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## Developing A Framework For Professional Practice In Applied Performance Analysis

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# Developing a framework for professional practice in applied performance analysis

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## ABSTRACT

Applied performance analysts are increasingly seen as sports science professionals; however, there is no accepted framework for professional practice. The purpose of this study is to develop and validate a framework for professional practice in applied performance analysis (PA) which identifies the components of practice and the expertise underpinning it.

A six-step framework analysis was conducted: (1) An initial conceptual framework was devised based on well-accepted components of applied practice; (2) A systematic review identified 90 papers relating to applied PA practice; (3) Papers were coded to the initial framework and additional themes recorded; (4) Themes were analysed and synthesised to construct a draft framework; (5) This draft was validated by surveying 24 experienced applied performance analysts and academic experts; (6) A revised framework is reported based on stakeholder engagement feedback.

Nine components of practice were identified; establishing relationships and defining roles, needs analysis and service planning, system design, data collection and reliability checking, data management, analysis, reporting to [key stakeholders](#), facilitation of feedback to athletes and service review and evaluation. Our evidence suggests that applied PA practice is underpinned by five areas of expertise: contextual awareness, building relationships, performance analysis and sporting expertise, technical expertise and professional behaviours.

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applied practice; framework  
analysis; analyst

## 1. Introduction

Performance analysis (PA) is a widely accepted discipline of sports science which involves the systematic analysis of actual sports performance and provides valuable input to inform the coaching process (Drust, 2010; O'Donoghue, 2015). The growth of PA has been described as exponential (Drust, 2010), and there are an increasing number of references in literature to applied performance analysts (PAs) as professionals (Lames, 2008; Huggan et al., 2015; Van den Berg et al., 2018, Bateman and Jones, 2019; Carling,

2019), with their activities termed "professional practice" (Butterworth & Turner, 2014; Buttfeld & Polglaze, 2016; Mackenzie & Cushion, 2013b; McKenna et al., 2018). The speed of this evolution has led to many PAs practicing, but the "trappings" of professionalism, such as demonstrable theoretical and practical expertise, guides for practice, codes of practice, organisation and regulation (Carr, 1999) have been slow to follow. Professional practice, in applied PA, is poorly defined, there is limited regulation and no accepted professional framework for practice (Hammond, 2018, Wright et al., 2014). This is an interesting contrast to the more established applied sports psychology discipline, or coaching, where there have been long-running debates about models for practice to develop expertise and set standards for accreditation and recruitment (Rodolfa et al., 2005, Collins et al., 2015a, Cruickshank et al., 2020; Lyle & Cushion, 2010).

A frequently cited reference point for applied PA is Franks and colleagues' coaching process model (Franks et al., 1983). However, this has been termed an "idealistic and unproblematic" representation of what we know to be a messy, chaotic coaching process (Groom et al., 2011; ; Mackenzie & Cushion, 2013b). Additionally, there is a somewhat "magical" quality to the analysis process, in which information appears in a box within the models, yet the practitioners helping to formulate and facilitate feedback opportunities are invisible. Wright et al.'s, (2014) adaption of the original model to represent a weekly cycle in soccer analysis service delivery goes some way to addressing this. However, without a clear and comprehensive definition of the required knowledge and expertise for delivery of PA, it is very difficult for aspiring analysts to build appropriate skill sets in preparation for a sustainable career. While acknowledging the large variation across PA roles, there is a growing consensus in the literature advocating for more investigation into the generic components of applied PA practice and the expertise required (Murray & Hughes, 2001, Bampouras et al., 2012; Francis & Jones, 2014; Wright et al., 2013, Wright et al., 2014, Carling et al., 2014, Martin et al., 2018; Huggan et al., 2015; Hammond, 2018). Increased professionalism and clear role descriptors may go some way to addressing some of the analyst difficulties evident in the literature, such as; general role ambiguity (Wright et al., 2014, Hammond, 2018; McKenna et al., 2018); ad-hoc recruitment and job insecurity (Huggan et al., 2015, Bateman and Jones, 2019); continually having to "prove their worth" in an often volatile micro-political climate (Huggan et al., 2015, Collins et al., 2015b, Bateman and Jones, 2019); and general uncertainty about what skill set is required as the profession and technology rapidly evolves (Ferrari, 2017; James, 2018; Memmert & Rein, 2018).

The revised accreditation system for the International Society for Performance Analysis in Sport (ISPAS) proposed by Hughes et al. (2019b) is a significant step forward in meeting this need. This system focuses strongly on the technical skills required to carry out the role of an applied performance analyst. Robertson's (2020a) recent article considering how PAs are the human interface with technology and data, emphasises the importance of a broader professional skill set, highlighting open-mindedness, versatility, evidence-based decision-making, and thorough evaluation of practice as key traits for analysts of the future. Thus, in addition to the development of strong technical and PA skills, the identification and cultivation of other elements of practice, such as relationship building and professional behaviours, is also a key area of an analyst's development. Evidence of novice practitioners struggling to establish themselves (Huggan et al., 2015; McKenna et al., 2018), suggests that aspiring analysts may lack a broader personal and professional skill set required for practice

(James, 2006; Lyons, 2005; Nelson et al., 2014). At the other end of the career spectrum, experienced analysts make constant professional judgements around if, how and when to adopt new technology and decision-making support systems (Browne et al., 2021; Buttfield & Polglaze, 2016; Gamble et al., 2020; Schelling & Robertson, 2020).

This study aims to construct and validate a framework for professional practice in applied performance analysis (PA) which identifies the components of practice, and the expertise which underpins it. This framework has potential benefits for the education, professional development and accreditation of analysts. Analyst educational offerings are varied, provided by universities (Butterworth & Turner, 2014; Carling, 2019; Nicholls et al., 2018b), software companies (Ferrari, 2017), and internships or studentships within sports institutes (Lyons, 2005) and other sporting organisations (Carling, 2019). In the absence of a framework for practice, it is difficult to evaluate the effectiveness or propriety of this education to applied PAs, or how prepared they are for the reality of practice. The research questions guiding this work were: are there identifiable common components of practice in applied PA, and what areas of expertise underpins this practice? The framework analysis resulted in the development of a "best fit" framework for applied PA (Dixon-Woods, 2011), and a definition of the role of practitioners.

## 2. Methods

A framework synthesis methodology was adopted as an iterative way to develop a coherent picture of a "messy" heterogeneous collection of studies (Thomas et al., 2012). Systematic review methodology was used to search and identify relevant literature following the Evidence for Policy and Practice Information guidelines as outlined by Gough and colleagues (Gough et al., 2012). The initial conceptual framework was based on established literature in the field and evolved as the importance of different concepts became clear and the research synthesis developed. A draft framework was subjected to a stakeholder assessment in the form of a survey, which informed the final framework presented.

### 2.1. Ontological & epistemological stance

A critical realist approach to data analysis and synthesis was adopted (Bhaskar, 2013), which assumes that an external reality exists and can be observed and analysed. However, it acknowledges that it is "*our theories and notions of reality that constitute our knowledge of it*" (Danermark et al., 2002:200). The lens of critical realism influenced our search strategy as we endeavoured to capture a holistic picture of the practice of PA delivery. While we wanted to identify and describe the activities of practitioners, we also sought insight into how their social interactions influenced the reality of their role (Danermark et al., 2002). Through our experience as former practitioners and currently educators of novice analysts, we understood that good professional relationships are linked to successful practice; however, this had not been explored or conceptualised. Search criteria were designed to systematically capture the breadth of peer-reviewed literature available, ensuring that the narrative of individual actors would be heard, in addition to applied case studies where their actions and interactions were observed (Suri, 2013).

In advance of data extraction, an initial conceptual framework was designed, consisting of five broad components of practice well established as key to the delivery of PA (Dixon-Woods, 2011) (Table 1). Themes were deductively coded to the pre-defined initial framework and simultaneous inductive coding captured data that did not fit into the initial framework (Creswell & Creswell, 2017). Our aim to identify the processes involved in the *effective* delivery of applied PA, led us to go beyond the surface observations of what analysts said they did, to search for the explanations for their behaviours and consider any patterns emerging (Ryan et al., 2012). In so doing, we recognise the limitation that, as with all knowledge, our insights are fallible, our interpretation of the interpretations of other people (Danermark et al., 2002). Our collective industry experience (44 years' experience in delivering PA/Biomechanics support, 55 years' experience preparing undergraduate students to work in PA/Biomechanics), creates a bias that must be acknowledged. This knowledge and experience, however, afforded us the insight to identify what was not explicitly reported, to treat explanations as dynamic, to search for exceptions or surprises, all essential elements of the critical realist approach (Ryan et al., 2012; Suri, 2013). An example of this is the fact that no analyst stated they had negotiated a job description, despite evidence from various analysts indicating that this would be a positive process on engaging an analyst role (Hammond, 2018, Wright et al., 2014). In bringing this critical realist perspective and our experience to the synthesis of the literature, we endeavoured to construct a framework, which would begin to define not only what analysts do, but how they can thrive as people in this complex socio-political environment.

## 2.2. Search criteria and strategy

The search terms used were; sport, sports; performance analysis; video analysis; match analysis; notational analysis; time-motion analysis and feedback; coaches; coaching; analyst; video; applied practice. For consideration, studies had to be peer reviewed, in English and published between 2001 and 2019 inclusive. The same systematic search was performed in SPORTDiscus, PubMed and Web of Science. Search results were imported into EndNote software and any duplicates removed. Hand searches of the International Journal of PA in Sport and the proceedings of the World Congress of PA in Sport (WCPAS) were undertaken in addition to checking the reference lists of all included papers (Brunton et al., 2012). The search terms used were: ["Sport"] AND ["Performance Analysis" OR "Video Analysis" OR "Match Analysis" OR "Notational Analysis" OR "Time-Motion Analysis"] and ["Feedback" OR "Coach\*" OR "Analyst" OR "Video" OR "Applied" OR "Practice"].

## 2.3. Inclusion criteria and selection

Studies were included if they met one of the following criteria: Describe an applied PA intervention involving an *applied* PA; Interview/survey coaches or athletes about their interaction with an *applied* PA; Interview/survey of *applied* PAs about their applied practice; Contain reflections of coaches or analysts involvement in *applied* PA practice; Contain commentary on the role of an applied practitioner. The first author (DM)

Table 1. Initial coding framework: five components of practice well established in the delivery of applied PA.

Cluster	References
Needs Analysis & System Design	Carling et al. (2005); Hughes (2015a); O'Donoghue (O'Donoghue, 2015)
Data Collection and Reliability Check	K. Robertson (1999); Lyons (1988); Hughes and Franks (2008); Carling et al. (2009); Hughes and Franks (2015); O'Donoghue (2015)
Analysis and Reporting to Coaching Team	O'Donoghue and Holmes (2015); Carling et al. (2009); O'Donoghue (2015) Hughes et al., ( Hughes et al., 2015); Wiltshire (2013)
Facilitation of Feedback	Carling et al. (2005); O'Donoghue & Mayes, (2005); Hughes (2015b)
Reflection & System Evaluation	Lyons (1988); O'Donoghue (2015)



completed the title screening in Endnote and a random sample of 100 titles were screened by DMcG to ensure agreement. Abstracts (n = 447) were screened by DM And DMcG independently using Covidence software and full-text review (n = 154) was completed in Endnote independently by each author until agreement was established.

## 2.4. Data extraction

Data were extracted from papers using QSR Nvivo (Qualitative Solution Research 2002, Version 12, [www.qsrinternational.com](http://www.qsrinternational.com)). Author, Year, Journal, Geographic Location, Study Design, Sample Size, Sporting Context (Elite, Professional, etc.), and Sport were recorded for each paper in addition to the aims, methods and any limitations noted by the authors of the papers. The initial conceptual framework which was designed based on the well-established processes involved in the delivery of PA (Table 1), was used as an initial coding framework for data extraction (Thomas et al., 2012). A framework of nodes for each theme of the five-component model was created; Needs Analysis; System Design and so on. Each paper was then coded by DM and DMcG independently, with deductive and inductive analysis conducted simultaneously to capture data not included in the model, for example, the various relationships established by analysts, their educational backgrounds and employment status, or themes of conceptual interest (Creswell & Creswell, 2017). A total of 4613 codes were recorded in this phase.

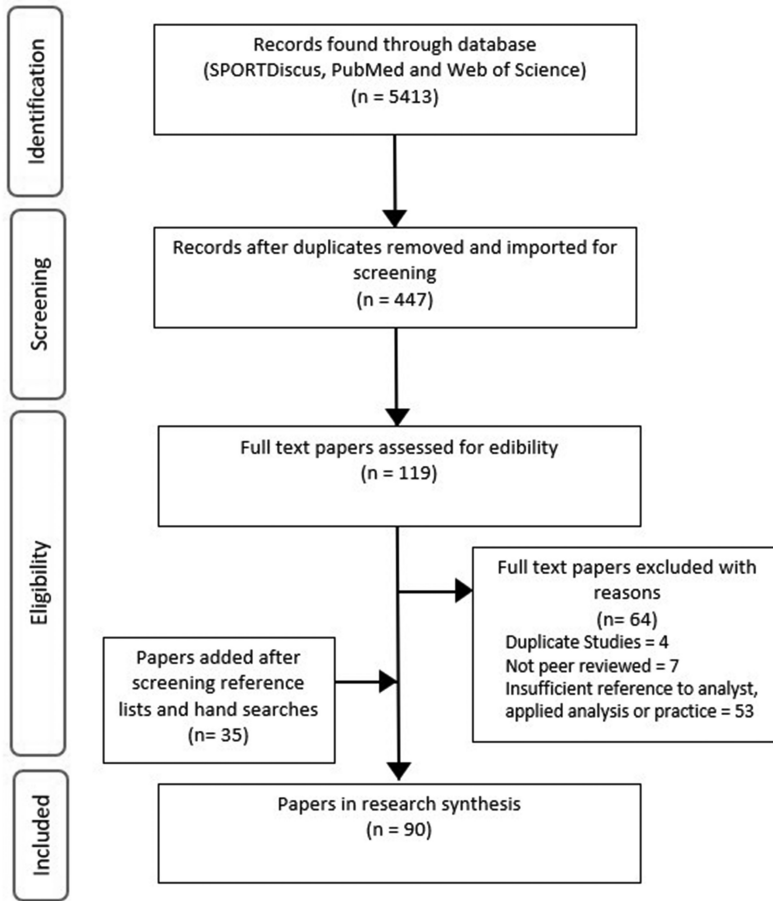
## 2.5. Data analysis and synthesis

### 2.5.1. Phase 1

Following Braun and Clarke's (2006) approach, codes were integrated into preliminary themes, then the themes for each element of the framework and additional inductive codes were reviewed. This was conducted by DM and interrogated by DMcG to ensure the integrity of the codes and themes. Critical realism requires researchers to reflect on not only events which occurred, but to consider what could have happened or what has not happened (Ryan et al., 2012). This quote from a study of novice analysts' experiences in the field provides an illustration of this critical realist analysis approach.

*"... one set of analysts experienced the following: "It was the first week and we asked what the coach wanted tagged... 'well you're the experts'... 'go and pick out the key bits'"... so to start with they weren't sure how to use it" (McKenna et al., 2018:310).*

In considering this quote, we recognised the analysts' difficulty in interacting with coaches who were seemingly unable to give them direction about what performance information to capture through a simple needs analysis. On reflection we wondered about the recruitment process for these interns from the local university. Were role descriptors and service level agreements in place? Would it have been valuable for the coaches who were to receive this support to commit in advance to making themselves available for a "needs analysis" and follow up meetings? Were the students aware of the importance of formalising a needs analysis and how to "informally" approach it, particularly with coaches unfamiliar with PA support? Did this paper represent the broader



**Figure 1.** PRISMA flow diagram representing the systematic search process for papers relating to applied performance analysis.

experience of novice analysts? Would listing professional behaviours be helpful to other aspiring analysts?

### 2.5.2. Phase 2

Rather than report a hierarchy of themes, the intention was to synthesise themes into clusters of processes for each component and note the themes which recurred across multiple components. The initial framework was reviewed and amended to comprise of nine components of practice, and themes were synthesised into a list of processes for each. The original codes were reviewed and recoded according to the revised framework with a final total of 2598 codes (Thomas et al., 2012). An Excel database was created capturing the name of each process, the number of papers and specific references to it, and at least two supporting quotes from the body of literature. Themes which occurred in each component area were refined and identified as the potential areas of expertise underpinning the processes.

### 2.5.3. Phase 3

A "work in progress" framework and the supporting database were presented separately to JB and an experienced coach developer and analyst, via video calls, and their feedback was used to refine elements of the framework, which was drafted as a [figure](#). [Figure 1](#). A commentary or description of each process and its rationale for inclusion was also added to the database. This was presented to PO'D and DMcG for further interrogation and refinement of wording. Some processes were merged, and others separated in an iterative process, which saw a net gain of one process to the final number of 118 processes. At this point, it was agreed that "Reflection and Evaluation", which was a recurring theme and had been a potential area of expertise in its own right, would be incorporated to Professional Behaviours, while PA-Sporting Expertise and Technical expertise were separated into two individual areas. The database was then interrogated by each author and another meeting convened to finalise the proposed "best fit" framework and supporting tables.

## 2.6. Stakeholder assessment

A stakeholder assessment informed a final review of the framework (Rees & Oliver, 2013). Following ethical approval (University College Dublin No: LS-20-74), a series of focus groups were convened to assess the validity of the proposed framework in reflecting the reality of applied PA practice. A sample of 24 analysts and academics were recruited in different categories: elite multisport ( $n = 7$ : ave. 17 years' experience in PA); Elite Soccer ( $n = 5$ : ave. 18 years' experience); Elite GAA ( $n = 6$ : ave. 9 years' experience); Academics ( $n = 6$ : ave. 15 years' experience). Participants were typically "Head of PA" at elite clubs, National Governing Bodies or Sports Institutes, or academics with applied PA experience and/or those with a body of research included in the systematic review. They were currently working in a variety of countries/continents: Africa (1), Europe (10), UK (10), North America (1), Oceania (2).

In advance of the focus groups, participants were invited to complete a survey created in Google forms that listed the processes included in the framework with a toggle button to indicate how frequently, if at all, they undertook each process. There was also a space to make comments on each component of practice. The results of the focus group discussions are reported elsewhere, while the findings of the survey were used to inform a final revision of the framework. Aiken's V was used to assess the content validity of each of the 15 groups of processes undertaken by an applied PA. The mean V value for each component ranged from 0.63 for Data Collection and Reliability to 0.83 for Service Planning with 12 of the 15 components having mean V scores of 0.7 or over. A total of 84 of the 120 processes had V scores of 0.7 or greater. This represents an acceptable level of content validity for the items identified by the respondents. The "never" responses were mostly attributable to diversity of employment settings, role responsibilities and work-place time constraints across the cohort.

As it was apparent that the survey respondents did all of the processes at some point, no processes were removed. However, the survey identified three specific issues to be addressed. The language was considered "jargon" at times and the wording of some specific processes was highlighted for simplification. They identified the potential to merge some of the processes to make the framework more condensed. The final

consideration was around the inclusion or otherwise of processes which related to professional training and development (e.g. *Seek professional accreditation and a community of practice*), and not directly to an applied PA's role in service delivery. Guided by this stakeholder feedback, the research team reviewed, reworded, and amended the processes in each component to arrive at a final Framework with 78 processes. Having validated the content of the framework as being reflective of PA practice in the real world, our final step was to design a way to effectively visualise applied PA practice. Given the feedback from the stakeholder engagement, it was decided to represent the Framework using a simple jargon-free analogy in order to optimise understanding of the concepts involved and to promote its use in non-academic settings (Figure 2).

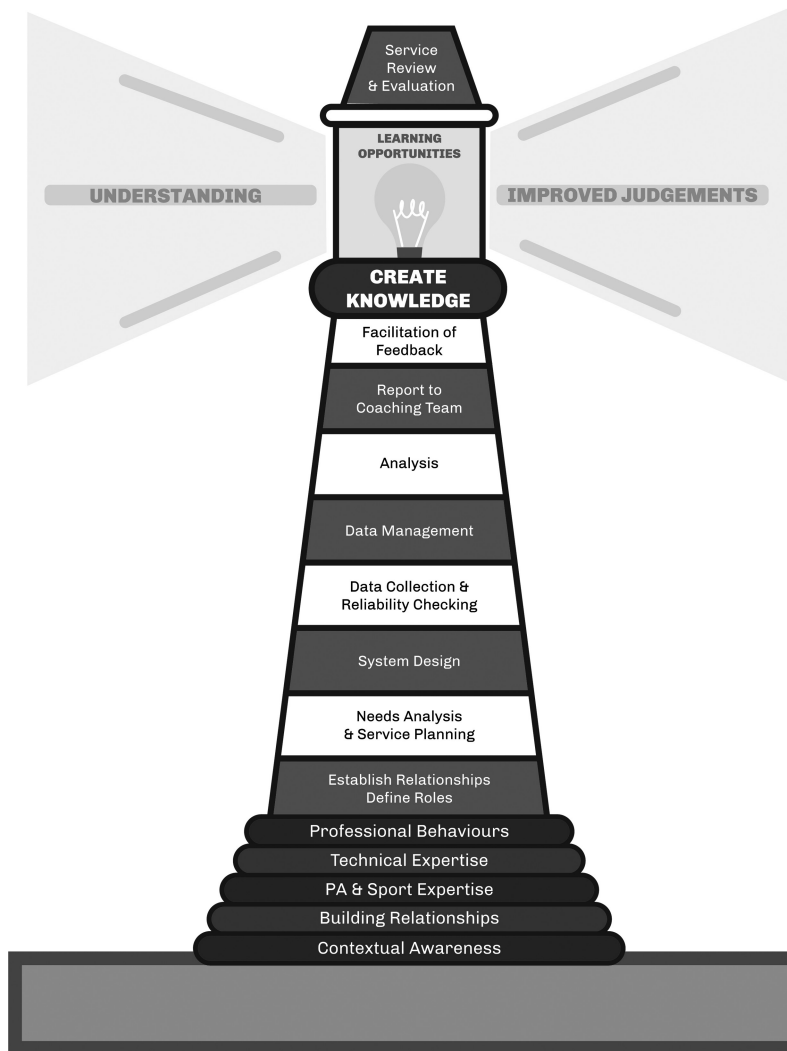
### 3. Results and discussion

#### 3.1. The literature

The process of searching and selecting papers from this heterogeneous body of literature was not straightforward, with over a third of the included articles coming from screened reference lists and hand-searches. The 90 papers which were included in the research synthesis, have a considerable UK and European bias, with over three-quarters of the sample originating in this region (Table 2). This is potentially due to the language barrier built into the study design where English was a criterion for inclusion. However, the lack of papers from North America, where English is the first language, suggests other factors at play. The PA research community has been active since the late 1980s terming the disciplined notational analysis until 1998 (Lyons, 1998). Initially, the community was dominated by UK academics, and the series of 12 WCPAS between 1992 and 2018 have all taken place in Europe (O'Donoghue, 2010). Analysis of performance has certainly been practiced in sport in North America dating back before the high profile use of Sabermetrics in baseball (Lewis, 2003). While PA activity has continued to be high profile in North America, with few exceptions, North American practitioners have not published research on the use of PA as much as their counterparts in Europe. Professional soccer was the most common contextual backdrop for researchers (24%), with 24 other sports featuring, mostly in elite settings.

#### 3.2. A definition for an applied performance analyst

While PA is built on the systematic collection of data, applied PA is about more than data *per se*, it is about what can be learned from data to prompt behaviour changes, enhanced decision-making and judgements. This framework aims to capture the reality of applied PA practice, where the focus is on translating data into actionable insights that can be used to impact performance, mirroring Ackoff's theory of the journey from data to wisdom (1989). Applied PAs have acquired a myriad of different titles from "Video Coaches" to "Scouts", "Head of Insight" and so on. Regardless of the title, we are distinguishing applied PAs as those who interact regularly with decision makers; coaches, athletes, support staff, performance directors (PDs) or equivalent **executives and** strategic managers. As the volume of data available to these time-poor people continues to grow exponentially, the



**Figure 2.** A lighthouse analogy represents the objective of applied performance analysis (PA), the role of the practitioner, the components of practice and the expertise which underpins applied practice. The lightbulb represents the knowledge created by an applied performance analyst who designs learning opportunities, so others see this knowledge to gain understanding and foster improved decision-making and judgements. The components of practice make up the body of the lighthouse supporting the systematic creation of valuable knowledge and the evaluation of learning which may have taken place. The five areas of expertise which underpin practice, form the foundations of the lighthouse.

role of applied PAs as data translators potentially becomes even more important. We contend that applied PAs should be considered "service providers" and their role defined as follows;

*The role of an applied PA is the integration of objective, reliable and relevant data to co-create knowledge, and [translate this](#) by designing learning opportunities so that this*

**Table 2.** Papers included in the framework synthesis by global region.

Region	Number	Authors
Africa	4	Ferrari (2017); Kraak et al. (2018); Painsczyk et al. (2017); Van den Berg et al. (2018)
Asia	4	Fuchs et al. (2018); Lee (2008); Ong and Koh (2005); Ong et al. (2006)
Europe	18	Benito Santos et al. (2018); Cordes et al. (2012); Fernandez-Encheverria et al. (2017); Gesbert et al. (2016); Gomez (2018); Hammond (2018); Lames (2008); Macquet et al. (2015); Martin et al. (2018); Martin et al. (2017); Memmert and Rein (2018); Moreira and Peixoto (2014); Palao et al. (2016); Sarmiento et al. (2015); Sarmiento et al. (2014); Schaffert and Mattes (2015); Seve et al. (2013); Tilp et al. (2006)
UK	49	Bampouras et al. (2012); Bateman & Jones (2019); Booroff et al. (2016); A. D. Butterworth et al. (2012); Butterworth and Turner (2014); A. Butterworth et al. (2013); Carling et al. (2014); Collins, et al. (2015b); Cooper et al. (2007); Elleray and Jones (2012); Francis and Jones (2014); Francis et al. (2019); Francis et al. (2015); Gasston (2004); Glazier (2010); Groom et al. (2011b); Groom et al. (2012); Groom and Cushion (2005); Horne (2012); Huggan et al. (2015); Hughes (2004); M. D. Hughes and Bartlett (2002); Hughes et al. (2001); James (2018); James (2006); James et al. (2007); Jenkins et al. (2007); Mackenzie and Cushion (2013b); Mackenzie and Cushion (2013a); Mayes et al. (2009); Middlemas and Harwood (2018); Murray and Hughes (2001); McKenna et al. (2018); Nelson and Groom (2012); Nelson et al. (2014); Nicholls et al. (2018b); Nicholls et al. (2018a); O'Donoghue (2006); O'Donoghue & Longville (2004); Reeves and Roberts (2013); Robins (2014a); Robins (2014b); Taylor et al. (2015); Thomson et al. (2013); Wells et al. (2009); Wells et al. (2012); Williams & Manley (2016); Wright et al. (2014); Wright et al. (2012); Wright et al. (2013); Wright et al. (2016)
North America	4	Judge et al. (2011); Judge et al. (2008); Robinson et al. (2011); Smith et al. (2002)
Oceania	9	Baker, (2010); Burkett and Mellifont (2008); Buttfield and Polglaze (2016); Croft et al. (2017); Giblin et al. (2016); Hunter et al. (2007); Lyons (2005); Middlemas et al. (2018); Woods et al. (2019)

*knowledge can be understood by stakeholders, prompting enhanced decision-making and judgements.*

In this definition, the concept of understanding is critical to differentiate between data as a product, for example, sports data provided by media outlets, and the applied PA-service role in assisting stakeholders achieve an understanding of information and how it could be interpreted, which is often a co-creative process. Ackoff (1989) highlights that the generation of understanding and the development of wisdom, from which good judgment emanates, are educational processes. Thus, in applied PA, the analyst designs learning opportunities for coaches, athletes, support staff or strategic managers to achieve as complete and accurate an understanding of performance as possible. The concept of applied PA for learning is well established (Groom et al., 2011; ; Liebermann et al., 2019 2020); however, the pedagogical role and activities of the applied PA practitioner have not been sufficiently investigated, **particularly in a digital age**. The gap in our body of knowledge around a supported professional pathway for applied PAs is **also** an important area for future investigation.

### **3.3. Framework for professional practice in applied PA**

We have established that the purpose of applied PA is to create valuable performance knowledge and design learning opportunities so this knowledge can be understood and applied to enhance the judgements of coaches, athletes, PDs and other stakeholders. The literature has revealed five areas of expertise which, to varying degrees, underpin each component of practice. Nine components of Applied PA practice were identified which are loosely sequential and highly iterative. Rather than present a complex flowchart

visual, we have used a lighthouse analogy to represent the relationships between the required inputs and desired outcomes of applied PA and the components and expertise required to deliver these (Figure 2).

A lightbulb is central to the analogy. This is the knowledge created by the applied PA, appropriate to the context in which they are operating. We all know that a lightbulb is only useful if it is switched on. Switching on the lightbulb is an analogy for the applied PA design learning opportunities for stakeholders to see and understand the value in the feedback provided. Thus, the apparatus of the lighthouse represents the required input from an applied PA, to create knowledge (lightbulb) and to design opportunities for that knowledge to be understood (switching the light on). If these learning opportunities are effective, and "lightbulb moments" have occurred, the desired outcomes will be evident. In this analogy, the outcomes are illustrated by the rays of light emanating from the lighthouse, representing understanding and informed judgements. Lighthouses have long been used to guide seafarers, traditionally acting as points from which sailors could establish their location. Applied PA is often used in a similar way to benchmark where a team, athlete or organisation is in relation to their competitors. Given their often-unforgiving locations, lighthouses are built on very strong foundations. In this analogy, the foundation of applied PA practice is built on five areas of expertise: contextual awareness, building relationships, PA and sporting expertise, technical expertise and professional behaviours. The framework includes the following nine components of applied PA practice; establishing relationships and defining roles, needs analysis and service planning, system design, data collection and reliability checking, data management, analysis, reporting to [key stakeholders](#), facilitation of feedback to athletes and service review and evaluation. These are represented as the lighthouse walls building upwards towards the lightbulb of knowledge. While the components of applied PA are to some extent sequential, we understand that the linear nature of the analogy is a simplification of the messy and iterative process of coaching and PA. This is particularly the case for the final component, service review and evaluation, as truly reflective practitioners will constantly evaluate and amend their practice.

### **3.4. Five areas of expertise underpinning applied PA**

Expertise has been described as *"the ability to make value judgements, to identify and deploy the optimum blend of techniques to meet complex and dynamic situations"* (Cruickshank et al., 2020:240). The five areas of expertise presented were based on the resounding themes in the literature; contextual awareness, building relationships, PA and sporting expertise; technical expertise and professional behaviours. It could well be argued that contextual awareness and responding to context is the application of expertise in the other four domains. While acknowledging this, we feel that the capacity and awareness to recognise what the context is at any point in time, is a critical skill set for applied PAs in its own right.

#### **3.4.1. Contextual awareness**

The emergence of the contextual awareness of practitioners as one of the key themes in this research is reflective of the increasing body of literature focusing on how we deliver



analysis, rather than what can be measured (Groom et al., 2011 2011b). Practitioners should be cognisant of tailoring PA delivery based on quantifiable parameters, such as requested variables, competition requirements, timeframes, availability of resources, athlete age profile and availability. It would seem, however, that some of the contextual parameters, which matter most are not easily quantified. These include the more nuanced needs of *stakeholders*; the level of technical and educational support coaches or executives require to commission and understand analysis; their current focus based on the coaching environment and results; the readiness of athletes to embrace analysis depending on their maturity, personalities and attitude to learning, previous experience of PA and preceding results (Middlemas & Harwood, 2018, Booroff et al., 2016; Nelson et al., 2014; Mackenzie & Cushion, 2013b, Bateman and Jones, 2019). All of these variables could be considered to comprise the "PA age" of an athlete, coach or PD, similar to the well-understood concept of an athlete's "training age" (Pichardo et al., 2018). Contextual awareness extends to being attuned to the power dynamics within the organisation, executive management, the coaching team, the performers and between each group. The emergence of contextual awareness as a key expertise underpinning the delivery of applied PA, highlights the importance of practitioners developing skills such as empathy and micro-political awareness in tandem with their technical and PA skill set. Aspiring applied PAs should have the opportunity to learn how to identify and evaluate a PD or coach's perspective based on their background and philosophy, their leadership style, their coaching record, the current role and expectations, the funding pressures, and how these factors could potentially impact the practice of the analyst (Huggan et al., 2015; Macquet et al., 2015; McKenna et al., 2018; Nicholls et al., 2018b).

### 3.4.2. Building relationships

Perhaps the most fundamental expertise is building relationships. Without a coach or PD, there is no applied PA and it seems the quality of the coach–analyst relationship is key to the delivery of effective PA. In many cases, this is presented as a subordinate relationship, as the following quotes from soccer analysts illustrate;

*"the gaffer is the one at the top, with the decision making. He's got the final say on everything, but he's got to have his own staff, and he's got to have staff that want to work for him"* (A2) (Bateman and Jones, 2019:8).

*"At the end of the day, he's the manager of the football club. Whether he deserves respect or not, you have to give it him because that the nature of the industry we're in"* (A1) (Bateman and Jones, 2019:9).

A critical realist approach recognises the transformative potential of workplace relationships where the power of the relationship can cause events to occur (Ryan et al., 2012). The transformative potential of the coach–analyst relationship is apparent throughout the body of PA literature where positive relationships enabled the service to flourish and vice-versa. This contrast is apparent in juxtaposed quotes from a single-subject case study tracking "Ben's" soccer analyst career;

*"Faced with the reality of leaving soccer or remaining in difficult conditions under [Brian] Atherton [the coach], Ben decided to stick it out . . . . He chose to simply withdraw his maximum effort, 'coast through' and bide his time until Brian left the club . . ."* (Huggan et al., 2015:514).



*"The unwavering support of the manager and assistant meant he [Ben] was free to put his vision into practice and begin the creation of an analysis department."* (Huggan et al., 2015:515).

The last quote is one of many linking an effective, thriving analyst to a strong coach–analyst relationship (Lames, 2008; McKenna et al., 2018, Wright et al., 2014 ). There is evidence of analysts developing other significant professional relationships with athletes, PDs, administrative or management staff, and multi-disciplinary sports science colleagues. There is perhaps an additional role for analysts as a knowledge broker, acting as an interface between these stakeholders. The capacity to initiate, foster and consolidate professional relationships is therefore a critical area of expertise for applied PA practice (Bateman and Jones, 2019, Francis et al., 2015, Bartlett and Drust, 2020).

### 3.4.3. PA and sport expertise

It is the role of any professional to "profess" knowledge and judgements based on a specific body of knowledge in a particular domain (Taylor & Garratt, 2010). In PA, that domain expertise is based on intelligence about what to measure within a specific sport and the well-established PA principles about how to measure, collect and interrogate data to create information and knowledge. In applied PA, PA and sport expertise extends beyond the creation and presentation of knowledge. In professional practice, applied PAs are expected to understand and apply pedagogical principles necessary to create learning opportunities for stakeholders to interface with the performance knowledge created in a way which accelerates understanding and increases their efficiency and effectiveness (Ackoff, 1989). The specialist body of knowledge in PA is well established and continually growing, with [much](#) research on what and how to analyse (Hughes et al., 2019a). Analysis of the literature demonstrated how coaches and analysts felt that in-depth, sport-specific knowledge and understanding was very desirable for applied PAs (Butterworth & Turner, 2014; Sarmiento et al., 2015; Thomson et al., 2013; Wright et al., 2013), and there were instances of applied PAs also being qualified coaches (Macquet et al., 2015; Palao et al., 2016; Robins, 2014b; Wright et al., 2013). If a profession claims authority based on the concept of its jurisdiction on a specific body of knowledge (Taylor & Garratt, 2010), then applied PAs can lay claim to a robust body of literature in respect to creating knowledge about sporting performance. However, there are considerable gaps in the body of knowledge supporting the second facet of professional practice, which is the analyst's capacity to design effective learning opportunities to impart knowledge created to stakeholders.

### 3.4.4. Technical expertise

In this digital age, the execution of PA expertise is inextricably linked to technical expertise. It is difficult to identify or visualise trends in data without basic working knowledge of a sports analysis software package or data management software. The type of technical expertise required for a specific role varies hugely, depending on its nature and context and there is some debate as to what level of technical expertise analysts in the future will need as data science becomes more pervasive. Robertson (2020a) suggested that contemporary PAs should adopt "computational thinking" and be open to learning open-source programming languages as necessity requires. James (2018) predicts that the analyst

role will evolve to exclude data collection and analysis and focus on interpretation and "translation" of data into the language of coaching. The identification of the components of applied PA in this framework may be helpful to organisations and applied PAs to audit their processes, capabilities and future requirements, and consider how best to build capacity to meet the applied PA service demands of the organisation.

### 3.4.5. Professional behaviours

Professional behaviours include expertise in self and time management, ethical practice, communication, reflection and evaluation. It is manifested as consistent good judgment, evidence-based decisions and responding appropriately to context (Collins et al., 2015a). Given the lack of role descriptions currently evident in this discipline (Wright et al., 2014, Hammond, 2018), it seems that understanding the processes of effective self-management and professional practice could be a significant advantage to novice analysts. Training in how to negotiate a simple role descriptor and service-level agreement may alleviate some of the stressful scenarios described by analysts;

*"Kevin Green [Coach] may not have understood a great deal about Ben's role, but at least he did not actively belittle his work in front of the other coaches or players."* (Huggan et al., 2015:513)

*"Initially, there was role ambiguity with analysts finding it difficult to establish information essential to their role."*

*"... the analyst needs to remember he's the analyst and not the coach"* (McKenna et al., 2018:310)

Data management and safeguarding sensitive data are increasingly important professional responsibilities for which we hope analysts have sufficient ethical and technical training. All analysts could arguably benefit from a greater emphasis on reflective practice and more formal evaluations of intervention programmes (Robertson, 2020a). Professional development hinges on self-knowledge, self-awareness and reflection and it may be difficult for analysts, often working long hours in isolation, to carve out time for this (Wright et al., 2014, Carling, 2019). The process of accreditation or joining a community of practice is often an opportunity for structured reflection on practice, philosophy of practice, knowledge sharing (Lyons, 2005, Hughes et al., 2019b) and access to multi-faceted social support which can mitigate against the solitary aspects of the role (Sheridan et al., 2014). One of the four key components for successful delivery in high-performance sport has been identified as sports scientists making time to understand their philosophy of practice and how it impacts and influences those around them (Bartlett and Drust, 2020).

### 3.5. The components of applied PA

Some general principles emerged in the creation of each list of processes and the tables, which house them (Tables 3–13). The framework is loosely sequential, but not linear, as the initial processes are iterative and there is considerable overlap between some of the components. For example, data management underpins data collection and analysis. The intention is that the table for each component can stand-alone, making sense if taken in isolation, and that each process is understandable without the accompanying quote. The number of papers and references associated with each process are an indicator of the

**Table 3.** Processes undertaken by an applied performance analyst in the establishing relationships and defining the role component of applied PA.

Processes	Expertise	Papers*	Refs†	Example Quote
<b>BACKGROUND RESEARCH</b>				
Find out about the context, culture and environment of the organisation and people	Contextual Awareness, Professional Behaviours	16	26	Rather, he tailored most of his coaching decisions around the development of the most gifted players in his squad. Terry explained to us that he did this in response to the increasingly problematic nature of the club's finances and the associated pressures and expectations that accompanied his role as a result of the club's changing circumstances in this regard. (Booroff et al., 2016: 119)
<b>BUILD RELATIONSHIPS</b>				
Meet and build rapport with the key stakeholders and managers in the organisation	Building Relationships, Professional Behaviours, Contextual Awareness	8	14	Although he had kept the same job title and salary at the club throughout the turmoil he began to realise the importance of the chairmen of soccer clubs to his career going forwards. (Huggan et al., 2016: 515)
Meet and build rapport with the coaching staff and multi- disciplinary team	Building Relationships, Professional Behaviours, Contextual Awareness	18	51	Informal opportunities to talk also helped to build initial relationships with coaches . . . : "It took them a month to learn my name . . . eventually we ended up talking about normal stuff, social stuff, and from then it was 'see how we do this, do you think we should do it like that?' . . . it took a while." (McKenna et al., 2018: 310)
<b>DEFINE ROLES</b>				
Define and agree the role of the analyst and establish reporting relationships	Building Relationships, Professional Behaviours, Domain Expertise, Contextual Awareness	10	18	Initially, there was role ambiguity with analysts finding it difficult to establish information essential to their role. (McKenna et al., 2019: 310)
Total		36	113	

\*Papers refers to the number of papers in the study which made reference to this process – † Refs refers to the number of individual references to this process

prevalence of that underlying theme or issue in the literature reviewed. Our aim is that the processes could potentially be followed by a novice analyst as a checklist for practice. It is not expected that every analyst will carry out each process, that will depend on their role. Scouting analysts, for example, may not be involved in facilitating feedback to athletes. Some processes are very broad, for example, "Operate data collection technology, equipment and systems". This is deliberately broad and flexible, to capture the range of technology analysts use, from pen and paper notational analysis to the use of machine learning for data collection.

### 3.5.1. Establishing relationships and defining the role

The novel inclusion of this component of applied PA may seem unnecessary for applied PAs past the initial phases of establishing a new role. There are many instances, however, in which even the most established analysts need to build new relationships and define or redefine their role, for example, a change of management, support staff, [athletes](#) or club ownership, evolving performance questions and requirements, or increased

**Table 4.** Processes undertaken by an applied performance analyst in the needs analysis & service planning component of applied PA.

Processes	Expertise	Papers*	Refs	Example Quote
<b>AUDIT AVAILABLE RESOURCES</b>				
Determine available resources; analyst capacity and expertise to deliver; time demands of competition schedule; available budget, hardware, software, and internet connectivity	Professional Behaviours, Domain Expertise, Technical Expertise	36	59	In Africa, the inaccessibility to technological equipment due to its cost (not always affordable for the budget of an amateur football club) and the instability and high rate of the internet connection represent a barrier for the exchange of video-data and related video-analytical feedbacks. (Ferrari, 2017:439)
<b>EVALUATE CURRENT KNOWLEDGE OF SPORT</b>				
Evaluate the current body of knowledge in the sport (academic/coaching literature, blogs etc)	Domain Expertise, Professional Behaviours	22	33	Existing research provides a lot of useful information for training but this information is often ignored by coaches or not transferred to actual practice. (Fernandez et al., 2017:151)
<b>CAPTURE STAKEHOLDER NEEDS</b>				
Design a strategy to capture the needs of key stakeholders	Domain expertise, Professional Behaviours, Contextual Awareness, Building Relationships	13	15	This initial system was used as a communication tool to promote discussion with the coach and help elicit requirements for the system to be used by the Welsh senior netball squad in the FENA (Federation of European Netball Associations) tournament in February 2004. (O'Donoghue & Longville, 2004:12)
Capture the ideas, needs and preferences of the coach & coaching team; athletes; multi-disciplinary team and other stakeholders where required	Domain expertise, Professional Behaviours, Contextual Awareness, Building Relationships	46	98	In doing so, one must consider and involve the athlete as an active agent within the coaching process; their interpretations/meanings assigned to performances are influential for success. (Collins et al., 2015b:1093)
Collaborate with the coaching team or other key stakeholders to define the performance question or issue	Domain expertise, Professional Behaviours, Contextual Awareness, Building Relationships	9	14	The comprehension and usefulness of results derived from an innovative technology is driven by an understanding of the questions or problems that the new technology is trying to answer or solve. (Buttfield & Polglaze, 2016:11)
Consider if a research project should be conducted in tandem with the work package	Domain Expertise, Professional Behaviours	14	19	These advances [in professional practice] come about through good research and development, often in formal settings (such as university-based and peer reviewed research) but also, importantly, in informal settings (such as the everyday research which occurs in professional clubs and sports institutes that often remains unpublished). (Buttfield & Polglaze, 2016: 11)
<b>AGREE SERVICE PLAN</b>				

*(Continued)*

Table 4. (Continued).

Consider the impact of the coach's philosophy and leadership style on the service delivery plan	Contextual Awareness, Domain Expertise, Professional Behaviours	12	26	They [Head Coaches with Transformational style leadership] wanted athletes to think for themselves and contribute to the decision-making process. (Macquet et al., 2015:36)
Negotiate and agree aims and a plan for PA service; a model for delivery and how it will be evaluated	Domain Expertise, Professional Behaviours	13	18	... the national coaches are well advised to prioritise and use the services of the performance analyst in the most effective way to achieve the goals set for that tournament and in the long term. (Hughes et al., 2001:2)
Total		77	282	

\*Papers refers to the number of papers in the study which made reference to this process † Refs refers to the number of individual references to this process

responsibilities. The literature suggests that to be most effective, applied PAs should prioritise three key processes when establishing relationships; undertake background research, actively build relationships, and clearly define their role. Background research on the context in which an applied PA will operate involves finding out about the culture and environment within the organisation, the people involved, or new person arriving, and the external competitive environment (Huggan et al., 2015, Booroff et al., 2016; Gomez, 2018; Groom et al., 2011; Mackenzie & Cushion, 2013b; Middlemas & Harwood, 2018; Moreira & Peixoto, 2014; Nicholls et al., 2018b). Much of this information can be found online or through a professional network. The value of a strong professional network for applied PAs was evident, particularly in securing a role (Butterworth & Turner, 2014, Bateman and Jones, 2019; Huggan et al., 2015), where "being known" seemed to be a considerable advantage. Robertson's (2020a) recent suggestion that analysts should be open-minded, innovative, versatile, self-aware, reflective and strong communicators, all echoed in the reviewed literature, in addition to empathy (Macquet et al., 2015; McKenna et al., 2018), micro-political awareness (Booroff et al., 2016, Huggan et al., 2015) and knowing your place in the process. The latter traits on this list are critical to the ability to build rapport and foster quality relationships with stakeholders which was consistently identified as vital in delivering an applied PA service effectively (Francis et al., 2015; Nicholls et al., 2018b). This, however, does not seem to be a prominent feature of applied PA training.

### 3.5.2. Needs analysis and service planning

Although the phrase "needs analysis" is used only once (Wells et al., 2012), the concept it encapsulates is well established in the body of literature, largely incorporated within system design. In the initial framework, needs analysis was combined with system design (Carling et al., 2005; Hughes, 2015a; O'Donoghue, 2015); however, the volume of papers identifying processes specific to this pre-design phase, guided the decision to cluster these independently. Many of these processes are self-explanatory and well embedded in practice; however, they are not clearly captured elsewhere. Capturing the minutia of the actions of experienced analysts as steps which could be followed by a novice may

**Table 5.** Processes undertaken by an applied performance analyst in the system design component of applied PA.

Processes	Expertise	Papers*	Refs	Example Quote
<b>EXPLORE SYSTEM REQUIREMENTS</b>				
Establish what to measure and test valid operational definitions for the variables (consider complex systems, intangibles, and measuring interdependencies between variables)	Domain Expertise, Professional Behaviours, Building Relationships	26	68	... it is critical that the practical worth (i.e. the association with performance and the relationship with other relevant factors) of any proposed testing or monitoring protocol is carefully evaluated to avoid the potential situation of gathering data that has little 'real world' use. (Smith et al., 2002:542)
Research all potential technical solutions – consider non-PA specific options, seeking specialist expertise if required	Domain Expertise, Technical Expertise, Professional Behaviours	25	46	Though technology can provide the initial leap forward in professional practice, it is often the small steps taken when refining the application and metrics derived from a new technology (sometimes in areas unforeseen by even the developers of the technology) that provide the greatest benefit. (Buttfield & Polglaze, 2016) p11
Based on system brief, agree system parameters – personnel, timeframes, budget, technology	Domain Expertise, Professional Behaviours, Building Relationships	33	51	However, it is important for a club to understand and accept the cost of setting up this service, in addition to the usability and uptake of the service by the players, in order to make it a financially viable system. (Francis & Jones, 2014:200)
Seek ethical approval and consent if a research project is incorporated in the work	Domain Expertise, Professional Behaviours, Building Relationships	6	7	Data capture occurred during the final preparation phase for the Paralympics 2012. Ethics approval for this study was obtained from the scientific committee of the University of Hamburg in agreement with the German Rowing Association (DRV). Data collection was part of routine measurements in routine sport science support. (Schaffert & Mattes, 2015:412)
<b>SYSTEM DESIGN AND TESTING</b>				
Test & select most appropriate tools – software and hardware	Technical Expertise, Domain Expertise, Professional Behaviours	8	16	It is incumbent on the individual sport scientist or coach to establish the accuracy and usefulness of any new technology or metric that becomes available. This is not to say that they need to personally validate each new system themselves, but just ensure this process has been completed before incorporating the new tool. (Buttfield & Polglaze, 2016:10)

*(Continued)*

Table 5. (Continued).

Collaborate with coaches/multi-disciplinary team to design and pilot test the system, considering the athlete experience	Domain Expertise, Technical Expertise, Professional Behaviours, Building Relationships, Contextual Awareness	18	43	The template underwent two pilot tests on a randomly selected elite wheelchair basketball game from a pre-tournament held in 2015. (Francis & Peters, 2019:4)
Collaborate with coaches to agree strategy for reporting and feedback	Professional Behaviours, Domain Expertise, Technical Expertise, Building Relationships, Contextual Awareness	4	7	The system developers should understand the information to be provided as feedback and then determined the raw data to be collected to enable the system to provide the summary information required. (Gasston, 2004:9)
Devise data management strategy and related infrastructure	Technical Expertise, Domain Expertise, Building Relationships	7	12	A risk was taken to build everything from scratch and in our case, there is now a database solution for the Singapore Sports School that was designed primarily with a coach-driven approach. (Ong & Koh, 2005:109)
Total		64	251	

\*Papers refers to the number of papers in the study which made reference to this process † Refs refers to the number of individual references to this process

potentially accelerate learning or eliminate simple novice errors such as not having a strategy to find out what a coach wants to analyse (Table 4) (McKenna et al., 2018).

The process which prompts practitioners to "*Consider if a research project should be conducted with the work package*," is based on the identification of a considerable gap between applied practice and academic research (Buttfield & Polglaze, 2016, Carling et al., 2014, Wright et al., 2014, Mackenzie & Cushion, 2013a), as demonstrated by this quote;

*"...for practitioners to consistently implement research within the elite environment, research needs to better reflect the real world of elite sport by incorporating elite populations within investigations useful to them (i.e. practitioner or sport)"* (Nicholls et al., 2018b:7)

This phenomenon is common to many sports science disciplines and has been attributed to the divergent factors which drive the actions of practitioners and researchers (Drust & Green, 2013). Relative to the dynamism of elite sports settings, researchers work slowly. Their goals are usually aligned with academic progression, which is achieved by research metrics that reward productivity, studies with high sample size, and quantitative outputs well ahead of single subject case-studies (Oravec, 2019). Front line practitioners are required to work fast driven by performance outcomes and gaining a competitive edge (Harper & McCunn, 2017). If they do have the research skills, lack of time and privileged information are significant inhibitors (Drust & Green, 2013). The concept of practitioner-researchers is increasingly evident in applied PA as a step towards addressing this gap; however, these studentships require planning and significant oversight (Bartlett and Drust, 2020).

Service-level agreements (SLAs) are a commonly used tool in professional practice for many analysts, but they were not referred to once in the body of literature. Beaumont



(2006) describes SLAs as fundamental to gaining and retaining client respect, whether the client is external to the organisation or another department within. Negotiating a SLA has been described as an educative process for the client (Beaumont, 2006), which is perhaps a compelling reason for applied PAs to embrace them, as it appears that considerable ambiguity exists in coaches' understanding of the analyst role (McKenna et al., 2018). Given the sometimes-precious nature of employment evident (Huggan et al., 2015), SLAs also have the potential to help administrators understand what they are paying for and see the long hours which are delivered (Carling, 2019). Learning the process of service planning is an important professional expertise, particularly for novice analysts, that is, how to negotiate and write aims, describe work packages and estimate time allowances for them; consider what successful programme delivery looks like and how it could be evaluated.

### **3.5.3. System design**

The system design processes applied PAs use will vary according to their role (Table 5). We propose that this framework could be used as a checklist or signpost for good practice which may be useful for practitioners designing new systems or reimagining older ones. A significant challenge for practitioners is the push to look beyond counts of isolated variables to consider patterns of interaction between variables (Croft et al., 2017), factors linked directly to game philosophy and strategic outcomes (Cordes et al., 2012), and measuring intangibles, for example, what athletes are feeling, thinking and perceiving during performance (Gleeson & Kelly, 2020; Sève et al., 2013). There is some evidence of the consideration of ecological dynamics in the selection of variables monitored (Glazier, 2010; Woods et al., 2019), though it has been slow to emerge as the Grand Unifying Theory for sports science inter-disciplinary integration envisaged by Glazier (2017). This may be due to a lack of access to experts in the necessary range of specialisms, or the fact that many applied PAs operate in highly pressured environments and do not have the time to step back and focus on the more holistic, but abstract, constraints of performance.

### **3.5.4. Data management**

Data management was referred or alluded to in over fifty papers, confirming its centrality to the delivery of applied PA (Table 6). The increasing need for effective data management is exemplified by a case study of a New Zealand Mitre 10 Professional Rugby Team (Middlemas et al., 2018). The study identifies three different sources of video and statistical data; team, individual and unit analysis provided by a local university to the coach; an online video database of all teams in the competition maintained by external providers; and training footage from handy-cams and drones. In this scenario there was no "in house" analyst, leaving the responsibility and considerable workload for managing and archiving the data, presumably to the one full-time coach. There is a growing imperative on any organisation accumulating volumes of data to have strategies in place for its effective management.

The intricacy of technical processes on how to build data management infrastructure are well served by a wealth of literature (Alamar, 2013). The professional behaviours required by analysts in data management are not as prominently discussed so merit reference in this context. The first of these is the concept of developing consistent operating procedures for data handling and archiving, such as file naming structures.



**Table 6.** Processes undertaken by an applied performance analyst in the data management component of applied PA.

Processes	Expertise	Papers*	Refs†	Example Quote
<b>BUILD INFRASTRUCTURE</b>				
Build integrated performance databases which can be effectively mined and operate real-time if necessary	Technical expertise, Domain Expertise	31	88	Sports analysis workflow requires tools and techniques that ideally would provide a way to effectively filter the data being analysed on demand and display this data in a way that enhances the experts' analysis capabilities in the context of the problem. (Benito Santos et al., 2018:2)
Develop/use consistent operating procedures for data handling and archiving (file naming protocol etc)	Domain expertise, Technical expertise, Professional Behaviours	3	5	The workshop noted the importance to be attached to the use of metadata in performance analysis and agreed a national metadata standard (the Australian Government Locator Service) and a thesaurus to standardise nomenclature (the SIRC Thesaurus). (Lyons, 2005:156)
<b>MANAGE ACCESS TO DATA</b>				
Manage access to and sharing of data	Technical expertise, Domain Expertise, Building Relationships, Contextual Awareness, Professional Behaviours	32	45	By this time I am in addition working at the Lee Valley white water centre during the 2012 Games as part of a technical video team providing live video feeds to the competing nations' analysts. (Butterworth & Turner, 2014:554)
Protect sensitive data	Professional Behaviours, Domain Expertise	4	5	The use of a specific cycling prosthesis will depend on the individual's stump length and remaining musculature as well their sensitivity to "prosthetic rubbing" associated with cycling. Burket & Mellifont (2008:101)
Store and archive data	Domain Expertise, Technical Expertise, Professional Behaviours	12	22	KISS [Korean Institute Sport Science] developed an archive system to construct the basic infrastructure of the system and support performance in preparation for 2004 Athens Olympics. Lee (2008:111)
Total		53	165	

\*Papers refers to the number of papers in the study which made reference to this process † Refs refers to the number of individual references to this process

The advantage of recording this working knowledge of "how we do things" into written procedures, is that we can easily pass them on to others to share the workload, or for critique to see if there is a better, faster way to work. An awareness of the logic of how we work is the first step in developing the "computational thinking" skills deemed essential for the next generation of analysts (Robertson, 2020a). The second professional behaviour essential to data management is the protection of sensitive data. All analysts should receive training in data protection and have adequate policies and procedures in place for secure data sharing. If coaches are known as "gatekeepers" of information (Bampouras

**Table 7.** Processes undertaken by an applied performance analyst in the data collection & reliability component of applied PA.

Processes	Expertise	Papers*	Refst	Example Quote
<b>PREPARATION PHASE</b>				
Undergo system training, upskill and prepare coaches/others to collect data if required	Technical & Domain expertise, Professional Behaviours, Contextual Awareness, Relationship Building	18	32	Numerous persons within a team set-up collaborate to obtain sport performance and statistical data. These may include the coach, sport scientist, or a performance analyst (Van den Berg et al., 2018:34)
Create a protocol for data collection and video capture including: obtaining permission to film/share data; briefing athletes where required	Technical & Domain expertise, Professional Behaviours, Contextual Awareness, Relationship Building	16	41	Everything was setup as in the blueprint during the event. (Ong et al., 2006:87)
Prepare equipment	Professional Behaviours, Technical Expertise	3	7	Prior to each match, the battery for the video camera is fully charged and electricity supplies for the laptop computer are checked at the venue. (Jenkins et al., 2007:62)
Adapt to context & logistics "on location"	Professional Behaviours, Domain Expertise, Technical Expertise	5	8	The 'real' situation in setting up the infrastructure and the planning for the data capture is sometimes almost never exactly the same nor as predictable as what was planned (to be described later). The set-up has to be done at the scene according to the localised physical conditions and culture. (Ong et al., 2006:85)
<b>EXECUTION PHASE</b>				
Engage with external analysis providers or mine public data sources to obtain data	Professional Behaviours, Relationship Building, Domain & Technical Expertise	10	21	This study did identify that 70.2% of the analysts use an external company to code games. (Wright et al., 2013:256)
Systematically observe and judge what data to record	Domain Expertise, Technical Expertise, Professional Behaviours	24	38	... isn't it ultimately you who decides which factors to analyse, what definitions to apply, and what aspects to concentrate on when collecting and analysing your data? As such, isn't the quantitative analyst heavily involved in the process? (Nelson & Groom, 2014:697)
Operate data collection technology, equipment & systems	Domain Expertise, Technical Expertise, Professional Behaviours	50	92	Indeed, practitioners working in elite soccer clubs are using an ever-increasing range of technologies to quantitatively and qualitatively track and monitor performance in their own players and that of the opposition ... (Carling et al., 2014:6)
<b>RELIABILITY PHASE</b>				
Systematically check and recode data, applying appropriate statistical tests if required	Technical & Domain expertise, Professional Behaviours	14	85	If many operations are required to correct the error, a few rallies could be missed in a real-time scenario. In the program, it was possible to correct the shot number using only two clicks. (Fuchs et al., 2018:2659)

*(Continued)*

Table 7. (Continued).

Processes	Expertise	Papers*	Refs†	Example Quote
Interpret and evaluate reliability results in the context of performance	Domain expertise, Professional Behaviours, Contextual Awareness	8	13	Indeed, this view of reliability is not the same as just describing errors in measurement; it involves the analyst having to make an informed decision by considering the implications of those descriptions of measurement error – it is this that distinguishes the sport performance analyst from the mere technician. (Cooper et al., 2007:88)
Total		64	337	

\*Papers refers to the number of papers in the study which made reference to this process† Refs refers to the number of individual references to this process

et al., 2012), then applied PAs are surely custodians and curators of data with the associated responsibilities.

### 3.5.5. Data collection

The PA and technical expertise required for the various phases of data collection are previously well documented (Hughes et al., 2019a, Jayal et al., 2018; O'Donoghue, 2015). What emerged clearly in the literature was the role and influence of the human in the preparation and execution of data collection (Table 7) (Nelson & Groom, 2012; Wells et al., 2012). In the context of discussion around how the role of an applied PA may become obsolete (Robertson, 2020b), it is timely to consider what impact the person has in data collection. The danger of confirmation bias by coaches and analysts is highlighted by several authors (Collins et al., 2015b, Croft et al., 2017), with artificial intelligence and large-scale data collection recommended as a potentially more objective, systematic and open-minded way to gather and interrogate data (Benito Santos et al., 2018). While technology exists to supplant the mechanical, repetitive, aspect of data entry, there is also evidence that coaches view applied PAs as an extension of their "coach's eye" (Gesbert et al., 2016; Sarmento et al., 2015; Wright et al., 2013), which is at times subjective:

*"The analyst often found himself recording contributions for some players as positive that would have not been included for more experienced players"* (O'Donoghue, 2006:9).

Identifying, isolating and evaluating the processes involved in a current data collection and analysis workflow are vital to appraising if new technology is worth the investment of time required to deliver a similar or better outcome than a trained applied PA (Robertson, 2020a). The review also highlights the role of analyst's judgment in deciding if data is to be considered reliable enough to inform decision-making in a given context, with an understandable drop in reliability for live data collection (Cooper et al., 2007; Thomson et al., 2013). The importance of reliability to the process of PA delivery was named or alluded to by 25 papers, emphasising how critical the integrity of data is to the credibility of analysts and coaches (Gesbert et al., 2016; P.G. & Longville, 2004; Wells et al., 2009).

**Table 8.** Processes undertaken by an applied performance analyst in the analysis component of applied PA.

Processes	Expertise	Papers*	Refs†	Example Quote
<b>PREPARE DATA &amp; PROCESSES</b>				
Formulate standard operating protocol for the analysis workflow	Domain Expertise, Technical Expertise, Professional Behaviours	4	4	... a processing layer must be constructed to first extract relevant pieces of information from the data and then combine (processing) and visualise them (reporting). (Memmert & Rein, 2018:69)
Import, tidy, transform, sort and organise data from multiple sources	Domain Expertise, Technical Expertise	9	11	At the processing of data stage, macros formulae are used to generate the parameters for the swim similar to the SWAN format (Mason, 2003) in Microsoft EXCEL. From here, the data is input to populate the database. (Ong & Koh, 2005:105)
Mine and filter own and third party databases to extract and compare data	Domain Expertise, Technical Expertise	15	32	... if an entire league of teams were using the same company, there is an inherent advantage in that clubs could then benchmark themselves against each other as every game is analysed in the same objective method (Wright et al., 2013:256)
<b>INTERROGATION OF DATA</b>				
Interrogate data to identify trends, selecting appropriate statistical techniques where appropriate	Domain Expertise, Technical Expertise, Contextual Awareness	20	50	Consequently, the aspiring analyst would be prudent to develop a good knowledge and practical understanding of the techniques required to successfully investigate trends and significantly explore data beyond the descriptives within their potential working environment. (Nicholls et al., 2018:770)
<b>PROFILES &amp; VISUALISATION</b>				
Create performance profiles, considering the stability of the data	Domain Expertise, Technical Expertise, Contextual Awareness	23	50	Thus, as previously mentioned in the preparation process, when evaluating an opponent it is important that the correct games are selected based on context and standard of opposition so the correct strategy can be adopted. (Sarmiento et al., 2015:485)
Create effective data visualisations and reports using simple or complex tools to illustrate trends	Domain Expertise, Technical Expertise, Professional Behaviours	14	23	Moreover, it is clear that data in the form of reports or performance trend analysis plays a vital role within a large proportion of the coaches surveyed. (Nicholls et al., 2018:770)
<b>MANAGE TIMELINES</b>				
Manage timelines for the delivery of analysis outputs	Professional Behaviours, Domain Expertise	22	37	Moreover, time restrictions limit analysis volume, therefore coach preferences are critical. (McKenna et al., 2018:316)
Total		48	207	

\*Papers refers to the number of papers in the study which made reference to this process † Refs refers to the number of individual references to this process

### 3.5.6. Analysis

This Framework proposes a two-step process for knowledge creation, making a clear distinction between the processes involved in analysing and interrogating data (Table 8) and the generation of insight and translation of data to information to be consumed by stakeholders (Table 9). This clear delineation reflects the reality that some organisations outsource data collection and analysis (Fernandez-Echeverria et al., 2017; Kraak et al.,

**Table 9.** Processes undertaken by an applied performance analyst in the reporting to **key stakeholders** component of applied PA.

Processes	Expertise	Papers*	Refs†	Example Quote
<b>DATA TRANSLATION</b>				
Interpret and translate data into performance insights, and narrative if requested	Domain Expertise, Relationship Building	14	23	... the translation of this analysis and data must provide meaningful insights or changes in behaviour to render it worthwhile. (Hammond, 2018:26)
Facilitate delivery of live data and insight to coaching team	Domain Expertise, Technical Expertise, Contextual awareness, Relationship Building	13	20	To track progress during the match a dashboard was created as seen in Figure 5 to indicate whether the team had successfully (dark green) or unsuccessfully (red) implemented the strategy. (Croft et al., 2017:1041)
Filter and prepare content for analysis by stakeholders, distilling data to manageable volumes	Domain Expertise, Technical Expertise, Contextual Awareness, Relationship Building, Professional Behaviours	22	37	They [experienced game analysts] report frequently that information has to be filtered prior to a presentation to the coaches, that there are long discussions with coaches on the meaning and consequences of the observational data ... (Lames, 2008:111)
Prioritise and facilitate a coach review meeting to reflect, discuss and co-analyse data	Professional Behaviours, Domain Expertise, Technical Expertise, Contextual awareness, Relationship Building	24	37	The results from the study support the use of analysts reviewing their analysis with the coaching team before providing or conducting any feedback to the players as 89.9% already do this as part of their own analysis cycle. (Wright et al., 2013:257)
Ensure understanding of the data provided, teach to use analysis tools where appropriate	Domain Expertise, Technical Expertise, Contextual awareness, Relationship Building	14	16	[The review meeting ensures that] the information is understood by the coaching staff and management allowing for them to be more knowledgeable when delivering feedback on performance, thus enhancing the quality and conciseness of their feedback. (Wright et al., 2013:246)
Ensure access to larger databases which can be referred to answer specific queries	Professional Behaviours, Domain Expertise, Technical Expertise	6	8	To make sure that it's fresh [data analysis], that it's kept up to date and, that if a coach came to you, for example, ... the coach came to you with some more detailed questions, you have the ability to talk them through one-to-one. (Analyst 1: 0–4 years' experience) (Nicholls et al., 2019:68)
Consider when, where and how to challenge assumptions & biases	Building Relationships, Domain Expertise, Contextual Awareness, Professional Behaviours	13	20	"A lot of them don't understand, because they are old school, because they think we are challenging their thinking, they fear the challenges. Sometimes they don't even allow the guys with the camera to provide the video" [Analyst, Interview 1]. (Ferrari, 2017:438)
<b>STRATEGY PLANNING</b>				

*(Continued)*

Table 9. (Continued).

Processes	Expertise	Papers*	Refs†	Example Quote
Assist coaching team to build and articulate game and training strategy	Building Relationships, Domain Expertise, Contextual Awareness, Professional Behaviours	14	24	While during the period of intensive training, the Chinese team are likely to spend much time discussing the tactical features of their opponents, who were categorised into three levels. For the opponents at the first level, the whole team (including coaches, players and researchers [analysts]) will have a discussion together and adopt complete match analysis to analyse each opponent, and then apply the corresponding suggestions to training (Fuchs et al., 2018:660)
Agree strategy and content for the facilitation of feedback to athletes	Building Relationships, Domain Expertise, Contextual Awareness, Professional Behaviours	11	18	The hours need to happen before the feedback happens, so you go in with a very clear message, these are the outcomes of that session or that competition, these are the key feedback parameters, these are the key performance parameters ... (Analyst 1: 0–4 years' experience) (Nicholls et al., 2019:69)
Total		55	205	

\*Papers refers to the number of papers in the study which made reference to this process † Refs refers to the number of individual references to this process

2018; Mackenzie & Cushion, 2013b ; Martin et al., 2018) and subsequently interpret the data in the "Reporting to **key stakeholders**" phase. The essence of the "Analysis" component is the interrogation of performance data in the context of existing datasets. The continuing evolution of technology to do this better than humans will be a significant driver as analysis systems evolve;

*"Hereby, the computer starts to replace the analysts with respect to the evaluation of game situations, yielding more objective records of soccer-specific events". (Memmert & Rein, 2018:66).*

It remains to be seen whether sports organisations will seek to recruit and develop PAs with the data science skills to deliver this complex analysis or employ data analysts specifically for this role in collaboration with PA staff as proposed by James (2018:19);

*"The future of performance analysis is likely to be dominated by the cooperation of experts in sports coaching (deriving the questions), the data analyst (to collect and analyse the data) and the performance analyst (to interpret and visualise the data in a format understandable and applicable to the coach and players)."*

### 3.5.7. Reporting to **key stakeholders**

The identification of a two-step analysis process and dedication of a specific component "reporting to **key stakeholders**" is a novel contribution from this research. It could be argued that this is the most critical step in applied PA, as this is the step where the lightbulb is switched on and knowledge is disseminated. It is the point

where the explicit knowledge created by the applied PA is interrogated through the lens of the tacit knowledge possessed by the [executive](#) or coaching team to become insight (Von Krogh, 1998). The world of business use sport as a case in point in highlighting the need for "data translators" to provide opportunities for data to be understood and drive enhanced judgements through the use of appropriate language, effective visualisation and the presentation of knowledge by asking questions, not making assertions (Brady et al., 2017). The term " [key stakeholders](#)" is a catch all to include [coaches](#), athletes and support staff or may actually represent a briefing to PD, sporting director or [executive](#) manager (Parnell et al., 2018). There are multiple examples of the co-creation of analysis and insight through meetings with coaching staff and athlete leaders (Francis & Jones, 2014; Fuchs et al., 2018; Macquet et al., 2015; Murray & Hughes, 2001). Indeed, one soccer study found that the applied PA's view of performance was altered by this meeting;

*"The results may suggest that reviewing your analysis [with [key stakeholders](#)] is an effective method in production of analysis as 56.3% of the analysts that responded believe that from the review their analysis changed before feeding back to the players" (Wright et al., 2013:257).*

This research confirms the importance of a reporting meeting as an opportunity to discuss, reflect on, and fully understand performance data, in advance of feedback to athletes (Fuchs et al., 2018; Macquet et al., 2015; O'Donoghue, 2006; Palao et al., 2016; Wright et al., 2013). This co-creation of knowledge is often based on qualitative analysis of video (Lames, 2008; Fuchs et al., 2018; O'Donoghue, 2006). McKenna and colleagues (2018) identify how some of the part-time coaches in their study struggled to make time for any meaningful engagement with their applied PAs in advance of player feedback, and thus did not use the analysis provided optimally. For well-established analysts, the review meeting is potentially the opportunity to challenge coach assumptions and bias;

*"They [coaches] very much use us not regularly to assess their thoughts on games and on players . . . . it allows them to reflect and get a more balanced view" (Analyst 1) (Reeves & Roberts, 2013:).*

It is important to note that in order to begin engagement with [key stakeholders](#), the applied PA must first judge how best to filter data for analysis by [these people](#) (Hammond, 2018; Lames, 2008), a curation process critical to the impact of their work;

*"Performance analysts can unfortunately all too easily drown themselves, practitioners and players in large amounts of cross-tabulated data, potentially leading to rejection of their work" (Carling et al., 2014:3).*

### **3.5.8. Facilitation of feedback to athletes**

This research synthesis urges applied PAs and coaches designing feedback opportunities to first complete a contextual assessment of the environment (Table 10), considering the various factors which will impact the potential learning experience. There is resounding evidence that athletes want to be involved and empowered to be part of the analysis and feedback process (Francis & Jones, 2014; Fuchs et al., 2018; Murray & Hughes, 2001; Nelson et al., 2014; O'Donoghue & Longville, 2004; Palao et al., 2016; Reeves & Roberts,

**Table 10.** Processes undertaken by an applied performance analyst in the Facilitation of Feedback to Athletes – Contextual Assessment component of Applied PA.

Processes	Expertise	Papers*	Refs†	Example Quote
<b>CONTEXTUAL ASSESSMENT</b>				
Consider best practice in the athlete experience of feedback: volume, timing, frequency, accessibility, empowerment, criticism	Contextual Awareness, Domain Expertise	28	81	The importance of addressing the requirements of the players as well as the coach was to ensure that the coach, players and analyst had co-ownership of the system. (O'Donoghue & Longville, 2004:4)
Build trust and rapport with athletes through presence and small deeds	Building Relationships, Professional Behaviours	6	11	Four essential components for establishing trust between myself, and the athletes and staff were identified: appearance and visibility, confidence, honesty and integrity, and self-care. (Franics et al., 2015:47)
Consider social and emotional needs of each athlete, impact of results and schedule on levels of mental fatigue individually and collectively	Contextual Awareness, Domain Expertise	21	84	Coaches may benefit from adopting a broader view of the post-performance review to include psychological recovery alongside performance enhancement aims. (Middlemas et al., 2018:10)
Consider the coach's leadership style and philosophy of feedback, in addition to the socio-emotional and micro-political needs of the coaching staff	Contextual Awareness, Domain Expertise	19	63	Transactional leaders provide players with pragmatic paths to goals. They give them solutions to the problems raised instead of encouraging players to find solutions on their own. Nevertheless, they are open to their players' suggestions. (Macquet et al., 2015:37)
Observe & identify the power dynamics within the athlete group and how they relate to the coaching staff	Contextual Awareness, Building Relationships	6	16	Coach 3 said: "This player is a leader. Sometimes, he makes mistakes in his distribution with regard to the quality of the reception . . . but I can't do without his leadership. I know that in money time he'll be able to excel. And even if his statistics aren't good, I know that he'll make up the difference". (Gesbert et al., 2016:623)
Consider the balance and timing of briefing versus debriefing, collaborate with performance psychologist if available	Building Relationships, Domain Expertise, Contextual Awareness	12	31	The coaches felt that a psychology practitioner could also work in tandem with the performance analysis practitioner [to deliver feedback]: "The analyst probably already has a better basic knowledge of performance than the psych, but the psych understands the impact better. This combination would be ideal for the coach" (Coach 5). (Middlemas & Harwood, 2018:36–7)
Total		42	286	

2013; L. W. Judge et al., 2016; Wright et al., 2016) and coaches also feel this is fundamentally important to the delivery of applied PA (Groom & Cushion, 2005; Groom et al., 2011 ; Macquet et al., 2015; Middlemas et al., 2018; Middlemas & Harwood, 2018). We strongly recommend that applied PAs ensure they are familiar with this body of evidence and advocate for the active involvement of athletes in planning



**Table 11.** Processes undertaken by an applied performance analyst in the facilitation of feedback to athletes – planning, preparation and delivery component of applied PA.

Processes	Expertise	Papers*	Refs	Example Quote
<b>PLANNING FEEDBACK STRATEGY</b>				
Collaborate with coach/athletes to decide on key feedback aims, messages, content, tone, timing and mode of delivery	Building & Developing Relationships, Domain Expertise, Technical Expertise	21	55	There are a number of very complex issues which the coach and analyst might have to consider while attempting to devise the most effective feedback sessions. (Wright et al., 2014:1019)
Advocate for bespoke feedback design promoting discussion, athlete reflection, empowerment and ownership of analysis	Domain Expertise, Building Relationships, Contextual Awareness	32	89	However, as coaching graduates, participants [analysts] felt they could inform pedagogical application. Some coaches embraced this, but others did not, reaffirming the importance of role clarity and power relationships. (McKenna et al., 2018:311)
Ensure athletes are informed and can contribute to decisions about how feedback will proceed	Domain Expertise, Building Relationships, Contextual Awareness	9	18	Additionally, the contribution, or lack of, from the player/s themselves will impact the delivery of video based performance analysis and how the process is negotiated by the coach. (Groom et al., 2011:30)
<b>PREPARATION</b>				
Assist coaching team to design scaffolding materials to provide athlete learning opportunities through reflection: meetings, questions, self-analysis or peer analysis, teaching coaches to use feedback technology where required	Domain Expertise, Technical Expertise, Contextual Awareness	23	81	In some instances players were set specific tasks to analyse aspects of their own performance, common examples included pass completion, attempts on goal, successful tackles and set piece analysis. (Wright et al., 2016:1019)
Refine data visualisation – statistics for athletes	Domain Expertise, Technical Expertise, Contextual Awareness	13	26	Arguably however, the performance analyst has access to a vast amount of information via various sources that incorporating 100% of the information within a feedback session would likely cause: 1) information overload, 2) the session to last significantly longer and 3) athlete confusion/lack of clarity within the "take-home messages". (Nicholls et al., 2018:772)
Edit feedback clips for athletes to ensure an appropriate volume	Domain Expertise, Technical Expertise, Building Relationships, Contextual Awareness	16	45	The coaches also highlighted that a great deal of care needed to be given to the construction of the video. (Groom et al., 2011:23)

*(Continued)*

Table 11. (Continued).

<b>DELIVERY</b>			
Facilitate and manage timely athlete access to appropriate feedback, during practice interventions, meetings or online	Domain Expertise, Contextual Awareness, Technical Expertise, Professional Behaviours, Building Relationships	19	34 "We could video a scrummaging session and watch it on a delay before we go into the next scrum ... I like learning like that because rather than watching 12 or 15 clips and watching them at the end of a session, you can watch them and pick up one or two things immediately" (Player 3) (Francis & Jones, 2014:193)
Design a way to capture feedback of the athlete experience and outcomes to allow evaluation of the learning opportunities provided	Professional Behaviours, Domain Expertise, Building Relationships, Contextual Awareness	13	20 "Research [done within the soccer Academy by practitioners] shows that smaller groups can increase learning, with individual sessions here providing players with the most focussed reflection/ education" (Analyst 1) (Reeves & Roberts, 2013:204)
Be available to engage with athletes and staff informally and on an ad-hoc, casual basis	Building & Developing Relationships, Professional Behaviours	7	12 Athletes were also encouraged to discuss their feedback with the analyst. Each analysis was basic to start, but player engagement with the process saw requests for more detailed information "can you get more clips? ... can you break it down into sections? ... passes, tackles? ... then (sub)sections even further?" (McKenna et al., 2018:312)
Total		51	380

\*Papers refers to the number of papers in the study which made reference to this process| Refs refers to the number of individual references to this process

and delivering feedback opportunities (Table 11). Groom et al., (2011) () clearly established learning and behaviour change as key target outcomes for the use of video interventions with athletes; however, the role of an applied PA was not considered. This research synthesis provides multiple examples of applied PAs' involvement assisting coaches design learning opportunities for athletes (Francis & Jones, 2014; Hughes et al., 2015, O'Donoghue, 2006, Reeves & Roberts, 2013; Sève et al., 2013). One study identifies frustration felt by novice analysts when coaches viewed them primarily as whizz kids with computers and did not recognise their potential to contribute pedagogically as coaching graduates (McKenna et al., 2018). Coaching literature increasingly highlights the importance of athlete empowerment and of feedback and feed-forward in accelerating learning (Richards et al., 2017; O'Sullivan et al., 2021), illustrating the alignment between the two schools of thought.

The evidence reveals the different strategies analysts and coaches employ to scaffold learning opportunities for athletes where;

**Table 12.** Processes undertaken by an applied performance analyst in the facilitation of feedback to athletes – running a team meeting component of applied PA.

Processes	Expertise	Papers*	Refs†	Example Quote
<b>BEFORE</b>				
Collaborate with coaching team to establish/plan their desired learning outcomes, content, and tone for the meeting.	Domain Expertise, Building Relationships, Professional Behaviours, Contextual Awareness	16	39	... John described how he had most respect for those coaches who he perceived to have invested considerable amounts of time and energy into the development of 'slick' and well-organised presentations that included edited video clips and had clear links to the objectives of training sessions. (Nelson et al., 2014:26)
Prepare required meeting content and brief for coaching team if required	Domain Expertise, Technical Expertise, Contextual Awareness	9	14	It is evident from this study that the analyst may compile the analysis for the coaching or management staff but the majority of them (72.9%) do not actually lead the feedback session. (Wright et al., 2013:258)
Assist coaching team to formulate appropriate questions based on content to achieve desired outcomes	Domain Expertise, Contextual Awareness, Building Relationships	7	21	Subsequently, the questions Dan asked were open, and forward-focused (i.e. "Ok, men. Let's pause that clip there. If a similar situation presents itself this weekend, what choices do you have?"). (Middlemas et al., 2018:5)
Prepare meeting room logistics, technology and environment in advance if possible	Professional Behaviours, Technical Expertise, Building Relationships, Contextual Awareness	7	7	They [coaches, including video coach] debriefed players in a quiet room at the hotel, with chairs oriented towards a screen and a flip chart, like a classroom. (Macquet et al., 2015:35)
<b>DURING</b>				
Support and ensure coach/athlete competence with video technology delivery, deliver feedback, or facilitate meeting if required	Professional Behaviours, Building Relationships, Domain Expertise, Technical Expertise	8	17	Sessions were generally coach led; however, participants demonstrated considerable value in a combined and/or analyst-led approach at certain instances. (Nicholls et al., 2018:772)
Keep track of meeting duration, acting as timekeeper if agreed	Professional Behaviours, Domain Expertise	13	29	At the start, coaches wanted to show everything ... it was so long ... it was an hour with 17 year olds ... I was getting bored, and it was my work." (McKenna et al., 2018:315)
<b>AFTER</b>				
Note if the meeting met the desired outcomes and capture any additional actions	Professional Behaviours, Domain Expertise	2	4	Therefore, field notes were recorded so as detailed information of the following aspects were maintained and analysed: The use of the match statistics by the coach and the analyst and the broad aspects of performance that were of concern .... (Jenkins et al., 2007:68)
Total		23	136	

\*Papers refers to the number of papers in the study which made reference to this process

† Refs refers to the number of individual references to this process

**Table 13.** Processes undertaken by an applied performance analyst in the service review and evaluation component of applied PA.

Processes	Expertise	Papers*	Refs†	Example Quote
<b>REVIEW</b>				
Capture formal/informal feedback on PA support from key stakeholders	Professional Behaviours, Building Relationships, Contextual Awareness	11	20	Research shows that smaller groups can increase learning, with individual sessions here providing players with the most focussed reflection/education. (Where participant Analyst 1 refers to research, they are explicating research undertaken within their own Academy and not peer-reviewed research.) (Reeves & Roberts, 2013:204)
Review engagement data and performance data in line with original project aims to evaluate if learning opportunities were appropriate	Domain Expertise, Technical Expertise, Professional Behaviours, Contextual Awareness	16	29	There was a clear improvement in the number of turnovers made as well as the proportion of these where England capitalised by scoring goals. The FENA Championships were not a laboratory experiment and it must be recognised that there are many factors responsible for England's improvement between the beginning and the end of the tournament. (Gasston, 2004: 10)
<b>EVALUATE</b>				
Reflect on, and evaluate your role in delivery, strengths and weaknesses	Professional Behaviours	10	24	"standards remain really high, so the quality of the work you're producing is still of the standard that's required that I think that helps maintain that relationship along the way" [Analyst 4] (Bateman & Jones, 2019:7)
Based on collated evidence, debrief original service plan with relevant staff, evaluating if aims were achieved.	Professional Behaviours, Building Relationships, Contextual Awareness	5	11	Standardised questionnaires assessed the athletes' perceived experience during rowing with acoustic feedback and included also an evaluation by the coach of its benefits for technique training in elite standard Para-Rowing. (Schaffert & Mattes, 2015: 413)
<b>SHARE</b>				
Collate evaluation findings into a report for the organisation	Domain Expertise, Professional Behaviours, Building Relationships, Contextual Awareness	6	8	"So I already had that relationship with the chairman once he'd signed off on it and then made sure – just as due diligence really – to give him regular updates on how it was going and the differences that we were making." (Huggan et al., 2015: 516)

*(Continued)*

Table 13. (Continued).

Processes	Expertise	Papers*	Refs†	Example Quote
Consider if, and/or how, lessons from the work could be disseminated	Domain Expertise, Professional Behaviours, Building Relationships, Contextual Awareness	17	28	... it is often the small steps taken when refining the application and metrics derived from a new technology ... that provide the greatest benefit. These advances come about through good research and development, often in formal settings ... but also, importantly, in informal settings (such as the everyday research which occurs in professional clubs and sports institutes that often remains unpublished). (Buttfield & Polglaze, 2016:11)
Total		44	120	

\*Papers refers to the number of papers in the study which made reference to this process

† Refs refers to the number of individual references to this process

*"scaffolding refers to support that is designed to provide the assistance necessary to enable learners to accomplish tasks and develop understandings that they would not be able to manage on their own"* (Hammond & Gibbons, 2005:).

The most frequent example of scaffolding is the team meeting or small group meeting, where open questions are carefully planned in advance (Middlemas et al., 2018), where athletes are facilitated to debate a particular strategy based on purposeful selection of clips (O'Donoghue, 2006), or sessions were player led (Middlemas et al., 2018), and players are encouraged to take notes (Francis & Jones, 2014). Team meetings were so prevalent in the literature that a cluster of processes on how to conduct one was compiled, as this is not prescribed elsewhere (Table 12). One-to-one meetings were also seen as a key learning opportunity facilitated by coaches (Middlemas et al., 2018; Middlemas & Harwood, 2018; Reeves & Roberts, 2013) and analysts (McKenna et al., 2018; Nicholls et al., 2018b; Wright et al., 2013). Other learning opportunities were created via peer meetings (O'Donoghue, 2006, Francis & Jones, 2014; Nelson et al., 2014), self-confrontational interviews (Sève et al., 2013), and bespoke practice environments (Woods et al., 2019). The provision of data to athletes to consume in their own time, usually online, is increasingly evident (Nicholls et al., 2018b, Williams and Manley, 2016); however, it is also apparent that;

*"... simply having the information available is not necessarily sufficient to facilitate effective self-reflection on behalf of the player. Some players clearly need further guidance and support in what to look for and why"* (Wright et al., 2016:1023).

While the literature tells us that some applied PAs play a supporting role as "learner designers", there is little or no exploration of how to acquire the skills and experience to do this effectively. Looking from the other perspective, there is no investigation of how coaches optimise their analyst as a resource to help them create "coachable moments" (Cote et al., 2013), or of best practice for the many coaches operating as analysts.

### 3.5.9. Service review and evaluation

A perennial dilemma for applied PAs is considering how to capture the stakeholder's experience of feedback and evaluate if they actually learned anything from the opportunities provided in the short, medium and long term (Jenkins et al., 2007). This is a hugely important area for future investigation. One case study noted very positive outcomes from the applied PA intervention programme; however, the evidence seems to have been anecdotal;

*"... the process alone made the players more analytical and focused in their approach to matches and tournaments, which, arguably, is a singular positive effect in itself. The process itself is one of analysis and, more importantly, of self-analysis and change" (Murray & Hughes, 2001:193).*

Strategic evaluation of applied PA service delivery was not a strong feature of the body of literature, which can be viewed as a weakness in applied PAs' claim to professionalism. Robertson (2020a:5) concurs that evaluation is *"often overlooked"* and suggests a user feedback framework which can be adapted to elicit feedback and facilitate an effective evaluation process. Returning to the written aims from a SLA or plan would afford the opportunity to reflect, evaluate and consider the lessons to be learned from any programme.

## 4. Limitations

We acknowledge several limitations with this research. By their nature, academic publications lag-behind practice, so in reality PA practice has evolved beyond the body of literature reviewed. Few systematic reviews can claim to be exhaustive (Brunton et al., 2012) and the exclusion of non-English studies may influence the overall findings, potentially omitting culturally significant aspects of applied PA practice. We acknowledge that the substantial weight of UK publications in the sample may mean this framework is most reflective of applied PA practice in the UK, and further research is required to test its global application. While the voice of PAs is heard in many of the papers reviewed, and through the stakeholder assessment survey, a more in depth, qualitative assessment of the content and potential value of this framework to a variety of users is merited. This paper does not deal with the philosophical arguments about where PA sits in relation to biomechanics, motor control and other elements of sports science, but accepts that the role is real and varies according to the context of the sport and organisation. We submit that the framework and processes are flexible enough to cover this range.

## 5. Conclusion

As a novel contribution, this paper interprets the body of literature in applied PA to synthesise and validate a framework for professional practice which identifies both the components of practice and the expertise that underpins it. We establish the critical importance of identifying context and building relationships to successful practice. Our study has examined the minutia of the applied PA role with a level of granularity that lends itself to use by educators, novice and experienced analysts and strategic managers

in sporting organisations to consider their practice. We offer a definition of the role of an applied PA centred on the creation of knowledge and design of learning opportunities for stakeholders. This work is timely in contributing to the debate around the formulation of a professional development pathway for applied PAs, and what that would entail. The study identifies several specific areas for further investigation, including the pedagogical role and activities of the applied PA practitioner and the professional behaviours required for effective practice.

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