

Institution: Manchester Metropolitan University		
Unit of Assessment: A3 Allied Health Professions, Dentistry, Nursing and Pharmacy		
Title of case study: Spreading the word: Multidisciplinary research drives public engagement with microbiology and physiology worldwide		
Period when the underpinning research was undertaken: 2005 - 2019		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Joanna Verran James Redfern	Professor Research Associate, Lecturer	1980 – 2018 (retired) 2014 – present
Period when the claimed impact occurred: 1 August 2013 – 31 December 2020		
Is this case study continued from a case study submitted in 2014? No		
<p>1. Summary of the impact</p> <p>A broad portfolio of multidisciplinary research has given direct impetus to three charities/learned societies to prioritise education and public engagement about microbiology in their multi-year strategic plans. The Microbiology Society (MS) distributed co-produced microbiology teaching resources, used in up to 5.5% of UK secondary schools. It also ran Antibiotics Unearthed, a flagship, national citizen science programme to find new antibiotics. The Physiological Society (PhySoc) and the Federation of European Microbiology Societies (FEMS) added education and public engagement as strategic priorities with emphasis on spreading evidence-based best practice to approximately 34,000 researchers, educators, students, public outreach staff and industry professionals. PhySoc quadrupled its maximum funding for outreach projects, and FEMS funded a novel Twitter microbiology massive open online course (MOOC) that reached 3,000,000 unique users worldwide. In 2019, Prof. Joanna Verran received the American Association for the Advancement of Science Public Engagement with Science Award for “devising and delivering innovative microbiology-focused public engagement with the same rigor as laboratory-based research.”</p>		
<p>2. Underpinning research</p> <p>Verran has led applied laboratory microbiology research at Manchester Metropolitan University for more than 20 years, researching the biodynamics of bacteria-surface interactions and biofilms. She has investigated how features of the inert substratum, including its topography and cleanability, may facilitate or impede microorganism adhesion, retention or growth, thus impacting on surface contamination and microbial transmission. During this period, she has authored well over 200 peer-reviewed journal papers on experimental data, which have collectively accumulated over 3,500 citations. Major breakthroughs include pioneering work on the use of the atomic force microscope to measure the attachment of bacteria to surfaces [1].</p> <p>Reflecting on key themes from this research, Verran increasingly realised that non-scientists also needed to appreciate and understand the science of surface hygiene, fomites and human behaviour in disease transmission; effective infection control depends on everyone's engagement and participation. For the past 15 years she has, therefore, conducted parallel, pioneering and multidisciplinary research on how to address microbiology literacy among non-scientists, using rigorous hypothesis-led methods. This body of work is described in at least 16 peer-reviewed papers and seven book chapters; uniquely, the research is published largely in microbiology peer-reviewed publications (rather than journals for education or general public engagement) in order to share evidence-based practice across the microbiology community.</p> <p>A collaboration with the MS to develop new educational resources stands out within this body of work [G1]. This was the first time that the MS had worked with external stakeholders to ensure that it developed resources for schools, using rigorous co-production methodologies. A teacher survey revealed for the first time fundamental misunderstandings of how microbiology could be taught through practical classes in schools. The findings showed that teachers lacked confidence in microbiological techniques and needed help to deliver focused laboratory exercises, linked directly to the school curriculum. The survey highlighted teacher concerns around safety, expertise and cost [2]. A subsequent analysis of school curricula revealed significant opportunities for inclusion of microbiology in the classroom from Key Stage 3 through to post-16 education (A-Level). Redfern, Verran and MS staff (Darial Burdass) co-produced topic-focused resources through iterative two-way dialogue with teachers, school technical staff</p>		

and professionals supporting school science education [3]. The cross-disciplinary project encompassed education, teacher education, science education and philosophy.

This project spearheaded further interdisciplinary research. The EPSRC-funded NanoInfoBio project [G2] spawned MoMiMa (Monsters, Microbiology and Maths). Microbiologists, science communicators and computer scientists collaborated to create the SimZombie software to help simulate and visualise the spread and control of infectious disease (and zombies) under different conditions [4]. The researchers used the software to stimulate in-depth discussion with diverse audiences – at science festivals, in schools and to 500 adults as part of the award-winning, immersive theatre experience *Deadinburgh* at the Edinburgh Festival in 2013 – on the principles of disease transmission and parameters and measures for outbreak control. Formative evaluation methodologies revealed that it was particularly important to focus on the scientific aspects of the learning activities to avoid distraction from the ‘monsters’ element of the simulation, which proved versatile in a variety of activity scenarios.

SimZombie led to Simfection [G3], which models how disease would spread through vaccinated and unvaccinated populations, using examples of diseases caused by viruses. One study compared teenager attitudes towards vaccination before and after engaging with Simfection, a non-digital intervention, or no intervention; the work revealed that attitudinal change is a complex phenomenon not typically altered by any single intervention [5].

Verran collaborated with English literature researcher, Xavier Reyes. Using mixed methodologies they studied how reading groups provided a ‘safe space’ for scientists and the public to come together to explore the mechanisms of infection, epidemiology and disease control by regularly reading fiction about infectious disease [6].

A distinctive feature of the Manchester Metropolitan team is its original, structured approach to engagement and education, incorporating social science techniques alongside the quantitative analyses more familiar to microbiologists. For example, the group’s studies extended to a careful consideration of venue and evaluation, highlighting how the ‘message’ of a public engagement event and any evaluation methods should resonate with, and be contextualised within, the surroundings. They also advocated the benefits of developing activities (and embedded evaluation) using a hypothesis-driven framework.

Verran played a key role in the institution’s involvement in the GBP1,200,000 Manchester Beacon for Public Engagement initiative funded by RCUK, the Wellcome Trust and HEFCE. The project’s findings and methods contributed to emergent national discourse to change culture, develop and disseminate best practice in public engagement under the aegis of the RCUK/Wellcome Trust-funded National Coordinating Centre for Public Engagement (NCCPE). Verran was showcased as a ‘change champion’ for public engagement in the final report. The outstanding quality of her research and leadership in this field is also evidenced by numerous awards and prizes, most recently the 2019 American Academy for the Advancement of Science’s Mani L Bhaumik award for Public Engagement with Science.

3. References to the research

1. Boyd RD, **Verran, J**, Jones, MV, Bhakoo, M (2002). Use of the atomic force microscope to determine the effect of substratum surface topography on bacterial adhesion. *Langmuir*. 18(6): 2343-2346. DOI: 10.1021/la011142p *Citations: Web of Science 103 (expected 58.06)*
2. **Redfern J**, Burdass D, **Verran J** (2013). Practical microbiology in schools: a survey of UK teachers. *Trends in Microbiol.* 21(11):557-559. DOI: 10.1016/j.tim.2013.09.002.
3. **Redfern J**, Burdass D, **Verran J** (2015). Developing microbiological learning materials for schools: best practice. *FEMS Microbiol. Lett.* 362(6):fnv020. DOI: 10.1093/femsle/fnv020.
4. **Verran J**, Crossley M, Carolan K, Jacobs N, Amos M (2014). Monsters, microbiology and mathematics: the epidemiology of a zombie apocalypse. *J. Biol. Educ.* 48(2):98-104. DOI: 10.1080/00219266.2013.849283. *Citations: Web of Science 9 (expected 7)*
5. Carolan J, **Verran J**, Crossley M, **Redfern J**, Whitton N, Amos M (2019). Impact of educational interventions on adolescent attitudes and knowledge regarding vaccination: A pilot study. *PLoS ONE* 13(1):e0190984. DOI: 10.1371/journal.pone.0190984. *Citations: Web of Science 5 (expected 5)*
6. **Verran J**, Reyes X (2018). Emerging Infectious Literatures and the Zombie Condition. *Emerg. Infect. Dis.* 24(9):1774-1778. DOI: 10.3201/eid2409.170658

Funding

Since 2000, Verran has secured more than GBP1,000,000 as PI for laboratory-based microbiology research projects from the European Commission (Sixth Framework Programme), EPSRC, Wellcome Trust and industry.

Verran has also received funding for her public engagement and education research, often awarded in response to competitive calls. Individually these tend to be small awards, but together have totalled more than GBP100,000 since 2013. Awards associated with the research described in Section 2 include:

G1. Development and evaluation of innovative microbiological laboratory practical activities for secondary schools. 2010-2013. Microbiology Society GBP60,000. PI: Verran.

G2. NanoInfoBio. 2009-11. EPSRC (Bridging the Gaps 3-year programme. Ref: EP/H000291/1). Total award: GBP289,095. PI: Professor Martin Amos (Computing).

G3. SimFection. 2014-2017. Society for Applied Microbiology. GBP:9,000. PI: Verran

Additional indicators of quality

- According to Altmetrics, reference [3] is in the 99th percentile for more than 16,500,000 research outputs tracked (Attention score: 167). It is ranked #3 of 222 outputs from *J. Biol. Educ.* [<https://www.altmetric.com/details/1870095>, accessed 30 Dec 2020].
- According to Altmetrics, reference [4] is in the 97th percentile for more than 15,000,000 research outputs tracked. Its attention score is 50. [<https://www.altmetric.com/details/31960845>, accessed 30 Dec 2020]
- Verran has received the Microbiology Society award for Innovation in Microbiology Education (Peter Wildy Prize, 2005); the Society for Applied Microbiology Communications Award (2011); National Teaching Fellow (2011); and the American Association for the Advancement of Science Award for Public Engagement with Science (2019).
- James Redfern received the Microbiology Society Outreach Prize in 2013 in recognition for his contribution to the microbiological support materials for schools and outreach activities.

4. Details of the impact

Changing culture, building capacity: making public engagement a mission priority

The research has sparked a cultural shift in three charities/learned societies. The Microbiology Society (MS), the Physiology Society (PhySoc) and the Federation of European Microbiology Societies (FEMS) have all embedded public engagement and education as mission priorities in their multi-year strategic plans.

The MS-funded schools resources project demonstrated the value of co-production methodologies to generate useful outputs validated by users. It also provided MS with evidence to justify investment into a major strategic public engagement programme (alongside more typical, ad hoc, small grants). The collaboration with Manchester Metropolitan helped MS add rigour to its public engagement, especially around hypothesis-led design for measurable outcomes and evaluation.

Based on this learning, MS designed and funded a single, flagship, four-year national programme about antimicrobial resistance and discovery to prevent dilution of key messages [A]. *Antibiotics Unearthed* – the Society's first ever citizen science project – launched in 2015; undergraduates from 18 universities and students from 17 schools took part [A]. Deputy CEO at MS during the project (and co-author for references [1-2]), remarks: "*Antibiotics Unearthed gave the general public, students and educators throughout the UK and Ireland a unique opportunity to work with scientists as part of a global initiative to discover new antibiotics from soil bacteria... By taking part in real research, they experienced what it would be like to follow a scientific career and hopefully think about a future career in science*" [A]. One A-Level biology teacher said participation "*proved to be pedagogically beneficial on numerous levels, such as complementing and challenging the students' understanding of their curriculum content, strengthening scientific literacy skills and encouraging authentic inquiry-based science. The teacher in me was inspired by the educational value of the project and the impact it had on the students*" [A].

Pop-up events also gave hundreds of non-scientists an opportunity to submit soil samples (including one from the Prime Minister's garden) and track their analysis online. Fifteen "talented bacterial strains" that kill targets, including antibiotic-resistant bacteria, are currently undergoing further characterisation that may identify new antibiotic compounds [B].

In 2016, the Deputy CEO of MS became Chief Executive of PhySoc (4,000 members) [A]. She immediately spearheaded work to increase PhySoc's focus on public engagement "*directly informed by [her] experiences of working with Professor Verran and the subsequent Antibiotics*

Unearthed projects” [A]. The new Engagement strand is outlined in PhySoc’s Strategy 2018-2022: ‘Engage for success – improving our two-way commitment and communication to increase recognition of the importance of physiology’ [A]. The Chief Executive states: “This is the first time that engagement has been explicitly embedded into our strategic framework, delivery plans and KPIs. In particular, I was keen that funded projects were carefully planned to enable good evaluation as highlighted through Professor Verran’s research. I also wanted to encourage cross-disciplinary activities, for example with art. These themes were directly inspired by my experience in collaborating with Prof Verran” [A].

Implementing this strategy, in 2019 PhySoc increased its maximum grant for outreach from GBP5,000 to GBP20,000, with new emphasis on citizen science, evaluation and iterative improvement from small pilots to large-scale events [C]. PhySoc has also embarked on a new collaboration with the Vagina Museum (delayed due to Covid19) to reach the 16-25 year-old target audience through an art exhibition that *“gives people who think science is not for them, a way in” [A]. The collaboration has used outputs from Verran to assist the project’s development [A].*

Verran’s research and advocacy also transformed culture at FEMS, which supports 30,000 researchers, educators, students, public outreach experts and industry professionals in 41 countries [D]. According to FEMS’ MD: *“Jo’s enthusiasm and passion for research-informed teaching and use of evidence-based teaching and engagement methods in her practice, were compelling and convinced FEMS that this was an important element of being a microbiologist...We were keen to leverage her research to raise awareness of the importance of public engagement and see that her best practice was adopted by members and embedded into training and professional development activity. As a champion for research-informed education and public engagement, Jo has spearheaded the promotion of education and public outreach as a priority across the activities of FEMS, through our 2015-2020 strategic framework” [D]. The appointment of a new FEMS Director and Trustee for Education and Public Engagement demonstrates the strategic importance and board-level accountability for the activity [D].*

Significant impacts arising from the implementation of this strategy include: growth in the readership of the Professional Development section of FEMS Letters; rising attendance at education sessions at the FEMS biennial congress (70 delegates in 2013; 300 in 2019) and growing engagement in International Microorganism Day (4,000 social media posts in 2019 versus 1,400 in 2018; 2,200 people involved in 2019 versus 858 in 2018; 35,000 minutes livestream viewed and 11,000,000 impressions for #InternationalMicroorganismDay in 2020) [D]. FEMS also funded and facilitated the world’s first, open microbiology course via Twitter (#EUROmicroMOOC), which reached 3,000,000 unique users (47,000,000 impressions) [E].

Verran’s involvement in the Manchester Beacon provided early research evidence that fuelled discourse and contributed to subsequent training and dissemination of best practice in public engagement driven by NCCPE. The Beacon’s projects underpinned continuous RCUK/UKRI-funded follow-up work, including Catalysts for Public Engagement with Research (2012-15), Catalyst Seed Fund (2015-18) and SEE-PER (2017-19) projects to embed a culture for public engagement with research [F]. This body of work has contributed to the learning, best practice and culture change championed by NCCPE, as well as its training and networking of hundreds of public engagement professionals, freelancers and museum/science centre staff through the Engage Conference, PEPNet and the Engage Researchers’ Academy [F].

Leading by example: impacts from evidence-based engagement activity

Verran’s own engagement activities have also delivered impacts. The MS school resources were distributed to 750 secondary schools in 2012/13. A 12-month follow-up survey showed that 48.9% of respondents had used the resources, suggesting use in up to 366 schools (5.53% of 6,617 UK secondary schools in 2013/14) [G]. Teachers remarked that the resources facilitated practical-based education at Key Stage 3, GCSE and post-16, but also supported informal learning in science clubs, exhibitions and open days, thus reaching alternative audiences beyond the school setting [G].

Since August 2013, Verran and colleagues have delivered almost 100 events with a total footfall above 6,500 people and direct engagement with approximately 3,500 participants (face-to-face and through online platforms). These have included activities (sometimes using SimZombie/Simfection) reaching a range of different interest groups at renowned events including Manchester Science Festival, Bradford Literature Festival, Cheltenham Festivals,

Orkney International Science Festival, Manchester International Festival and the Manchester Children's Book Festival (which attracts families from deprived areas). Four years before Covid19, Verran was already challenging people to think about infection control; her article *How to stop a zombie apocalypse – with science*, reached over 133,000 readers in nine countries [H].

Most events, however, were deliberately designed to allow small, adult audiences to engage deeply with scientists – without the distractions of children! At one event in an air raid shelter, evaluation revealed a shift from passive to epistemic engagement and curiosity. Adults with diverse motivations for attending were enthralled by storytelling and swabbing activities [H,I]. Evaluation of an event about superbugs staged in a courtroom indicated participants felt the topic was relevant and they had learned something new [H].

Verran's research (reference [6]) revealed how the intimate environment of the Bad Bugs Book Club (BBBC) allowed participants to explore research around infection and transmission. In a feedback survey, attendees indicated changes in attitudes and learning, for example: "*It's been a **real insight** into the world of microbiology.*" Others said: "*I certainly have a **much better understanding** of contagion patterns and containment*"; "*The books I've read so far really helped me (to) **get a bigger picture** on the current pandemic*"; "*I have referenced some material in teaching sessions*" and "*occasionally I'll have a little nugget of insight on microbiology which could only have come from BBBC*" (added emphasis) [H].

The MS acknowledged the significance of the BBBC in 2020 when it headlined the format in its 75th anniversary celebrations and encouraged people to set up spin-off clubs (including virtual 'pandemic' clubs). The MS webpages received 1,512 unique views (March to October 2020); the BBBC reading guide library is accessed approximately 50 times per month [H]. During the pandemic, 75 people discussed BBBC on Twitter; posts reached approximately 270,000 followers (1,000,000 impressions) and generated 682 engagements (e.g. likes, retweets) [H].

In 2019, the significance of Verran's contribution to public engagement and education received international recognition when she won the American Association for the Advancement of Science Mani L. Bhaumik Award for Public Engagement with Science. The award citation praises: "*her commitment to devising and delivering innovative microbiology-focused public engagement with the same rigor as laboratory-based research, with attention to appropriate design, thorough evaluation and wide dissemination.*" Verran was only the fourth female recipient in the 33 years since it was established in 1987 [J].

5. Sources to corroborate the impact

- A. Statement from former Deputy CEO of the Microbiology Society (2014-16) and CEO of the Physiological Society (2016-present); PhySoc and MS web pages; copy of PhySoc Strategy 2018-2022 *collectively evidence the influence of research on Antibiotics Unearthed and PhySoc strategy, and the reach and significance of public engagement activity and outcomes.*
- B. Advert on FindaPhD is *evidence of outcomes from ongoing research to characterise candidate bacterial strains samples collected as part of Antibiotics Unearthed.*
- C. Physiological Society Outreach Grants webpage is *evidence of higher funding and emphasis on citizen science, evaluation and project pilots.*
- D. Statement from MD of FEMS and news about the new Director/Trustee post are *evidence of the influence of the research on the FEMS Strategic Framework and its implementation.*
- E. '#EUROmicroMOOC: using Twitter to share trends in Microbiology worldwide' (DOI: 10.1093/femsle/fnz141) *provides evidence of the MOOC's reach.*
- F. Corroboration of *impact on national public engagement agenda* available from Director of Business and Strategy, National Coordinating Centre for Public Engagement.
- G. 'Developing microbiological learning materials for schools: best practice' (DOI: 10.1093/femsle/fnv020) and national schools census data *provide evidence of reach and use of resources in schools and alternative diverse settings.*
- H. Event and BBBC evaluations and web analytics *show reach and significance of impacts arising from public engagement delivered by Prof. Verran 2013-2020.*
- I. 'Fitting the message to the location: engaging adults with antimicrobial resistance in a World War 2 air raid shelter' (DOI: 10.1111/jam.13937) *gives evidence of high engagement and curiosity at an event.*
- J. Image of the AAAS Award for Public Engagement with Science *with citation.*