

Institution: The Open University		
Unit of Assessment: B10 Mathematical Sciences		
Title of case study: Research-inspired outreach stimulating public interest in mathematics, the history of mathematics, and mathematicians		
Period when the underpinning research was undertaken: 1 Jan 2000 - 31 July 2020		
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:
Prof June Barrow-Green	Professor of History of Mathematics	1992- present
Period when the claimed impact occurred: 1 Aug 2013 - 31 Dec 2020		
Is this case study continued from a case study submitted in 2014? N		
1. Summary of the impact		
<p>This case study is based on Barrow-Green's extensive public engagement activities, building on her award-winning research in the history of mathematics, which includes work on the relationship between war and mathematics, and the historical development of the role of women in mathematics. The impact has been on the public interest in mathematics, especially young people's, through her key role on the advisory committee for the Science Museum's new mathematics gallery; her leading role in the Sublime Symmetry Exhibition at the London Guildhall; her academic consultancy work on BBC4 television series; and her numerous public lectures and media appearances, notably related to the historical role of women in mathematics.</p>		
2. Underpinning research		
<p>Barrow-Green is a world-leading mathematical historian, an elected member of the International Academy of the History of Science in Paris, recipient of the 2014 Chandler Davis Prize for Expository Excellence for the article [O1], and panel chair for History of Mathematics at the International Congress of Mathematicians (ICM) in Rio de Janeiro, 2018.</p> <p>She has made major contributions to history of mathematics research: a seminal monograph on Henri Poincaré, editor of the leading international journal <i>Historia Mathematica</i>, one of the editors (with Professor Sir Timothy Gowers and Professor Imre Leader) of the authoritative <i>Princeton Companion to Mathematics</i>, and a key contribution to documenting the history of applied mathematics [O2].</p> <p>Barrow-Green's role as the premier historian of mathematics researching in the UK, especially her historical expertise in mathematics since the end of the 19th century, makes her one of the UK's 'go to' academics to present mathematics and historical information about mathematicians to a non-expert audience. Her entire research record is therefore relevant, but the works most pertinent to this impact case study are those in two interrelated topics:</p> <ol style="list-style-type: none"> i. the relationship between war (especially WW1) and mathematics. ii. the historical development of the role of women in mathematics. <p>Barrow-Green's paper [O3] in <i>Revue d'Histoire des Mathématiques</i> is a very detailed study of how the statistician Karl Pearson built a team of the UK's finest mathematical problem solvers to work successfully on ballistics in relation to anti-aircraft gunnery; at the start of WW1, massive technical weakness had become apparent in this highly important area of defence. Her paper shows that it was a matter of team leading and politics, and demonstrates how the interactions between the great mathematicians Littlewood and Hill, and Pearson himself, a statistician with fine mathematical skills, led the team to provide essential technical guidance to the Ministry of Munitions.</p> <p>Barrow-Green's chapter [O4] on the response of Cambridge mathematicians to WW1 described the significant split in mathematical support for the war effort at Cambridge University – the dominance of Cambridge over British mathematics and the central role of the Mathematical Tripos, in the nineteenth and early twentieth centuries, made this split a matter of national importance.</p>		

The historical under-representation of women in mathematics has also been a major research theme for **Barrow-Green**, and she has given many talks on the subject to academic audiences and to the wider public. This theme can be seen in [O5], an article based on her talk at a satellite conference of the 2018 ICM, and in [O6], a recent article on Philippa Fawcett, arising from some correspondence between Fawcett and Karl Pearson discovered by **Barrow-Green** in the Pearson archive at UCL. A more popular account of the difficulties faced by female mathematicians can be found in her essay 'Women and mathematics in late nineteenth-century Cambridge' in the book *Mathematics: The Winton Gallery*, edited by David Rooney, which accompanied the launch of the Science Museum's new Winton Gallery in 2016.

3. References to the research

- O1. Barrow-Green, J.E.** (2011) 'An American goes to Europe: Three letters from Oswald Veblen to George Birkhoff in 1913/1914', *The Mathematical Intelligencer*, 33, pp.37–47. ISSN 0343-6993. <https://doi.org/10.1007/s00283-011-9248-x>. [The paper received the 2014 Chandler Davis Prize for Expository Excellence].
- O2. Barrow-Green, J.E.**, and Siegmund-Schultze, R. (2015) 'The history of applied mathematics', In: Higham, Nicholas ed. *The Princeton Companion to Applied Mathematics*, Princeton University Press, pp. 55–79. ISBN 978-0691150390.
- O3. Barrow-Green, J.E.** (2015) "Anti-aircraft guns all day long": computing for the Ministry of Munitions', *Revue d'Histoire des Mathématiques*, 21, pp.111–150. ISSN 1262-022X.
- O4. Barrow-Green, J.E.** (2014) 'The response of Cambridge mathematicians to the First World War' in *The War of Guns and Mathematics: Mathematical Practices and Communities in Allied Countries around World War I* (eds. C Goldstein, D Aubin), American Mathematical Society, pp.59–124. ISBN 978-1-4704-1469-6C.
- O5. Barrow-Green, J.E.** (2019) 'The Historical Context of the Gender Gap in Mathematics' in *World Women in Mathematics 2018, Proceedings of the First World Meeting for Women in Mathematics (WM)²* (ed. Carolina Araujo, Georgia Benkart, Cheryl Praeger, Betül Tanbay), Springer, 17 pp. ISBN 978-3-030-21170-7.
- O6. Barrow-Green, J.E.** (2020) 'The Accident of Being the First Woman Senior Wrangler' in *London Mathematical Society Newsletter*, July, pp.21-26. ISSN: 2516-385X.

4. Details of the impact

Barrow-Green's research on history of mathematics and her activities underpinned by her research have had impacts on creativity, culture and society, and on people's understanding and learning of history of mathematics. Some of the impacts are directly linked to **Barrow-Green's** research and others, as described below, arise from the ongoing interaction between impact and the further development of her research.

Impacts on creativity, culture and society

The vehicles for achieving cultural and societal impacts include contributions to several exhibitions.

- i. The Science Museum's GBP5M gallery *Mathematics: The Winton Gallery*

In December 2016, the Science Museum, London, opened its landmark new permanent mathematics display, *Mathematics: The Winton Gallery*. This 900-square-metre gallery tells the story of how mathematics has underpinned some of our most fundamental human concerns through history.

Barrow-Green was appointed to the External Advisory Panel for this gallery on the basis of her body of research in the field. She provided a wide range of advice, recommended and introduced additional experts, advised on research that might impact the gallery during its lifetime, and acted as a critical reader of the entire gallery content. She played a key role in providing historical information on the mathematical exhibits, the historical themes and the mathematicians involved, which were written into the exhibits and frequently related to her WW1 research described above. The lead curator of the gallery has said that:

“June was a hugely supportive Panel Member and her contribution to the development and success of this major project was immense. She brought a deep understanding of the history of mathematical practice as well as a clear awareness of the challenges involved with translating academic knowledge into narratives suitable for the broadest audience” [C1].

Barrow-Green also authored an essay ‘Women and mathematics in late 19th century Cambridge’ in the book *Mathematics: How it Shaped our World*, published by the Science Museum for the gallery launch. This explored women and mathematics in the nineteenth century and was described by the Lead Curator as *“a critically important and engaging account that helped deliver to the project’s ambition to actively counter traditional gendered histories of the subject” [C1].*

In its first year alone, the gallery was visited by 1.23 million people, approximately one third of all Science Museum visitors. Audience research has showed that an unprecedented 99 per cent of visitors took away the gallery’s intended key message. The gallery was also a critical success, with highly positive reviews from Waldemar Januszczak in the Sunday Times, Will Gompertz on BBC News, Mark Hudson in The Telegraph, Jonathan Morrison in The Times, and Alex Bellos in The Guardian [C1]. It received a prestigious RIBA London Award in 2017, with RIBA judges praising its *“extraordinary content” [C1].*

- ii. *Sublime Symmetry: The Mathematics Behind William De Morgan’s Designs*, London Guildhall, 2018.

Sublime Symmetry is a touring exhibition by the De Morgan Foundation, partly funded by the LMS, focusing on the work of William De Morgan, the renowned 19th century ceramicist whose ceramics designs are highly mathematical. In 2018, the exhibition appeared at London’s Guildhall Art Gallery, attracting about 59,000 visitors including over 3,000 school pupils. This exhibition included a special display researched and curated by **Barrow-Green**, who worked closely with the main curator [C2, p.5]. This comprised a room at the Guildhall exhibition devoted to the life, mathematical work and interests of Augustus De Morgan, father of William De Morgan, first professor of mathematics at University College London and founder of the LMS. **Barrow-Green** also gave a lecture on De Morgan during the launch of the exhibition. The final report of the exhibition states that:

*“The efforts of Professor June **Barrow-Green** in researching and curating a special display around the LMS complemented the main exhibition display extremely well and was critical to the success of the exhibition” [C2, p.2].*

The main curator of the exhibition states (see also the testimonial [C9]):

*“London Mathematical Society [...] connected me with Professor **Barrow-Green**, whose help and expertise proved indispensable from the start of the project. Her enthusiasm and determination to present her subject in innovative ways in the hope of encouraging new audiences to engage with mathematicians was unwavering from the start and really shaped the direction and outcomes” [C3].*

- iii. The ‘Local Heroes’ exhibitions, part of the LMS’s 150th anniversary celebrations in 2015

As LMS Librarian and Council member, **Barrow-Green** played a major role in setting up outreach events for the Society’s 150th anniversary celebrations [C4, p.1]. Most notably, she devised and organised a series of “Local Heroes” exhibitions at museums around the UK. These focused on the lives of Robert Adrain, D’Arcy Thompson, Robert Recorde, George Boole and Sydney Chapman, and were attended by over 15,000 visitors [C4, p.14].

Barrow-Green researched and organised the Sydney Chapman exhibition at Kensington Central Library, which formed part of London Council’s annual celebration of science. The then president of the LMS has stated that:

*“[**Barrow-Green**] did an excellent job in sourcing the material from the Imperial archives, the Royal Society, and elsewhere, and arranging his fascinating work and career in the form of six detailed and superbly illustrated posters. The posters made a well-received exhibition with a steady flow of the general public looking at them. They are still interesting*

and valuable resources today communicating the amazing contributions of a mathematician who was proud that he was personally named on Hitler's kill list" [C4, p.92].

According to the Tri-Borough Reference Information and Archives Manager:

"Customers were given the chance to learn something about a very personable mathematician, [...] and the LMS had the opportunity to [...] get mathematics onto the horizons of ordinary members of public" [C4, p.105].

- iv. The Science Museum's four-day festival, *What's Your Angle: Uncovering Maths*: part of the London Mathematical Society's 150th anniversary celebrations in 2015.

As another example of **Barrow-Green's** major contributions to the LMS 150th anniversary celebrations, she worked with the Science Museum to organise an LMS sponsored festival titled *What's Your Angle: Uncovering Maths*, consisting of mathematical displays by groups of academics and PhD students from eight UK university departments (including The Open University). **Barrow-Green** negotiated the details of this event, on behalf of the LMS, with the director of the Science Museum, building on her connections at the Museum via the Winton Gallery advisory panel.

The purpose of the festival was to inspire visitors to think about mathematics in new ways and realise that mathematics is everywhere and for everyone. The festival comprised: an adults-only *Lates* event, a school day, and two public days. Over 1,200 people visited the festival.

The Science Museum Groups' Contemporary Science Manager commented:

"Visitors were transported into a busy 24-hour newsroom to explore ways that researchers are using maths to solve problems and change lives. They could uncover the secrets of an archaeological dig, learn how best to surf a wave and even dress up as a cow to find out about herd health" [C5, p.26].

Visitors tweeted their headlines or presented them on camera. Comments from two young people who visited the Festival are pictured below [C6].



Impacts on understanding, learning and participation

The vehicles for achieving these impacts were:

- i. Media appearances including an interview for *Womanthology*, a digital magazine for working women; and acting as academic consultant to several TV programmes on BBC4, including *Magic Numbers: Hannah Fry's Mysterious World of Maths*.

The *Magic Numbers* series had over 2 million views, and over 6,000 people followed the BBC's link to the OU website, where they accessed specially prepared Open University materials where viewers could learn more about mathematics, mathematicians, and gender issues in mathematics, all written by **Barrow-Green**. As a consequence, 23 audience members requested a prospectus and two are known to have signed up for OU courses [C7].

Barrow-Green was interviewed by *Womanthology* in 2017: in that year, the magazine had a readership of over 100,000. One reader, the Artistic Director of Electric Voice Theatre, later commented that the article helped her to understand and make music in a really different and important way.

“June's article [...] resonated strongly with me, and has inspired me to think even more carefully about how I use maths and mathematicians (for example Mary Somerville, mentioned by June in her article) in the many music projects I have since done with young people all over the UK” [C8].

Since 2017, over 1,000 young people have taken part in these projects influenced by **Barrow-Green's** interview, and during the 2020 lockdown the project reached 11,000 people online, introducing them to women mathematicians past and present [C8].

- ii. Public lectures about the history of mathematics and women mathematicians

Barrow-Green has given [70 public lectures and talks](#) about the history of mathematics and women in mathematics between 2014 and 2020, many of which relied on her research mentioned earlier. Venues include the LSE, the LMS in London, the Yorkshire Philosophical Society, the NI Science Festival, Gresham College, and branches of the Institute of Physics.

As a result of her expertise and impact in this area, **Barrow-Green** was invited by Vice Chair of the International Mathematical Union Committee for Women in Mathematics to join an international panel to discuss *The Gender Gap in Mathematical and Natural Sciences from a Historical Perspective* at the 2018 International Congress of Mathematics in Rio de Janeiro [C9]. Other panellists were mathematician Marie-Francoise Roy and physicist Silvina Ponce Dawson, both major players in their respective international unions, with strong agendas to attract more young women to their disciplines and support their professional development.

*“I suggested inviting Professor June **Barrow-Green** to give a talk on this occasion as I was well aware of her ability both to give engaging public lectures and also to set the issues of the under-representation of women in mathematics in a historical context, something which I feel is usually missing from contemporary discussion on the subject. My suggestion was received with enthusiasm by other members of the organising committee. In the event June did this superbly with a fascinating and well received lecture, which was subsequently published and which led to further invitations.”*

“June's use of her academic expertise to engage and educate the public has been exemplary” [C9].

5. Sources to corroborate the impact

C1. Testimonial: Lead Curator, Mathematics: The Winton Gallery, Science Museum London.

C2. Final report on Sublime Symmetries.

C3. Testimonial: Curator-Manager, De Morgan Foundation.

C4. Impact evidence from London Mathematical Society:

- Testimonial: Former General Secretary, LMS.
- LMS AGM papers 2016, page 11.
- Testimonial: Former President, LMS.
- LMS Newsletter, December 2015, page 13.

C5. Science Museum Group Annual review 2015-16, page 26.

C6. What is your Angle: Twitter Feed.

C7. Magic Numbers viewing and website data.

C8. Testimonial: Artistic Director, Electric Voice Theatre.

C9. Testimonial: Vice Chair of the International Mathematical Union Committee for Women in Mathematics 2015-18 (and former president of the LMS).