End Project Report

QTFP Impact and Engagement Call

ST/Z510403/1: Engagement via classical and quantum light waves

1. Progress and development of the project (500 words)

Here you can expand upon how your project has evolved since submission of the proposal.

1.1 How have things developed in reality compared to the original ambitions you laid out in your application?

We have successfully delivered most of the project's elements.

While we experienced initial delays related to the receipt and transfer of funds, these were effectively managed through a 3-month FES extension. The delays affected the finalisation of the LEGO kit blueprints and the launch of the landing page in Nottingham, which in turn postponed kit assembly in Cardiff and impacted the associated teacher upskilling workshop. However, the additional time enabled us to complete full kit production at both sites.

Importantly, the extended timeline allowed us to exceed our original ambitions. We increased the number of public demonstrations of the single-photon interferometer (quantum kit) and secured participation in several events associated with the International Year of Quantum Science and Technology. The project is now well positioned for sustained future impact. All necessary hardware has been built with spares and replacements in place, and discussions are underway to expand the range of optical experiments supported by our LEGO platform.

1.2 Describe changes you have made to your objectives or delivery mechanisms, as well as key milestones, successes, challenges, and lessons learnt.

LEGO kit development

The first prototype was completed in November 2024, with the final design and full documentation finalised by April 2025. Eight kits were assembled in Nottingham in May 2025, followed by twelve in Cardiff in June 2025. Completion was also delayed by unexpectedly long lead times for LEGO components, with one bulk order taking five months to arrive.

Website launch

The Photon Bricks website launched in May 2025, providing building instructions, supporting materials, and details of the loan scheme for the LEGO kit. The loans are expected to begin in Nottinghamshire in July 2025, with Cardiff following from September 2025.

LEGO workshops

Four LEGO with Lasers workshops for A-level students were delivered in Nottingham in March-April 2025, despite challenges in coordinating multiple school schedules. A dedicated teacher workshop was arranged in Cardiff in June 2025 but postponed until Autumn 2025 due to lack of availability of teachers at this time of the school year.

Quantum kit development & Public demonstrations

The quantum kit became operational in January 2025 and was showcased at the Cosmic Titans art-science exhibition. The extended project timeline allowed us to double the number of planned public demonstrations, which were all fully booked.

Additional successes

We highlight the success of the LEGO kit in achieving prominent visibility across multiple platforms: a photo of the setup was selected by Nature as one of February 2025's Best Science Images; it was showcased at the House of Commons as part of the IOP Quantum Technologies Parliamentary Introduction; and will soon feature in the Royal Society Summer Science Exhibition. Both interferometers were also filmed by Veritasium, a YouTube channel with 18.1M subscribers.

1.3 Provide a list of people and organisations your project has engaged with.

25 undergraduate and PGR students in Nottingham and 19 in Cardiff

60 students from schools in Nottinghamshire (Bramcote Academy, Carlton Academy, Kimberley School, Magnus CoE Academy, Nottingham Academy, Nottingham Girls High School)

3 teachers from schools in the Cardiff area

University of Birmingham

Slovak National Center for Quantum Technologies

Veritasium

Lakeside Arts

UK Parliament (via the Institute of Physics)

Royal Society (via the National Quantum Computing Centre)

2. Wider benefits and added value of the award (1000 words)

Here you can describe wider, qualitative benefits of the award, beyond the quantitative metrics.

2.1 Summary of how your work has supported economic, social, cultural or policy impact (please describe the real-world problem/issue if relevant). How has the project demonstrated wider benefit beyond the original QTFP research project.

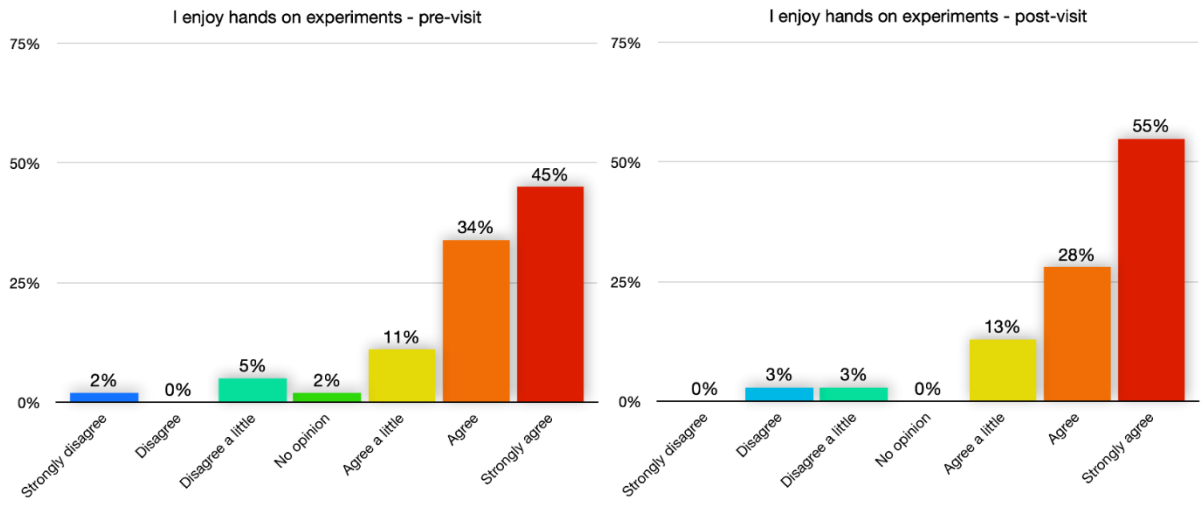
Activities delivered through this project transformed complex quantum science addressed by QTFP researchers into concrete objects and accessible concepts. The project addressed a key educational and cultural challenge: quantum technologies are often perceived as abstract and inaccessible, especially outside specialist circles.

The LEGO interferometer and quantum kit were displayed as museum exhibits for more than three months in the Cosmic Titans exhibition at the Djanogly Art Gallery in Nottingham. These were accompanied by wall-mounted explanations and set within a broader QTFP showcase, including a photo gallery, recorded interviews with leading researchers in quantum technologies including team member Hartmut Grote. This environment helped visitors connect real-world experiments to cutting-edge research.

This space was regularly transformed into a pop-up optics laboratory for public demonstrations of interferometry. One workshop participant commented, "*Physics has always been a closed book to me*", while another admitted, "*I had always found quantum concepts unbelievable*"

(nottingham.ac.uk). Through live demonstrations using real-world optical hardware, often inaccessible to the public, we helped make abstract phenomena, like the Schrödinger's cat principle, concrete and relatable. Our quantum kit is deliberately housed in a transparent enclosure. Unlike standard non-transparent enclosures, it allowed visitors to observe the kit components and understand how the system worked.

This same philosophy shaped our A-level workshops, which offered hands-on experience as students built and aligned LEGO interferometers themselves. Most completed the activity within the session, gaining both understanding and a sense of achievement. Evaluation data confirm the impact: 55% strongly agreed the workshop increased their interest in hands-on experimentation (a 10% rise from pre-session responses) directly supporting the development of the UK's future quantum workforce. Additionally, 100% of students either agreed (35%) or strongly agreed (65%) that they enjoyed the workshop. These results show that participants not only learned but also engaged deeply with the LEGO kits.



The workshops also introduced teachers to the loan scheme, positioning them as early adopters of this model for extending engagement beyond the university. A pilot is planned with Nottingham Girls' Academy, where students will use the LEGO kit to prepare and deliver a demonstration at their science fair. This approach empowers schools to run independent STEM outreach, while fostering confidence among students.

In the Cardiff area, the workshops will become a standard offering of school engagement programmes, complementing other physics and astronomy workshops.

2.2 An update on activities to embed equality, diversity, and inclusion and responsible innovation into your award

Equality, diversity, and inclusion

Our activities attracted a diverse demographic, with 39% female participants in the student workshops and 49% in the Quantum LEGO demonstrations. Remarkably, near-equal gender balance exceeds national averages for post-16 physics students, where only 23% are female (WISE Campaign 2021 report), challenging the stereotype that quantum physics primarily appeals to men.

We also promoted diversity within our team. Students involved in developing the LEGO kits came from a range of disciplines, including the Faculty of Engineering and the School of Law.

Accessibility of the LEGO kit represents a core principle. All resource materials are freely accessible (CC-BY-SA license), with building versions spanning multiple cost tiers, from a full kit as we developed it to a lowest-cost model. We created clear, graphical instructions that support a wide range of learners and classroom settings. The LEGO kits are compact, portable, and free to borrow through our loan scheme, making them accessible to schools regardless of budget.

Responsible innovation

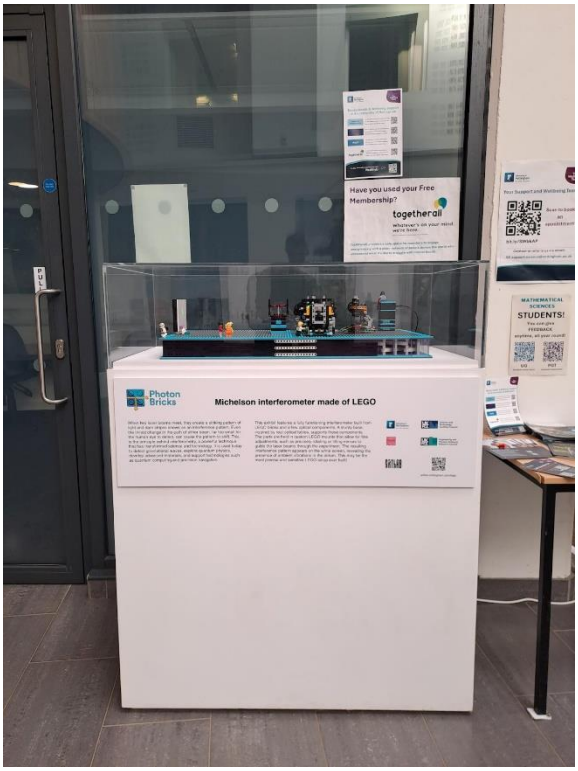
To ensure continued impact and recognition beyond the duration of the grant, we established a clear identity for the project by branding the LEGO kit as *Photon Bricks*. Outreach activities will be sustained by dedicated teams in Nottingham and Cardiff, supported by now-trained undergraduate students. Early feedback already demonstrates international interest, with users downloading the blueprints and building their own versions of the kit.

The quantum kit developed in Nottingham remains in active use, with plans for its potential integration into the Experimental Physics module at the University of Nottingham.

2.3 The value added to partner organisations

The project significantly strengthened outreach portfolios of both the University of Nottingham and Cardiff University. The University of Nottingham issued an early press release about the project, and we worked with the university's media team to promote our involvement in major outreach activities during June and July 2025. The project is currently being considered by the University of Nottingham as a case study for the upcoming REF report.

The LEGO kit provided a valuable platform for early-career researchers and students to develop skills in science communication, content creation, and public engagement. A team of undergraduate students contributed to the design of new LEGO builds, enhancing their technical abilities and sense for collaboration. Many of these students are continuing their studies at Nottingham or Cardiff and now form a trained cohort ready to support future outreach.



Through the media and social media (e.g. @gravity_laboratory on Instagram) outputs, we produced a visible and engaging content that presents cutting-edge quantum research in a format accessible to students, policymakers, and the public.

Finally, one of the LEGO kits is now on permanent display in the atrium of the Mathematical Sciences building in Nottingham.

2.4 Good practices you have developed that could be of use to other award holders

Blending creativity with technical rigour

The project successfully merged scientific equipment with visual tools and storytelling, showing how interdisciplinary framing can enhance the appeal and reach of complex scientific ideas.

Evaluation

The use of pre- and post-session questionnaires helped us measure changes in participants' perceptions of the value of research and estimate the impact of our activities. A full summary of evaluation results can be found here: (sharepoint.com).

Leveraging existing events

Tying our activities to public exhibitions and national initiatives (e.g. the International Year of Quantum Science and Technology) proved highly effective for visibility of the project. Other award holders may benefit from aligning their outreach with similar high-profile platforms. Our collaboration with Lakeside Arts for the Cosmic Titans exhibition included a well-resourced publicity and marketing team who were able to connect with diverse audiences locally and regionally.

Promote laser safety

We promoted laser safety by providing clear guidance during LEGO workshops and including advice on safe use of laser beams in Photon Bricks' user guide.

3. Outputs of the project (500 words)

Here you can list specific outputs of your project.

Hardware

We built a single-photon (quantum) interferometer, complete with a mobile support structure and laser-safe enclosure. In addition, 20 LEGO interferometer kits have been constructed (8 in Nottingham and 12 in Cardiff). The modular nature of these kits allows for continued expansion and future impact, with additional builds currently under development in Nottingham. These include new experiments such as the three-polariser paradox.

Landing Website (artlab-nottingham.com/lego)

Information about LEGO interferometers is presented on a dedicated webpage, serving as a central hub for the project. The website provides an overview, contact details, and information about the now active loan scheme, allowing schools and organisations to borrow our kits. Visitors can also access a comprehensive library of resource materials, including LEGO shopping lists, 3D models, assembly guides, and a user manual. All resources are distributed under a CC-BY-SA licence to encourage reuse and adaptation. The site also maintains a record of past and upcoming activities, media appearances, and links to related content, including YouTube videos. The site hosting will be in place for a minimum of two years.

Events

The investigator team successfully delivered most of the events outlined in the original project proposal. A kick-off workshop was held in Nottingham on 20 September 2024, bringing together team members from Nottingham and Cardiff to exchange ideas and discuss the work plan for the duration of the award. The team has since remained in contact through on-demand virtual meetings.

Both the LEGO and quantum optics kits were prominently featured during the Cosmic Titans art-science exhibition in Nottingham (25 January-27 April 2025). As part of this exhibition, we delivered eight Quantum LEGO workshops (8, 26 February; 8, 12 March; 10, 17, 24, 26 April), the impact of which is presented as a case study in Section 4.

In addition to public demonstrations, the LEGO kits were used in educational outreach. Dedicated workshops were held in Nottingham for A-level students on 11 (double session), 28 March and 4 April 2025, engaging approximately 60 students.

The portable design of LEGO kits has allowed us to participate in multiple events (past and future):

UK National Quantum Technologies Showcase (8 November 2024, London)
Security BSides London 2024 (14 December 2024, London)
QSimFP Community Workshop (16-21 March 2025, Nottingham)
SciOUT, workshop for science communicators (11 June 2025, Nottingham)
IOP Quantum technology parliamentary introduction (18 June 2025, London)

Royal Society Summer Science Exhibition (1-6 July 2025, London)
Big Bang-style Fair (10 July 2025, Nottingham)
European Researchers' Night (26 September 2025, Bratislava, Slovakia)
UK National Quantum Technologies Showcase (7 November 2025, London)

Media Coverage

Interview with Silke Weinfurtner on BBC Persian (youtube.com)
A photo of the LEGO interferometer among the Best science images selected by Nature (nature.com)
Interview with Patrik Svancara on Notts TV (youtube.com)
Article in Physics World (physicsworld.com)
Press release of the University of Nottingham (nottingham.ac.uk)

4. Case studies (500 words)

Here you can describe highlights of the work you have undertaken that we can use for a case study or to promote the QTFP programme.

One of the most impactful public engagement activities supported by the award has been *Quantum LEGO*, a series of hands-on demonstrations designed to introduce the public to the physics of interferometry and its role in modern research. Delivered by Dr Patrik Svancara as part of the Cosmic Titans art-science exhibition, the activity combined live optical experiments with an accessible talk explaining key principles of quantum mechanics. Both the demonstrated technologies and the underlying quantum phenomena are central to the work of the two consortia involved in the award (QI and QSimFP).

Between February and April 2025, we ran eight 45-minute sessions, each fully booked in advance, totalling 280 individual bookings. The demonstrations began with a hands-on LEGO-based setup to explain the basics of interferometry in an intuitive and visual way. This led into the highlight of the session: a single-photon interferometer showcasing self-interference, a purely quantum phenomenon. This observation is closely related to Schrödinger's cat thought experiment, in which a quantum system can exist in multiple states simultaneously until observed, as famously illustrated by a cat that is both alive and dead.

The interferometers were presented as part of a broader exhibition highlighting the QTFP and NQTP programmes. This included vintage and analogue photography, filmed interviews with leading scientists, and short video explainers by early-career researchers. The fusion of art and science created an engaging and accessible space for exploring quantum ideas introduced during the workshops. Participants represented a wide demographic, and the gender balance among attendees (51% male, 49% female) challenges the common perception that quantum science appeals predominantly to men, highlighting the potential to advance gender equality in STEM.

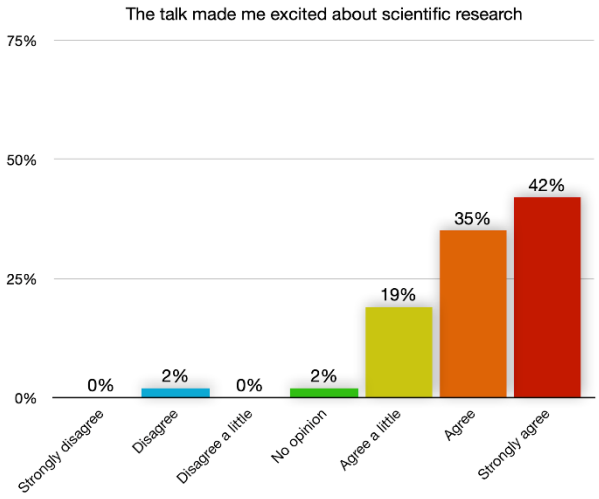
Feedback from participants was collected via questionnaires (45 responses collected), allowing us to assess the effectiveness of the sessions. While only 30% of attendees reported knowing what an interferometer was prior to the workshop, by the end, more than 90% said they felt confident explaining one to a friend or family member. This substantial increase in understanding demonstrates the impact of interactive, hands-on education, made possible through this award.

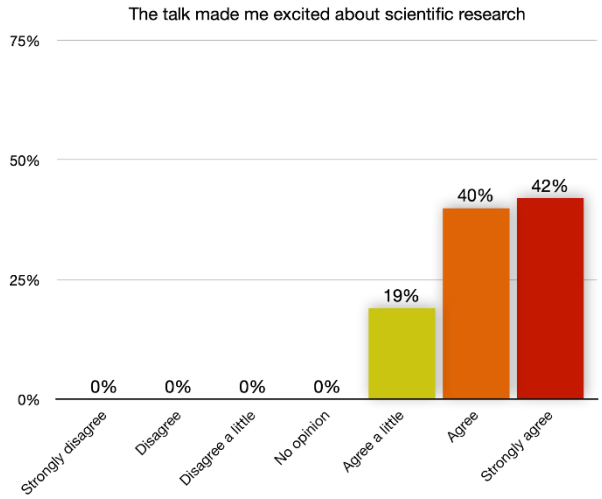
Participants frequently remarked on the clarity of the delivery:

— "*Well explained today and drew on what I'd learnt many years ago in A level physics.*"
— "*Explanation was clear with diagrams and equipment to further help my understanding.*"

The sessions stimulated lively discussions, with numerous questions from the audience reflecting a strong curiosity and eagerness to engage more deeply with quantum technologies. Informal conversations following the demonstrations provided further opportunities to explore key scientific ideas and helped guide visitors through the wider exhibition, deepening their understanding of the research supported by the QTFP programme.

The workshops also inspired genuine excitement about science among participants. This was evidenced by highly positive responses to statements such as “The talk made me excited about scientific research” and “The talk made me think more about scientific challenges” (see diagrams below). These results highlight the enduring value of experimental demonstrations in shaping public perception of quantum research and making complex ideas more accessible and meaningful.





Submit completed reports to qtfp@stfc.ukri.org. Submission deadline is 3 months after the end of your funded project.