgraduate research projects in the fields of physical literacy (e.g., Understanding the embodied nature of physical literacy: a case study looking at how children interact with their environment; Physical exercise classes as an intervention for the development of dynamic balance and physical literacy in older adults) and ecological dynamics (e.g., An ecological dynamics perspective on the relationship between physical literacy and motor creativity in adulthood; An ecological perspective on how manipulation of task constraints impact children's gameplay behaviours).

Informed by much of what I understand of the conceptual areas of physical literacy and ecological dynamics, my own practice focusses on the provision of learning environments that encourage a sense of success, set challenging but achievable goals, build confidence in movement, and finally, present learners with novel task and performance objectives that require creativity and experimentation with movement solutions in response to challenges faced. Teaching materials and activities are selected, prepared, and delivered with learners at the centre of the process. Both theoretical and practical content is designed to nurture the development of motivation, confidence, physical competence, and knowledge and understanding. Durden-Myers, Green, and Whitehead (2018) highlight that nurturing each of these elements in the 'what' we teach (content) and the 'how' we teach (pedagogy) is critical. An examination of my teaching would reveal opportunities for students to 'wayfind' through purposefully designed practical challenges, to experiment with and experience affordance rich learning environments, to understand how to celebrate success across multiple learning domains, and to experience physical activity in a wide variety of contexts (mainstream sporting activity, multisport activity, and activity in urban environments (e.g., street games and Parkour)).

The doctoral programme and immersion in the field of study has presented numerous opportunities to become involved with external agencies and projects. I helped to shape the Youth Sport Trust's *Reward and Recognition in Physical Education* scheme that is part of the recently produced *Physical Education Life Skills Award*. Additionally, I have been invited to be part of a special interest group looking at the development of physical literacy assessment tools, with the remit to co-create a feasible physical literacy assessment for use in primary-aged children in school and community settings. For the past two years I have organised and supported undergraduate students in the delivery of physical literacy interventions within community settings. These initiatives have been particularly welcome following the pandemic and the wide-reaching implications of lockdowns, social isolation and school closures. Alongside the thesis I have also engaged in more formal knowledge

transfer opportunities, disseminating practice through publication (Wilkie et al., 2021, 2022, 2023a, 2023b). This process has been fruitful not only in terms of generating outputs, but also as a consequence of the expert review provided on the work. This has further helped to critically shape my understanding of the area and how to effectively communicate insights from the research. Finally, throughout this process I have managed to build a developing network of academic and practitioner contacts, whether as a consequence of working with them on publications, data collection, or knowledge transfer that will position me effectively to continue my own journey in the field.

8.7 Synopsis conclusion

This is an exciting period for academics and practitioners interested in understanding how learners can realise their potential and how assessment in representative settings may provide more holistic insight into the physical literacy journey than has previously been possible. Through an ecological dynamics rationale, this thesis has explored the assessment of physical literacy in ways yet to be taken up in research and practice. Some features of the physical literacy construct remain more difficult to account for within assessment tools, but remain vital to any evaluation of physical literacy. The studies within the thesis provide a foundation for new perspectives on physical literacy assessment, remaining truer to the philosophical underpinnings of the concept and offer a valid alternative to the more reductionist approaches available. All children should have opportunities to develop and evidence their physical literacy in a manner meaningful to them. The emergent games-based assessment tool developed, validated, and deployed within this thesis values a more holistic and multidimensional orientation of physical literacy. It has the potential to chart growth over time, support assessment *for* and *of* learning, differentiate higher- and lower-physical literacy children, and enable practitioners to better understand how physical literacy reveals itself through embedded actions. Such insight could develop deeper understandings of the physical literacy construct, in addition to supporting a fulfilling physical literacy journey.

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