Institution: Sheffield Hallam University

Unit of Assessment: 26 Sport and Exercise Sciences, Leisure and Tourism

Title of case study: Public Engagement in Sports Science and Engineering Research

1. Summary of the impact

The Centre for Sports Engineering Research (CSER) has carried out public engagement activities for many years to create a dialogue around its research with those outside higher education. Specific research is described in tennis, aerodynamics, 3D motion-capture and performance analysis and ways in which findings have been used in public engagement. The impact of the activities is a raised public awareness of sports science and technology from 165 public lectures and workshops; an interactive science exhibition with 390k visitors; an increasingly popular blog with 248k hits; 15 popular science articles with a readership of over 835k; 10 interviews on TV and 46 on Radio; 8 short films with 25k downloads; and 101 articles in the national and international print press with 256 additional articles on their websites across 22 countries.

2. Underpinning research

Various aspects of research in CSER have been used to inform public engagement of which four have proved especially important:

Tennis research. Haake and Goodwill carried out industrially sponsored research (grant a) to develop a dynamic model of a tennis shot using finite element analysis (reference 1). The model had a frame, interlocking strings and a ball with a 2-shell structure and internal air bag. The model was validated experimentally using a bespoke impact test rig to look at effects such as friction on ball impact with the racket or the court (reference 2). The work showed that impacts with the court were directly affected by the friction coefficient, while those with the racket depended both on the coefficient and the complex movement of the strings. Choppin *et al* (reference 3) used photogrammetric techniques to look at the spin, speed and angle of the racket and ball during play and showed that most players sought to hit the node point of the racket where vibrations would not be imparted to the racket.

Aerodynamics research: Haake, Goodwill and Carré (reference 3*)* created a new measure of roughness to predict the aerodynamic performance of sports balls. This sought to create a simple non-dimensional parameter to characterise the different features of sports balls with nap (i.e. tennis), dimples (golf), or leather (football). The researchers found that the statistical measure of skewness of a surface was able to characterise the drag coefficient with the Reynolds number (airflow speed), giving a simple method for sports ball analysis.

3D Motion Capture. Methods to measure motion of a tennis ball were developed for laboratory, (reference 1), and for real, environments (reference 4), which supported the development of systems for UK Sport (grant b). This research showed that capture of useful 2D and 3D information in ecologically valid environments relied on a robust and practical camera calibration system, for which the planar calibration system was developed.

Performance improvement analysis. Haake, James and Foster (references 5 and 6) studied the statistics of performance since the early 1900s to determine the impact of technology on sporting performance in Olympic sports. A new measure was created called the Performance Improvement Index, based on energy expenditure, as a way of comparing performances across different disciplines. It was found that 4% of the sprint was attributed to technology, while in sports such as pole vault or javelin, technology affected sport by around 30%. The 1-hour cycling record improved by around 100% with the introduction of new bicycles. The research was expanded and deepened for use in public engagement through an EPSRC Senior Media Fellowship (grant c) and a Royal Academy of Engineering Public Engagement Fellowship (grant d).

All staff cited above, except Carré, were employed by Sheffield Hallam University as follows:

- Allen T, Senior Sports Engineer, 1/6/09-1/9/11; Senior Lecturer 1/9/11 onwards;
- Choppin, S, Sports Engineer, 1/6/09 onwards;
- Foster, L, Sports Engineer, 2/4/11 onwards;

- Goodwill, SR, Senior Sports Engineer, 1/3/06 onwards;
- Haake SJ, Professor of Sports Engineering, 1/3/06 onwards;
- James DM, Senior Lecturer, 1/3/06 onwards.
- Carré, M, Lecturer, Sheffield University, 1/3/06 onwards. Carré was cited on this reference 3 due to his football-related research. The main author of the work was Prof Haake.

3. References to the research

All outputs were published in peer-reviewed journals and are included in the REF submission.

1. **Allen T, Haake SJ & Goodwill SR** (2010). Comparison of a finite element model of a tennis racket to experimental data. *Sports Engineering*, 12(2), 87-98. Scopus SJR 0.283. Cited 9 times. (Goodwill REF output 3);
2. **Allen T, Haake SJ & Goodwill SR** (2010) "Effect of friction on tennis ball impacts", *Proceedings of the Institution of Mechanical Engineers, Part P: Journal of Sports Engineering and Technology,* 224(3), 224-236. Scopus SJR 0.274 - 0.616. Cited 6 times. (Goodwill REF output 4);
3. **Haake, SJ, Goodwill, SR and Carré MJ** (2007) "A new measure of roughness for characterising the aerodynamics of sports balls", Proceedings of the IMechE, Part C: Journal of Mechanical Engineering Science, 221(7), 789-806. (Haake RAE output 2)
4. **Choppin, S.B., Goodwill, S.R. & Haake, S.J**. (2011) "Impact characteristics of the ball and racket during play at the Wimbledon qualifying tournament", *Sports Engineering,*13 (4), pp. 163-170. Scopus SJR 0.283. Cited 7 times. (Goodwill REF output 1);
5. **Haake SJ** (2009) The impact of technology on sporting performance in Olympic sports, *Journal of Sports Sciences*, 27(13), 1421-1431. Scopus SJR 0.909. Cited 11 times. (Haake REF output 2);
6. **Haake, S.J., James D.J. and Foster**, L, (2013) "An improvement index to quantify the evolution of performance in running", *Journal of Sports Sciences*, 2013, Online first. Scopus SJR 0.909. (Foster REF output 1).

Grants associated with the impact

a) SJ Haake: Prince Racquets, £30,000, 1st Jun 2006 to 31st May 3009;

b) SJ Haake: UK Sport, £209,181, 1st Apr 2008 to 31st Mar 2012, UK Sport Innovation Partnership;

c) SJ Haake: EPSRC, £168,500, 1st June 2010 to 31st May 2013, Senior Media Fellowship;

d) DM James: Royal Academy of Engineering, £30,000, 1/5/2009 to 31/5/2011, Public Engagement Fellowship.

4. Details of the impact

The impact of CSER's public engagement is an increased awareness by the public of sports science and engineering research. Wherever possible, examples of impact below use metrics to show public engagement and evaluation statistics to describe the public dialogue.

Lectures

Staff within the CSER have been invited to give 21 keynotes and seminars to peers at non-academic meetings (e.g. IMechE, Royal Society, Royal Academy of Engineering) to disseminate their research with 70% of events in the UK, the rest across seven countries. In addition, they have delivered 144 public lectures with 88% in the UK and the remainder across 9 countries including the US, Germany, Australasia, Japan and Israel. Examples of lectures are given below.

Research Councils UK (RCUK) and Royal Institution lectures: Cutting Edge 2012 As an example of a key public engagement project, Haake (as an EPSRC Senior Media Fellow, grant c) and James (as a Royal Academy of Engineering Public Engagement Fellow, grant d) were commissioned in 2012 by Research Councils UK and the Royal Institution to develop a series of six public lectures around the country on the theme 'sport and research', focussing on six different

sports (basketball, athletics, diving, sailing, triathlon, and cycling). Research expertise in aerodynamics and mechanics (references 1, 3, 5), contextual knowledge (reference 6) and an ability to create innovative public engagement events were used to develop presentations for each sport with expert practitioners.

Following the debate at each event, an electronic system was used to ask a set of questions and collect answers from audience members (source 1). The total audience was 560 and analysis of the answers showed the following: 61% were male and the age range was normally distributed around a mode of 31-45 years. Almost all (89% to 98%) thought that science was beneficial to sport and only around 13% thought that the use of technology was the same as doping (with drugs). Around two thirds agreed with the general statement that "as well as natural talent, sport should be a test of how an athlete can exploit technology".

This was the only RCUK Olympic activity in 2012 (source 2) and the RCUK evaluation report (Cutting Edge 2012: The Research behind Sport Evaluation Report, v 3.0) showed that 100% of the audience (who filled in a questionnaire) enjoyed the events. Only 2% of respondents were unable to understand the scientific content of the events, while 85% found the speakers 'clear and easy to understand', 'interesting and engaging' and 'thought provoking. An analysis of media coverage by RCUK showed circulation and listening figures for local radio of 524k.

Haake SJ, "Boots and balls, the science behind the World Cup", The Royal Institution, London (6/6/2010). This drew on finite element analysis (reference 1), shoe-surface interactions (reference 4), and motion capture (reference 5). Evaluation forms from the family audience of 150 (modal age 26-35) all agreed, or strongly agreed, that they had learnt something new, while 73% agreed, or strongly agreed, that they wanted to find out more about research behind sport.

Exhibitions

In 2011, 'Sports Lab' opened at the Weston Park Museum in Sheffield, an interactive exhibition designed and partly built by CSER, funded through an £82,000 'Partnerships for Public Engagement' grant from the EPSRC. CSER's expertise on tennis (references 1, 2, 4), aerodynamics (reference 3, 5) and sports performance (references 5, 6) were used to design an exhibition on the historical impact of technology in sport. The exhibition attracted 140,000 visitors between 1/2/11 and 30/9/11. Monitoring data using a digital 'kiosk' (n>1,000 respondents) indicated good or excellent ratings as follows: quality 87%; interpretation panels 82%; layout 86%; and enjoyment 85% (source 3).

As a continuation of the project, the exhibition subsequently moved to the V&A Museum of Childhood in Bethnal Green and re-branded as 'Beautiful Games', attracting 250,000 visitors between 1/4/2012 and 31/8/2012 (source 4). The exhibition was shortlisted for the Podium Awards in London, 3rd May 2012.

Online articles to engage the public with research

An online blog has been created by CSER (www.engineeringsport.co.uk), designed to engage researchers and the general public in its research. Between 1/9/2009 and 31/7/2013 the blog had 248k hits, with average daily hits of 14 in 2009, 74 in 2010, 145 in 2011, 322 in 2012 and 252 to 31/7/2013. Typical topics relating to the research described here (author; reference; hits) are:

- How far could Usain Bolt jump? (Foster: 6; 29,732);
- The problem with the Wimbledon roof (Haake: 1, 2, 3, 4; 2,722)
- Physics of the groundstroke in tennis (Allen; 1 and 2; 1,247);

348 comments have been posted by readers with most on the use of the Kinect for motion capture in biomechanics. Readership spans 185 countries with the largest coming from English speaking countries such as USA (29%), UK (25%), Australia and New Zealand (11%), and Canada (4%).

Print media

Staff in CSER have been commissioned to write 15 popular science articles in publications such as the New Scientist, Professional Engineering, Physics World and Ingenia. They are also regularly consulted by national and international media with 101 pieces in national press such as the Times, Independent, Guardian and the Mail. This led to 256 articles on press websites across 22 countries (61% UK; 6% Americas; 5% EU; 4% Australasia; 3% SE Asia; 2% Africa). Two key examples of commissioned articles together with their reach and significance are outlined below.

Haake SJ, Instant Expert 24, New Scientist, 7 July 2012, 215(2872), pp 8. This was commissioned by New Scientist for the Olympics and included research around sports engineering, 3D motion capture (references 4, 5) and the analytics of performance improvement (reference 6). The aim of the Instant Expert was to introduce sports engineering. This approach is very popular with schools and colleges and contributed to an increase in sales. The issue had 131k+ print copies worldwide (UK & Ireland, 58%; Australasia, 17%; USA/Canada, 16%; others, 9%) with an estimated readership of 800k. In terms of impact on the readership, the Sports Engineering Instant Expert is in the top 10 of all (New Scientist) instant experts read online. Additionally, the features editor said of the article, *"To put this in to perspective, that's 5 per cent more than average sales for 2012 and 15 per cent up on the same week last year"* (source 5).

Haake SJ, Material Advantage, Physics World, 7 July 2012, 25(7), 26-30. This was commissioned by Physics World as part of a special issue for the Olympics and used the performance index developed in reference 6 to quantify the impact of technology on sporting performance. The issue had 35k print copies and 225k unique visitors to the website during that month with both national and international coverage (82% UK; 8% EU; USA 5% USA; 9% other). The article had 5.5k downloads by 31/7/2013.

Broadcast media: Live and recorded interviews

During the REF period, CSER staff were invited to give 10 live and recorded interviews on national TV including BBC's Newsnight (26/7/2012; 30/7/2012), Channel 4 News (16/7/2012), Sky News (13/7/2013), BBC Breakfast (19/6/2012), BBC News (5/8/2012), and BBC World (4/8/2012; 5/8/2012). There were also 46 live and recorded interviews on national and regional radio, including BBC Radio 4 Today Programme (6/9/2012), BBC Radio 4 World at One (2/8/2012), Radio 5 live (3/6/2010; 26/8/2011; 23/3/2012; 25/5/2012). There were also interviews on intentional radio in Ireland (RTE1 1/7/2009, 29/7/2009), Australia (ABC 17/12/2011), USA (Madelaine Brand Show 5/7/2012) and Germany (Deutschlandfnk, 27/7/2012). A 30 minute programme for BBC Radio 4 was co-developed by Professor Haake with the BBC Science Unit and drew upon his work on technology and sport for the Olympics (reference 6). It was hosted by Jonathan Edwards on 18/7/2012 and was the only sports and technology programme on the BBC (TV or Radio) during the Olympic Games. It obtained a national audience of around 123k+.

Films

The Physics World articles (see above) were linked to 3 films using CSER research on 3D motion capture (references 4, 5) and aerodynamics, with 4k+ downloads and views of the films by 31/7/2013. The Royal Institution created a 5-film collection on Engineering Sport http://richannel.org/. This was a co-production between Prof Haake and the RI, part funded by the EPSRC (grant d). It used all aspects of CSER's activities to explain the research behind sport with key stories on tennis dynamics (references 1, 2), motion capture (reference 5) and analytics (reference 6). The videos had 21k downloads by 31/7/2013.

5. Sources to corroborate the impact (indicative maximum of 10 references)

Verification of impact data

1. Senior Manager, The Royal Institution.
2. Senior Officer, Research Councils UK.
3. Senior Manager, Museums Sheffield.
4. Senior Manager, V&A Museum of Childhood.
5. Senior Editor, the New Scientist.