

Title: A Structured Approach for Technology Innovation in Sport

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Abstract

Technology innovation plays a vital role in elite sport, yet often proceeds in *an ad hoc* manner, emerging from the grass roots of sport rather than as a strategic programmed activity. This paper presents a model for systematic technology innovation in sport. It was developed from an extensive review of innovation and management best practice from the literature and draws on successful examples of innovation in sport. The model uses needs assessment, context and stakeholder theory, together with structured enquiry, to establish technological literacy and identify translational and technology-ready opportunities to meet existing and emerging needs. It consolidates existing knowledge, translates exemplars of innovation from sport and other settings, and highlights process innovation as being a vital element in the achievement of innovation. The model is then applied to a professional sports organization demonstrating its utility as an organizational tool for planning for innovation and highlighting areas of best practice. Identification of near and mid-term opportunities for innovation was a key outcome.

Key words

Innovation, technology, need, assessment, elite, sport

1. INTRODUCTION

Innovation in sport through technology advances is growing interest worldwide, and many sport organizations are searching for competitive advantage through innovation. Historically, technology innovations and their application to sport were mainly *ad hoc* rather than systematic initiatives (Adair & Vamplew, 1997). Early adopters of innovation included sports where technology was easy to integrate and essential to the performance of the sport, such as cycling and rowing. In the mid to

late 20th century, innovation and innovative coaches and sport scientists were embraced in swimming and athletics to produce performance excellence in international competition (Phillips, 2000). Similarly, in Great Britain, new approaches to coaching in swimming and greater integration of coaching, sport science and medicine expertise were contributors to performance success in the early 2000s (Australian Swimming Association, 2002; Green & Houlihan, 2005). Technology and innovation are now viewed as integral to every aspect of athlete development and performance and, according to an Australian Government report, will combine with research and science ‘to be drivers of Australian sporting excellence in the coming decades’ (Commonwealth of Australia, 2010).

Although some sporting organizations are relatively reluctant to adopt new technologies and favor the preservation of sporting ‘traditions’ (Smith & Stewart, 2010; Trabal, 2008), technology innovations related to sports science and improvements in on-field performance are often viewed positively, with many sport organizations now searching for competitive advantage through innovation (Riot & James, 2013). It is common for sports to rapidly take up new technology especially in areas of performance monitoring, and with the advent of large-scale manufacture of consumer products adapted easily to sport, technology innovation is increasingly more acceptable. For example, the use of Global Positioning System (GPS) is widespread in sport as it provides quality feedback for performance analysis and monitoring (Wisbey, Montgomery, Pyne, & Rattray, 2010; Cunniffe, Proctor, Baker, & Davies, 2009), and the recent adoption of information technology has had a transformative effect on sports performance (Liebermann, Katz, Hughes, Bartlett, McClements, & Franks, 2002) particularly in communications between athletes and coaches and in data analysis (for training, performance and competitor analysis).

Further, the application of media-friendly technologies - such as high speed and infrared cameras, and real time monitoring of athlete physiological outputs – provides vital information to coaches and officials. These ‘innovations’ differ greatly from previous applications of traditional engineering to enhance sport performance (Haake, 1996), and are rapidly adopted by sports particularly if the potential to enhance the attractiveness of the sport exists. For example, in the “Gen Y sport” of snowboarding, Harding et al. (Harding, Mackintosh, Martin, Hahn & James, 2009) introduced wearable performance analysis tools to enhance training and competition outcomes, and the innovation was viewed favourably by this elite sport community (Harding, Toohey, Martin, Hahn & James, 2008).

Despite the centrality of technology and innovation to a sustained competitive advantage in elite sport, little research has examined structured approaches for technology innovation and needs assessment in elite sport settings. Existing approaches to technology and innovation in elite sport tend to come from creative leaps within the community in a largely *ad hoc* manner, and *how* technology and innovation needs are identified to address performance gaps is not well known. Further, few studies have reported key stakeholders’ perceptions of need for technology and process innovations in elite sport.

The focus of this paper is the ‘real world’ requirement of helping elite sport organisations to identify needs and opportunities for innovation through technology advances. The paper describes existing innovation and technology advances in sport and considers how the task of identifying needs and opportunities for innovation should be approached. We follow a logical sequence to address the research problem, including an examination of relevant literature, design of a theoretically well-grounded tool for collecting relevant data, implementation of the tool, analysis of the

preliminary data, and discussion of the immediate implications, wider applications and possible next steps.

2. METHOD

To address the research problem we (1) undertook an extensive review of the peer-reviewed literature on theories and methods of innovation, needs assessment and stakeholder theory, (2) developed a model to identify need and opportunity for innovation, and (3) tested the model in an implementation phase with an elite sport organization to validate the model and determine if the method produced usable data.

2.1 Review process

A search was conducted using eight computer-based databases (e.g., Business Source Complete; PROQuest; SAGE journals online; Scopus; Informit Business Collection; Social Science Index, PsychLit, Google Scholar). Manual searches were also conducted using the reference lists from articles identified via the databases. Over fifty articles were located and reviewed, and the most salient are cited in this paper. The selected articles included a range of review papers, technical research and development articles, and original peer-reviewed scientific articles derived from multiple disciplines (e.g., health, engineering, sport science, science, business, and management).

2.2 Model design

A model was designed to enable new approaches to innovation in sport with an emphasis on the needs assessment stage of the innovation process. Development of the model was based on a synthesis of the theoretical and methodological frameworks explored in the review process.

2.3 Implementation

We implemented a study to test the model in a formal organizational setting (i.e., a professional sport organization). We employed both qualitative and quantitative research methods to assess the effectiveness of the model as a means for identifying needs and opportunity for innovation through technology advances.

2.3.1 Data collection

Needs assessment was based on interviews and focus group discussions with participants (key stakeholders). These were considered to be appropriate methods of enquiry because they provide opportunity to explore the topic, key themes and concepts fully. Interviews and focus groups can highlight unforeseen considerations and allow participants to raise points relevant to the topic without being constrained by any *a priori* categorization that otherwise could limit the field of enquiry (Fontana & Frey, 2005). For instance, the meanings of key themes and concepts can be uncovered by addressing “how” and “why” particular needs are prioritised. This insight extends the findings of survey research, which is often based on a series of pre-established questions with restricted response categories and little or no room for variation in response except in the infrequent circumstances where open-ended questions are included.

An interview guide was developed to provide a general framework for the interviews and focus group discussions. To assess its suitability, pilot interviews were conducted with a few key stakeholders and researchers, and refinements were subsequently made to address problems of ambiguity with instrument wording. Interviews and focus group discussions were recorded (with the consent of participants) for the purpose of data analysis.

2.3.2 Sampling procedures

Purposive sampling was used to select stakeholders that were information-rich cases about the core issue of interest (Patton, 2002). Purposive sampling was also used to select ‘expert’ individuals and groups who were considered difficult to access and comprised only a small percentage of the population. We used pre-determined criteria to select stakeholders who were identified as sufficiently experienced and well-versed to provide insight into technology and innovation needs in elite sport. The criteria broadly considered stakeholder representation (i.e., considering a diverse representation of stakeholders), and stakeholder legitimacy participation, power, and knowledge (i.e., taking into account the relative interest and influence of different stakeholders) (Finn, 1995; Mitchell, Agle & Wood, 1997). On this basis, we used an iterative process to select individuals and groups with “interest” in and “influence” over the core issue of interest (Eden & Ackermann, 1998).

2.3.3 Data analysis

The data analysis process involved transcribing interviews and focus group discussions verbatim, coding raw data, devising categories, and generating common themes through a process of examination, comparison, reflection and conceptualisation (Miles & Huberman, 1994; Strauss & Corbin, 1998). Quantitative analysis techniques were employed to further assist in drawing and verifying conclusions. Scoring of the frequency of agreement was used as a quantifying technique to convert qualitative data to quantitative data (Tashakkori & Teddlie, 2003). Frequency analysis served to highlight the more prominent factors upon which the research participants agreed (or disagreed) and operated as a data reduction technique.

Data units, gathered from stakeholder responses and coded for thematic analysis, were triangulated with a content analysis of organizational documents and review of technology innovation trends and developments in areas outside of sport, to produce a detailed understanding of technology innovation opportunities and solutions. The analysis process also included the independent verification and validation of the procedure at each stage of the data analysis, to make the analysis more rigorous and to reduce the element of bias. Verification and validation procedures included (1) participant validation (returning to a small sample of study participants and asking them to validate analyses) and (2) peer review that involved the independent reviewing and exploring of interview transcripts, data analysis, and emerging themes by another researcher to achieve inter-rater reliability. Where identified, inconsistencies were discussed until agreement was reached.

3.0 RESULTS

In this section we present the theoretical and methodological frameworks, the developed model, and demonstrate its application to a sporting organization.

3.1 Establishment of theoretical and methodological frameworks

From the review of literature we identified key theories and methods in relation to (1) the innovation process, (2) needs assessment, and (3) stakeholder theory to inform the development of the model.

3.1.1 Innovation Process

Innovation is a complex construct, broadly defined as the introduction of a new idea or behavior in the form of a technology, product, service, structure, system or process on to the market (Damanpour, 1992; Zaltman, Duncan & Holbeck, 1973). It is

“a different process to invention and involves the implementation and/or adaption of new knowledge” (Osborne & Brown, 2005) to represent discontinuity with the past. The OECD (1991) study on technological innovations describes the innovation process as the technological development of an invention combined with the market introduction of that invention to end-users or consumers through adoption and diffusion. That is, “a discovery that goes no further than the laboratory remains an invention” (Garcia & Calantone, 2002). Yet, technology is only one form of innovation and refers to the mechanical arts or applied sciences collectively and their application. Other forms of innovation include management innovation, defined as the invention and implementation of a management practice, process, structure, or technique that is new to the state of the art and is intended to further organizational goals (Birkinshaw, Hamel, & Mol, 2008; Damanpour & Evan, 1984; Knight, 1967).

The process of innovation has received a good deal of attention in the organizational literature (e.g., Newell & Swan, 1995; Sarros, Cooper, & Santora, 2008; Shrivastava & Souder, 1987), with a focus on business organizations and the determinants of innovation (Table 1). People within these types of organizations often conceptualize innovation as a series of events that unfold over time with the aim to either *generate* an innovation (such as a new product or process to resolve a problem), or *adopt* an innovation (carry out activities to further the use of an innovation already existing elsewhere).

[insert Table 1.]

Based on an extensive review of the innovation process literature, we identified that the early stage of the innovation process - identifying and assessing needs through the eyes of stakeholders within the relevant contexts of elite sport - is a key

subject of this investigation. This fits largely within the ‘Identify’ stage depicted in Figure 1 and entails identifying knowledge or performance gaps (that is, foreseeing or recognizing a problem).

[insert Figure 1.]

Our research focuses on this early stage of the innovation process because one of the most important determinants of the success of an innovation is how well user needs are identified and addressed (Veryzer, 1998; Maidique & Zirger, 1984; 1985). However, although user or stakeholder (e.g., organizational members) perspectives and awareness of a need or opportunity for change are significant driving forces of the innovation process and precursors to the incorporation of an innovation (Tornatzky & Fleischer, 1990), little is known about *how* an organization goes about achieving an understanding of user needs, particularly in an elite sport context. As a basis for developing a systematic approach, consideration must be given to the process of needs assessment and analysis, the “users” who define need, and the contexts of the need.

3.1.2 Needs assessment

Needs assessment in organizational management has a history that can be traced back to 1952 (Moore & Dutton, 1978), and is considered integral to the operations of many organizations. By definition needs assessment refers to identifying and prioritising needs to address performance gaps. It is a systematic process of asking questions, comparing answers, and making informed decisions about what to do next to improve conditions and performance (Witkin & Altschuld, 1995). In essence, a needs assessment is a problem analysis and a method that is used to map the needs and resources within sport organisations to better understand how services or

programs may serve an individual or group. Bradshaw (1972) suggests that four types of need can be considered, (1) normative need (defined by experts in the field and refers to the existence of standards or criterion established by custom, authority or general consensus against which quantity or quality of a situation or condition is measured), (2) perceived need (defined by those experiencing the need and what they think or feel about their needs), (3) expressed need (defined by those who seek out services to address a need), and (4) relative need (concerned with equity and refers to the gap between level of services existing in one group and those existing in similar groups).

A review of needs assessment models indicates a primary focus on interventions (methods-means) rather than on the results to be achieved through performance improvement. Watkins et al (1998) suggest this is a fundamental mistake that plagues many needs assessments, because it involves determining the solution before identifying the performance problem (e.g., a gap in results at the individual level). Consequently, the opportunity to gain the benefits of a needs assessment are often missed, as the focus is on the process of improving performance before really knowing what needs to be addressed (Watkins & Kaufman, 1996). Overall, effective needs assessment can be considered a proactive planning activity, and is considered vital for allowing organisations (decision-makers) to think broadly and systemically, consider interdisciplinary approaches, and provide justification for decisions.

3.1.3 Stakeholder theory

The term ‘stakeholder’ has been well explored in the management theory literature and refers to “any group or individual who can affect or is affected by the achievement of the organization’s objectives” (Freeman, 1984). In sport settings, these individuals and groups are often described as ‘experts’ who have an objective

and highly technical view of need, offer unique insights into need, and act as arbiters of the need criteria based on their expert experiences (Chelladurai & Chang, 2000). They are capable of providing rich information about the core issue of interest but comprise only a small percentage of the population and therefore can be difficult to access.

Identifying and analyzing the perceptions of key individuals and groups is important for problem-solving and organizational performance. In particular, stakeholders can identify, articulate, and prioritize performance gaps and search for solutions that are ‘valuable’ and ‘satisfy’ their needs. They assist in “recognizing a need, searching for solutions, becoming aware of existing innovations, identifying suitable innovations and proposing some for adoption” (Damanpour & Schneider, 2009). However, from our review, we identified that few studies have reported key stakeholders’ perceptions of need for technology and process innovations in elite sport. In one example, Justham et al (2008) surveyed key stakeholders (e.g., coaches, biomechanists and athletes) in the sport of swimming to identify user requirements and rankings of requirement importance, with the aim to develop a technology-based “end device”. Similarly, Ride et al (2013) grouped stakeholders into major categories (athlete, coach, sport scientist, researcher) and defined a set of situational contexts to illustrate the use of technology in swimming and improve training outcomes.

Our work aims to extrapolate further on this process by individually categorizing each stakeholder type and determining the type of information they would find useful. Although consultation with key stakeholders is an essential component of a systematic approach to the identification and realization of opportunities for successful introduction of technologies into sporting environments, the real challenge

is to work out how we identify (i.e., select and include) key stakeholders and what the consultation process should entail.

Although a broad range of methods and approaches have been developed for stakeholder identification and analysis, there is little information regarding how, when, and why they are effective and “this debate includes many questions about stakeholder representation, legitimacy, participation, power and knowledge” (Reed et al, 2009, p. 1934). In general, individuals should be involved if they have information that cannot be gained otherwise, or if their participation is necessary to assure successful implementation of initiatives (such as innovation initiatives) built on the analyses (Thomas, 1993). Chevalier and Buckles (2008) provide a range of ways to identify stakeholders such as by self-selection, identification by experts or other stakeholders, or using a checklist of likely stakeholder categories.

Other techniques available for stakeholder identification and analysis include the basic analysis technique, power versus interest grid, stakeholder influence diagram, and participation planning matrix (for more information refer to Bryson, 2004). For the purpose of our investigation we selected Eden and Ackermann’s (1998) “interest” versus “influence” method for identifying key stakeholders. This method was chosen because it encompasses an array of stakeholders on a matrix where the dimensions are the stakeholder’s interest in the issue at hand (e.g., athlete, coach who is immediately impacted), and the stakeholder’s power to affect the issue or organisation’s future (e.g., sport administrators’ capacity to facilitate and enable innovation). This method helps determine which stakeholder’s interests and influence bases must be taken into account in order to address the problem or issue at hand, and helps highlight coalitions and behaviours to be encouraged for long-term benefit. Further, business development literature advocates on-going and evolving involvement of stakeholders

beyond stakeholder analysis, at every stage of the project to ensure successful implementation of innovation initiatives built on the outcomes of needs assessment and analysis (Fraser, Dougill, Mabee, Reed, & McAlpine, 2006; Stringer, Prell, Reed, Hubacek, Fraser, & Dougill, 2006). In this way, the dynamic nature of stakeholder needs, priorities and interests can be captured throughout the duration of the innovation and beyond.

3.2 Model Design

Based on the available frameworks a model was developed to guide structured innovation in sport. The model is presented in Figure 2 and is a new approach to innovation in sport. It comprises three phases including (1) needs assessment, (2) needs analysis, and (3) innovation and review. All three phases of the model are supported by a continuous, iterative quality improvement framework that incorporates reflection on opportunities to address performance gaps through technology innovation. A description of the model is provided below, along with a summary of the outcomes of the implementation and testing process.

[insert Figure 2.]

3.2.1 Phase 1: Needs Assessment

The needs assessment phase of the model refers to the process of identifying and prioritizing need and deconstructing an identified need into component parts to determine solution requirements. The needs assessment process that we have designed is informed by the theoretical frameworks discussed earlier and is broken into several elements that provide a structured approach for conducting a needs assessment. The elements are (1) stakeholder identification, (2) context analysis, (3) data collection (interviews, focus groups), and (4) scoring (data analysis). It is important to note, that

“Scoring (data analysis)” is also a component of the needs analysis phase of the model (explained below).

Stakeholder identification - Needs assessment involves the gathering of information from stakeholders in different positions and at different levels of the elite sport system to understand technology innovation requirements and priorities for maximizing athlete development and organizational performance. For the purpose of a technology innovation needs assessment, the key individuals and groups in elite sport settings include athletes, coaches, sport administrators (e.g. high performance directors, athlete career and education advisors), sport science and medicine specialists (e.g., exercise physiologists, biomechanists, physiotherapists, medical doctors, nutritionists, psychologists) and people external to the organization (e.g. media personnel, orthopedic surgeons, other medical specialists (Table 2).

[insert Table 2.]

These individuals and groups have expertise in individual athlete development and performance, technology, and/or innovation, operate at the highest level of sport, and often have extensive experience and knowledge that helps them to identify and articulate technology performance gaps and process innovation needs, thereby reducing technological uncertainties and fostering innovation success. Overall, the internal stakeholders provide multi-disciplinary perspectives across all four areas of need (normative, perceived, expressed and relative).

Key external stakeholders include researchers, engineers and commercial partners who can help identify the innovation needs, and contribute to the development and testing of technology innovation. Researchers are not often considered to be key stakeholders. However, in a recent National Press Club conference on Australian

research and innovation it was suggested that the interests of researchers tend to be a good ‘barometer’ of relevant innovation issues (Australian Broadcasting Corporation, 2012). Researchers can add value by evaluating and improving the effectiveness and efficiency of particular technologies in intended environments while also bringing broader expertise sets. For example, the ‘evidence’ (data around specified variables that define performance characteristics and results) gathered by technological devices to aid coaches and sport scientists must be reliably produced, feasible to collect, and expected to influence performance.

Alongside coaches and sport scientists, researchers can also assist in defining the parameters within which evidence will be collected, how it will be aggregated, and how it will be used for monitoring, performance measurement and evaluation. In many contexts, coaches and sport scientists may feel that they are more able than researchers to assess the effects of specific interventions on performance, but the researchers can play a major role in providing the tools and adding rigor to the assessment. Collaborative effort needs to be focused on the impact of the technology on performance, rather than on the mechanics of the technology. Overall, each stakeholder represents an individual or group who can affect or be affected by an innovation. This method of identifying key stakeholders is in accordance with the power versus interest grid method previously described (Eden & Ackermann, 1998), and recognizes that the value of the perceptions of each stakeholder is determined by his or her influence over the subject of enquiry.

Context analysis - The contexts for the application of innovation to sport are wide-ranging. Needs assessment contexts for elite sport are summarised in Table 3 and Table 4. In many cases the needs assessment may highlight areas for management

innovation (also called process innovation), especially in the organizational context, and particularly where technology is an enabler of such.

Increasingly, emphasis is being placed on the use of technology to measure and define *performance*. For instance, at the competitive level of sport use of the stopwatch has been superseded by micro measurement of the timing of individual biomechanical actions to assess running gait (Wixted, Billing & James, 2010). In terms of physiology the use of heart rate monitors is now commonplace, and blood lactate and oxygen consumption (Wixted et al, 2007) are also sometimes measured. The *performance* context, broadly encapsulates Hahn's (2011) summary of technology innovation applications to high performance sport, and covers (1) determining characteristics of elite performers, (2) identifying talent, (3) testing and refining performance, and (4) monitoring competition performance outcomes.

[insert Table 3.]

In addition to the context of *performance*, *situational contexts* should be considered. Situational contexts include the location at which a sport is practiced (e.g., predominantly land, water, or air), whether or not the sport uses multiple forms of equipment and/or facilities, the number and type of bodily movements/functions required to perform the sport action, whether the sport is team or individually based, whether it places primary emphasis on aerobic or anaerobic energy pathways, the length of time the sport is practiced and other timeframe variables (e.g., number of seasons, sessions, competition time). Commonly used time units can serve as structural guidelines simply because of their ubiquity in data grouping. For example, in the sport of swimming structural guidelines based on time units can include lap (a single series of strokes with perceivable periodicity), trial (a continuous series of laps

having a set plan, usually with a prescribed plan as to technique such as five medium laps or one sprint lap at the end), session (a series of trials making up a training session), and season (a series of sessions making up a training season). The importance of the situational context in shaping and constraining technological need, development and innovation has not been well explored in the literature.

[insert Table 4.]

Data collection (interviews and focus groups) -

We developed a conceptual framework to guide interviews and focus group discussions. The conceptual framework was designed around three key thematic areas:

1. *Technology and innovation literacy.* To understand the extent of technology and innovation literacy we use a line of questioning that gathers information about interviewees' level of understanding of technology and innovation adoption and generation in sport, and their degree of technology acceptance. This baseline data is used to gain a better understanding of the potential barriers to technology innovation adoption and generation in elite sport settings.

2. *Current innovative practice and use of technology.* We explore interviewees' existing use of technology to (a) enhance sport performance and (b) assess sport performance. Questions relate to user satisfaction and the drawbacks of existing technology and innovations. This provides important information about technology innovation functionality, applicability, and usability in elite sport settings.

3. *Needs and wants.* Information about the short-term and long-term needs (perceived needs and expressed needs) of a sport with a particular focus on

identifying challenges and opportunities across a matrix of sport contexts or environments is gathered. Based on need assessment models, there is a focus on identifying and prioritizing needs in (1) performance contexts, and (2) situational contexts. The aim is to identify performance problems to assist the determination of solutions in the needs analysis and innovation stages of the model, in accordance with Watkins et al (1998).

Scoring (data analysis) – Interviews and focus group discussions are recorded and then coded to identify key themes that are used to produce key results and messages. Higher order themes are extrapolated from the data and frequency analysis is conducted. The data collection and data analysis techniques provide information necessary for Phase 2 (Needs Analysis) and Phase 3 (Innovation and Review) of the model and are in accordance with accepted qualitative research practices (e.g., Strauss and Corbin, 1998; Tashakkori and Teddlie, 2003).

3.2.2 Phase 2: Needs Analysis and Phase 3: Innovation and Review

The needs analysis and innovation and review phases of the model are concerned with the development of innovation solutions to address perceived gaps in knowledge and performance. The focus of the Needs Analysis phase is on stakeholders' perceptions as a means for prioritizing needs and solutions. In the Innovation and Review phase, creating or adopting solutions for the identified areas of need becomes a primary focus. Gaps between current and desired results are addressed by (1) establishing and testing lines of enquiry through strategic planning and action research, (2) creating support for solutions by identifying opportunity and technology resourcing, and (3) undertaking a process of review within a continuous quality improvement framework. Considerable variation and internal lack of cross

consistency among stakeholders is expected, the results of which can serve as a template to guide future work by tailoring end goals to specific users.

3.3 Application of the Model in an Elite Sport Organisation

3.3.1 Application process

A professional sports organisation was contacted, and consent to undertake a technology audit and innovation review was obtained. The technology innovation review was designed as a whole of organisation consultation strategy where all stakeholders were invited to participate in an interview or focus group discussion, and a feedback and innovation strategy presentation at the end of the project. The whole of organisation approach enabled early “buy-in” of key stakeholders and facilitated the retention of their involvement throughout the innovation cycle.

The sample for the audit and review consisted of sport administrators (e.g., management and operational personnel), service providers, and coaches drawn from a range of national and state sport federations/organizations, and publicly-funded organizations. In total, ten semi-structured interviews/focus groups were conducted at the organization and included 44% of organizational staff and almost 60% of the target population of key stakeholders. The protocol was approved by the University’s Human Research Ethics Committee (HSL/32/12/HREC).

Interviews were digitally recorded and transcribed into Microsoft Word documents which were analyzed and coded to produce key results and messages. From this, higher order themes were extrapolated from the data in each of the three areas of investigation (technology and innovation literacy; current innovative practice and use of technology; needs and wants), and frequency analysis was conducted with

data presented in Excel spread sheets. Throughout the process, perceptions of technology and innovation need across various performance and situational contexts were analysed, to provide a source of collated information.

3.3.2 Key findings from the investigation

In terms of technology and innovation literacy, interviewee's understanding of innovation varied considerably. There was some consensus that innovation was closely related to implementation of actions to provide better outcomes (e.g., putting good ideas to work). More than half of all respondents regarded themselves as innovative and technology was seen as only one aspect of innovation. Overall, the organisation was widely regarded as an innovative institution by interviewees and innovation was seen as very important to sustained success.

The analysis of current innovative practice and use of technology, revealed that technology was seen as an enabler of innovation through new possibilities arising from the technology, or through transforming the way things are done (i.e., process innovation) which assists organizational change. Overall, the frequency coding facilitated the identification of current technology and stakeholders' perceptions of need across varying contexts. For instance, Table 5 illustrates stakeholder group's perceptions of innovation priorities. The data are reported as frequencies to demonstrate the relative importance of each innovation priority for that stakeholder group. High frequency counts highlighted areas of opportunity for the future. The data established important baselines in ranking responses in the evaluation phase, and the results were indicative of common industry requirements. Table 6 provides a more general interpretation of the priorities among each stakeholder group as well as a summary of current technology use and technology based innovation opportunities.

[insert Table 5.]

[insert Table 6.]

Table 7 shows the results of the analysis as a series of recommendations for the organisation. The information obtained was used to build a strategic mind map (or needs matrix) of technology innovation needs and facilitated the identification of innovative strategies to address the identified needs.

[insert Table 7.]

Overall, implementation of the model revealed that integrating processes of stakeholder identification and context analysis with appropriate questioning and coding provided a framework for needs assessment, needs analysis, and innovation implementation and review.

3.3.3 Organisational outcomes and wider impacts

The model was effective in achieving (1) the identification of technologies that have high current usage, (2) technology based innovation opportunities across a range of performance and situational contexts, and (3) organizational capacity to foster innovation, and innovate. Based on the approach taken, key recommendations from the investigation were made and provided a framework for the organization's innovation strategy. The recommendations were reviewed by Senior Management and supported for implementation by the organisation. The senior management team provided their perceptions of the benefit of the research to the organisation and drew attention to the innovation gaps and wider considerations for innovation identified by the research and not considered by the organisation previously. For example, in a discussion following the investigation, participants explained that they were interested

in knowing more about “what’s next” for the organisation following the investigation, and believed that the whole of organisation and collaborative approach to innovation was valued by staff (up to two-thirds of participants reported this) and would be beneficial for the performance of athletes. Following the implementation of the model, other innovation-related studies have been implemented and fed into a new program.

Overall, the structured approach and processes used in Phase 2 and Phase 3 of the model enabled the discovery of technology opportunities by highlighting translational possibilities, unrecognized need and organization wide strengths and weaknesses. For example, in the context of needs analysis, similarities in outputs suggested that a modular design might be appropriate. That is, early prototypes may be based on a few modules that are easy to implement and appropriate to many stakeholders and implemented in a manner that recognizes that what is developed can provide an ability to change, adapt and branch in future iterations (refer to Davey, Anderson & James (2005) and James & Wixted (2011) for examples of hardware and software innovations).

4. DISCUSSION

This paper describes the development and application of a structured approach for technology innovation in sport to address “real world” requirements of elite sport organizations to identify needs and opportunities for innovation through technology advances. The paper formalized the innovation process in sport through the development of a model informed by a stakeholder and context analysis for programmed technology innovation using established principles from organizational literature.

Understanding and discovering technology innovation gaps in sport were the main foci of this work, and this is useful for several reasons. First, it enables understanding of the determinants and types of innovation in sporting contexts. Second, the model provides a tool for sport policy and decision makers to strengthen the ability of elite sport to innovate as necessary and strategically to achieve performance goals. Finally, it expands the body of knowledge surrounding technology innovation in elite sport as a precursor to development and potential commercialization opportunities.

The formation of the model has addressed several key challenges of innovating in sport settings such as, how to identify key stakeholders, what the consultation process should entail, how data arising from the consultation process should be analyzed, what factors should be considered in making decisions regarding the technologies to be targeted, what considerations are of key importance in project planning, how the chances of successful implementation of the plan can be maximized, and how the evaluation of outcomes should be approached. Based on the extensive review of literature we have provided informed solutions to the challenges and integrated these solutions into the model that has been tested in a professional sport organization. The model captures (in a structured way) a broader range of perspectives, involves all stakeholders in a consultative process, and considers how existing innovations can be translated into other sports or other areas of need.

The implementation of the model in a high performance sport setting has highlighted that a high degree of integration among key stakeholders is required for innovation success. Collaboration is seen as a mechanism to cope with dynamically changing environments (process innovation) and to embed specialist expertise (e.g. sporting and technical) into the innovation process. Linking knowledge obtained from elite athletes and sporting organizations with researchers and the sports technology

industry can, in entrepreneurial terms, increase the 'value proposition' of technology innovation thereby fostering innovation and promoting the diffusion of new ideas.

Further, the model provides sports organizations and technology partners with a tool to explore opportunities for innovation leading to product design, strategically plan directions for technology use, and ensure that technology resources allocations are appropriate. Therefore, innovation should be appropriate for the unique context of the adopting organization, and stakeholders play an important role in considering the various contexts for technology innovation in elite sport. The model can also provide sport with an opportunity to foresee and manage emerging cultural shifts in the use of technology. Therefore, researcher engagement is crucial in the cycle of innovation implementation and review. Researchers require detailed feedback - such as the validity and accuracy of data in context - to ensure that technology innovations remain current and usable.

Overall, the primary premise of the developed model is the development of new technologies to address areas of need. Yet, implementation effectiveness (the quality and consistency of targeted organizational members' use of an adopted innovation) is a function of (a) an organization's climate for the implementation of a given innovation and (b) targeted organizational members' perceptions of the fit of the innovation to their values and requirements. Therefore, innovation adoption will entail (1) careful consideration of the resources needed to address the needs of the sport (e.g., size, portability, validity, cost, the achievement of outputs and outcomes), (2) evaluation of the technology in terms of its efficiency (e.g., the ratio of inputs to outputs, or how much of a contribution to performance it provides in relation to cost), and (3) assessment of the effectiveness of the innovation (the achievement of outcomes as the result of utilizing the technology). The model has been successfully

applied to individual sports (Ride et. al, 2013) and can be applied to other settings (beyond a technology focus).

5. CONCLUSION

The role of technology in the development, training and competitive success of athletes in amateur and professional sports has accelerated in recent years. Many regard technology as a key difference between being competitive and being on the podium. This paper has drawn on numerous examples of technology as an enabler in sport. It also signifies the important of identifying key stakeholders and contexts to facilitate innovation. By drawing on the well understood practice of needs assessment a model has been developed that can help organizations and those interested in innovation to approach innovation in a structured, recipe-driven way. This bottom up approach complements the *ad hoc* practices of translational innovation between sports.

As a prescriptive approach, the model allows the harnessing of the innovative capacity, expertise and drive of all key stakeholders in sport to identify innovation opportunities. It moves away from the development of technologies “in search of a home” and helps to capture current trends organizationally, develop new directions and manage risk in what can be a costly and high-risk endeavor. When combined with the accepted practices of risk analysis and the methodologies of innovation (including agile development methodologies) the model can provide organizations with a near to mid-term implementation strategy for technology innovation in sport. The developed model provides a robust method for organizations or key stakeholders within them to approach technology innovation in a structured way alongside existing initiatives or as a new activity. Using this model it is possible to harness existing knowledge and

social capital within the existing resources to discover and prioritize innovation opportunities as an aid to future performance enhancement in sport or commercial success.

Overall, technology development should be an enabler of sport rather than a goal in itself. The developed approach can help sport organisations identify needs and opportunities for innovation through technology advances, and allow organizations to better align their resources to gain competitive advantage. It draws upon existing theories and methods of innovation and needs assessment, and considers various contexts (including operations and planning, training, and competition) and stakeholders (including athletes, coaches and support staff) that drive the need for technology innovation in elite sport. Future applications of the model can target the sub-elite and recreational sport levels. A critical analysis of pathways for technology development at these levels can facilitate commercial outcomes. This will require expansion of the stakeholder group and consideration of the readiness or capacity of sport to use technology fundamental to facilitating participation.

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TOC: A structured approach for technology innovation in sport encompassing needs assessment, stakeholder theory and contextual analysis to approach innovation in a programmed way

Table 1. Determinants of innovation

| Determinants of innovation and examples | | Literature |
|--|--|--|
| Environmental | Generally include cultural, societal, political, and geographical factors. Prominent environmental factors to influence product and process innovations include competition in the marketplace, market growth, legislative changes, and technological advances | Damanpour, 1991; Damanpour & Schneider, 2006; King, 1990; Wejnert, 2002; Wolfe, 1994. |
| Organizational | Resources, operations, structural variables, and culture of the organization. For instance, a performance gap as a result of internal inefficiency (e.g., human resource capabilities) may stimulate the adoption of a new strategy or structure. | Damanpour, 1991; Garcia & Calantone, 2002; Subramanian & Nilakanta, 1996; Wolfe, 1994. |
| Managerial or individual | Internal organizational dynamics; for example, the characteristics of individuals in decision making roles can influence innovation stages. Managers are largely responsible for the cultural values that prevail in support of innovation (and attitudes towards change) within the organization. | Damanpour, 1991; Damanpour & Schneider, 2006; King, 1990; Wejnert, 2002; Wolfe, 1994. |

Table 2. Stakeholders in the Needs Assessment Process

| Stakeholder group | Description |
|----------------------------|---|
| Athlete | The actual competitor, requiring knowledge of how to improve their technique and any performance metrics that can make them aware of their circumstances and hopefully motivate them. |
| Coach | The person required to keep the athlete on track, motivate them, push them to work harder and analyze overall performance and wellbeing. |
| Sport Administrators | The organizational managers and leaders that can instil cultures of innovation and provide the required resources and support to gain competitive advantage. Often supporting a highly mobile workforce there are numerous logistical challenges. |
| High Performance Directors | High performance directors are the glue, providing strategic vision and facilitating an environment that leads to high performance. This role requires access to information about all aspects of the sport |
| Sport Science | Scientists are tasked with understanding intricacies of technique and advising the coach of particular training techniques that should be of use. |
| Sport Medicine | These personnel work in preventative, performance enhancing and rehabilitation roles. Access to information for best practice and long term athlete needs and ways to provide support outside the clinic environment are important aspects. |
| Research & Development | Interested in finding new information that can be validated in a peer-reviewed demonstrable capacity and further developed. |
| Commercial partners | Looking for the ‘value proposition’ possibly through mass market appeal. |

Table 3: Need Assessment: Performance Contexts

| Performance contexts | Examples |
|-----------------------------|---|
| Talent identification | <ul style="list-style-type: none"> • warm-up and recovery • testing and monitoring |
| Training | <ul style="list-style-type: none"> • warm-up and recovery • testing, monitoring, and refining performance |
| Competition | <ul style="list-style-type: none"> • pre-competition preparation • performance analysis and monitoring • recovery and rehabilitation |
| Process and operations | <ul style="list-style-type: none"> • preparation activities (e.g., scheduling, booking, basic workflow) • pre-training and pre-competition workflow • in-training and in-competition workflow • post-training and post-competition workflow • travel (domestic or international) • inter-athlete considerations • time-frame and schedules |

Table 4. Need Assessment: Situational Contexts

| Situational contexts | Examples |
|---|---|
| Sport specific training and competition environment | <ul style="list-style-type: none"> • location (air, water, land) • equipment and facilities • body functions and movements • team or individual sport • aerobic or anaerobic sport |
| Non-sport specific training environment | <ul style="list-style-type: none"> • dry land • laboratory • gymnasium |
| Time frame | <ul style="list-style-type: none"> • intra-session (e.g., lap, trial) • end of session • end of season • multiple seasons |
| Process and operations | <ul style="list-style-type: none"> • preparation activities (e.g., scheduling, booking, basic workflow) • pre-training and pre-competition workflow • in-training and in-competition workflow • post-training and post-competition workflow • travel (domestic or international) • inter-athlete considerations |

Table 5. Model Results: Frequency Coding by General Dimension and Higher Order Themes for Innovation Priorities among Stakeholders Groups

| General Dimension | Higher Order Themes | Raw data | Scoring by Frequency Coding (all) | Scoring by Frequency Coding (coaches) | Scoring by Frequency Coding (support staff) | Scoring by Frequency Coding (admin.) |
|--------------------------|--|---|--|--|--|---|
| Needs and Wants | aspirations for technology innovations in the training environment | innovation director or leader | 3 | 0 | 2 | 1 |
| | | streamlined data management processes | 6 | 0 | 5 | 1 |
| | | optimised communication systems (ICT) / information sharing | 7 | 4 | 2 | 1 |
| | | athlete management | 9 | 5 | 2 | 2 |
| | | dedicated or centralised service team to support daily training environment | 9 | 4 | 5 | 0 |
| | | injury management and prevention | 6 | 4 | 0 | 2 |

Table 6: Uses of Current Technology and Technology Based Innovation

Opportunities

| |
|--|
| Current Technology |
| <ul style="list-style-type: none"> • Video (Sportscode, youtube, record pro/visual coach pro, phone apps, delayed feedback) • Sensors (motion, force, distance, velocity, feedback of information) • Internet communications (skype, email on the go, calendaring, file sharing) • Athlete tracking (injury, workload) |
| Technology Based Innovation Opportunities |
| <ul style="list-style-type: none"> • Video tools • Athlete databases for injury and workload • Specific sensor applications • Web 2.0 (social media) • Integrated systems for file sharing, avoiding duplication of data entry • Adoption and further development of convergence technologies (eg smart phone) |

Table 7. Organisation-wide innovation strategy outline for deployment of new technologies.

| Examples of organisation-wide innovation strategies for deployment of new technologies |
|---|
| <ul style="list-style-type: none">• provide a focused organisational approach for fostering innovation• identify and dedicate resources needed to encourage innovation• assess opportunities for development and/or adoption of new technologies on the basis of their potential to contribute to overall innovation, their cost relative to their expected benefits, and the availability of resources needed to ensure their effectiveness. |

Figure Captions

Figure 1: Innovation Stages

Figure 2: Model for Technology Innovation in Sport