



# Introducing Orbyts



At the heart of great science is opportunity. Find out what opportunities Orbyts offers in this introductory article from **Jasmine Kaur Sandhu** and **Michaela Mooney**, **William Dunn**, **Vicky Mason**, **Alex Thompson**, **Christian Lao**, and the Orbyts Leadership Team

**A**stronomy and geophysics can inspire people from all backgrounds and all identities, and our communities are undoubtedly richer when we embrace diversity. However, our scientific communities suffer from systemic and longstanding under-representation for certain demographics (documented by the UK parliament, RAS and IoP). So when and how does this under-representation start? In this article we discuss how experiences and opportunities at school reinforce inequity in the STEM workforce. And we present Orbyts – our multi-award winning movement that actively reduces barriers to STEM engagement faced by school students.

Within Orbyts, we partner scientists with schools to empower school students to undertake world-leading research, addressing diversity issues in STEM, as well as challenging shortages and retention of specialist science teachers. Orbyts has now been running for more than eight years and has created more than 150 transformational partnerships with 53 schools, reaching upwards of 2000 school students from Northumbria, the

Midlands, London and the South East. The novelty of Orbyts research is showcased by the publication of 18 unique research papers including roughly 300 school student authors of scientific papers, who are amongst the most diverse group in physics, self-identifying from over 48 ethnicities. Orbyts projects cover a range of science topics, including working on stellar lifecycles; discovering that coffee comes from stars, building Cube-Sats, launching experiments on high-altitude balloons, exoplanets, cancer diagnosis and treatment, using fluorescence to identify the causes of Parkinson's disease, quantum computing, Jupiter's spectacular aurorae, and analysing dust production in supernovae after the death of massive stars.

We are delighted to launch a series of Orbyts articles in *A&G*, highlighting the discoveries and impact of Orbyts projects. Many of these articles will be written by the school students undertaking space research projects. In this introduction, we discuss the programme and impact it has on school students, teachers and professional scientists.

## Join us!

If you are a researcher or teacher and you would like to get involved in Orbyts, or just want to find out more, then we'd love to hear from you. We also welcome industrial partnerships from STEM, science and engineering related companies to co-create and deliver bespoke Orbyts projects to inspire the next generation of scientists and engineers!  
[www.orbyts.org](http://www.orbyts.org)

## What is Orbyts?

Orbyts pairs researchers with schools to facilitate science research led by school students in bespoke research projects. While the programme started with exoplanet science, our projects now cover a huge range of STEM and interdisciplinary subjects. In the last year alone, our partner schools and their scientists have undertaken research on topics from the search for the potential presence of life on Mars (Ballard *et al.* 2023) to medical physics that can help to sustain life on Earth.

The nature of the projects depends on the expertise of the scientist that a school is paired with. A significant proportion of the projects fall directly within the astronomy and geophysics domains. For example, projects undertaken in 2023–24 include research on geomagnetic storm-prediction using artificial intelligence (AI), solar flares, photometric redshift and galaxy classification with machine learning models, exoplanet observations with JWST and Ariel, and a stratospheric martian simulation experiment using Lake Salda microbialites.

Our scientists visit their partner school each week or fortnight over several school terms to support the school's involvement with the research. The project begins with the professional scientist leading the research direction, but as the project progresses, ownership of the science transitions to the students and they choose the avenues that they wish to explore. This sense of agency shifts student perceptions from science as a body of inherited knowledge to something that their generation can create and own themselves.

Each year, our Orbyts programme closes with a conference hosted at a partner university, at which all our partner schools present their research discoveries to their peers and other researchers. The conferences celebrate the success of the students and help ingrain their sense of belonging in science. Inviting the students to their local university is hugely powerful. Many of the school students may be the first generation in their families to attend university or higher education. The first-hand experience of being on a university campus enables students to imagine themselves attending university, and introduces them to the university environment. According to Vee Cudmore, a Year 10 girl, "People enjoyed our findings, asked interesting questions and made intrigued observations. Knowledgeable students who'd been studying astrophysics for longer than we had looked to us for guidance. Suddenly, I didn't feel so out of place anymore."

Orbyts is successful in not only increasing STEM engagement amongst the students but, critically, in generating real, tangible benefits in supporting post-16 and higher education STEM choices. For example, an Orbyts partner teacher at an all-girls high school highlighted that "all of the Year 12 students mentioned Orbyts on their UCAS application forms and of the cohort (6/8 students) enrolled on STEM courses at university..." To ensure that these opportunities go to those who need them most, our programme requires that schools meet minimum criteria: at least 50% of students on an Orbyts project are girls and minority genders and at least 50% are receiving pupil premium. In addition, Orbyts targets schools with low numbers of specialist physics teachers.

## Challenges in the UK

The lack of diversity in our scientific communities reflects large-scale societal and economic inequities that pose barriers to potential scientists across their educational journey, from pre-school to



*School students presenting their research at the end of term conference.*

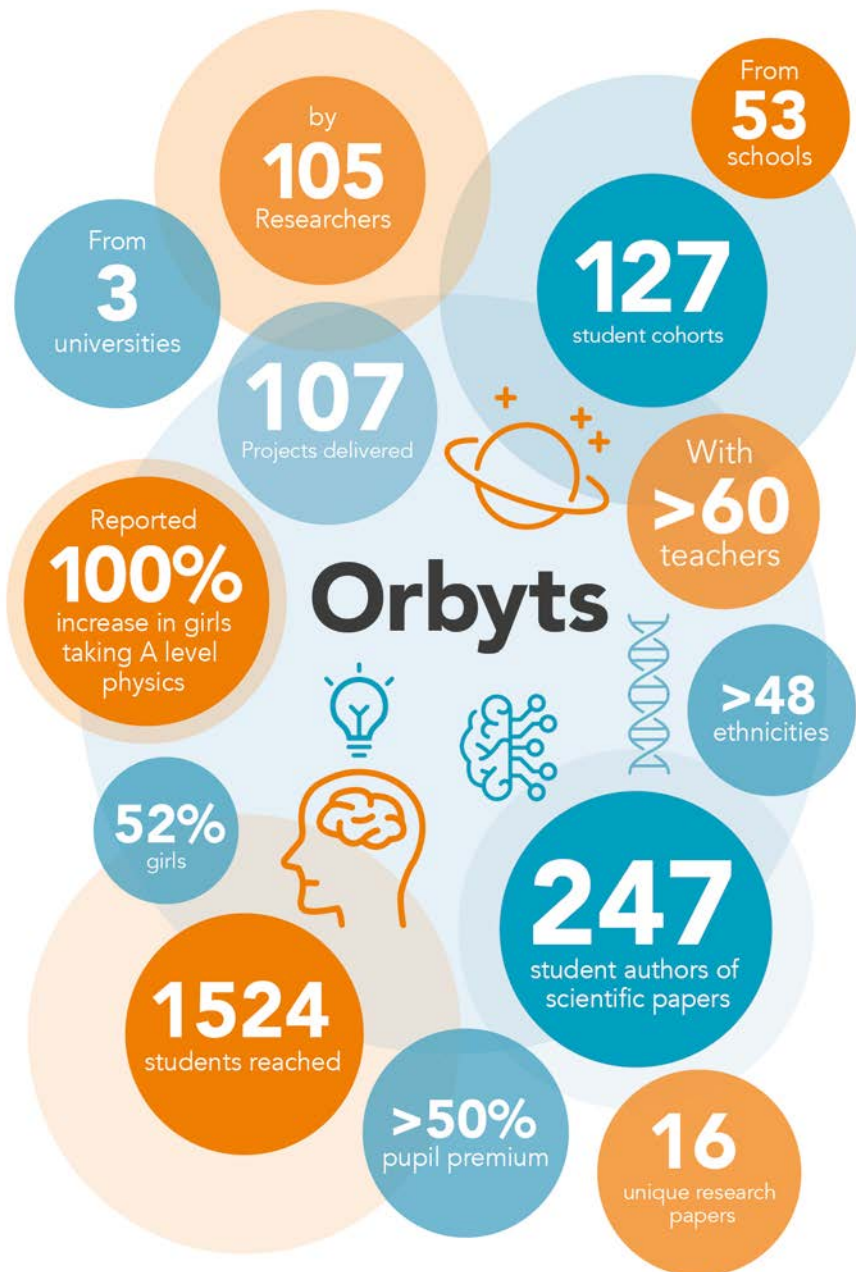
*"People enjoyed our findings, asked interesting questions and made intrigued observations. Knowledgeable students who'd been studying astrophysics for longer than we had looked to us for guidance. Suddenly, I didn't feel so out of place anymore."*

post-16 education and beyond. For example, girls, Black students and students from low-income backgrounds are highly under-represented at all levels of physics from GCSE onwards (data from the Royal Society of Chemistry and Institute of Physics). Less than 20% of post-16 physics students are girls and students from the most deprived backgrounds are three times less likely to take A level physics and six times less likely to achieve the top grades than those from the highest income backgrounds (IoP data *Why not Physics?* 2018, *Limit Less* 2020).

Research has shown that the more 'science capital' – science-related resources – a young person has, the more likely they are to see themselves as a 'science person' and aspire to continue with science post-16. Science capital includes a person's science knowledge, understanding and attitude to science as well as their activities and social contacts i.e. whether they regularly participate in scientific activities and whether they know someone who works in a STEM-related career (described in *Chemistry World*). Work by the ASPIRES project clearly demonstrates that young people from lower socio-economic backgrounds have less science engagement opportunities, fewer science role models, and typically lower science capital, which combine to directly limit science career opportunities (Archer *et al.* 2020).

An additional key challenge is the chronic shortage of physics teachers in UK science education. One in seven UK schools do not have a specialist physics teacher, and schools with higher levels of disadvantage are disproportionately more likely to use non-specialist physics teachers (Royal Society briefing data). As highlighted by the Institute of Physics, the declining recruitment and retention of physics teachers has severe consequences, noting that school students that do not have a specialist physics teacher are less likely to study physics at a higher level. These concerns are echoed in a letter from the House of Lords Science and Technology Committee, detailing how shortages and low retention levels are critical in limiting diversity in the UK STEM workforce and a contributing factor in the UK STEM skills gap. More widely, the letter focused on the UK STEM skills gap, highlighting a long-running and severe disparity between the national aim to become "a science and technology superpower" and the existing skill base of the UK STEM workforce.

An example of the increasing need for a sufficiently skilled workforce is evidenced by the UK space industry,



schools reporting, for example, a 100% increase in girls taking A-level physics. We identify the following key strands of our impacts on school students below.

### 1. Building a sense of belonging through real and relatable role models

Orbyts fellows provide relatable role models who humanise science research on an individual level, dispelling harmful stereotypes and misconceptions about who can be a scientist, increasing pupils' sense of belonging in science. For example, we find that 86% of students report "feeling like science is for them" after participating in Orbyts.

### 2. Building school student confidence in their ability to do science

Confidence is a significant barrier to science for students from widening access backgrounds (Archer *et al.* 2020). The long-term engagement style of Orbyts fosters a sense of agency and ownership of the science research which builds pupil confidence in their ability to do science. By shifting perceptions of who can be a scientist and empowering students with the needed skills and confidence, the programme is actively opening and building pathways into STEM careers.

### 3. Providing rigorous technical and interpersonal skills training

Orbyts projects equip students with data analysis and coding skills, as well as expanding their scientific vocabulary. The projects actively utilise precisely the skills required in science careers and those for which there are national shortages. Regardless of whether the pupils pursue STEM further, problem-solving skills and analytical thinking are crucial across careers and sectors. A Year 12 student with English as an additional language said: "The Orbyts project helped me see that science was something that anyone could participate in and if they were interested enough, they could be successful. I learned about simple computing language (python) for analysis and realised it can be used by anyone – I had no idea about coding but now I realise it's something I can actually do."

In addition to the technical skills, development of interpersonal skills is a key outcome of pupils' involvement in Orbyts, including communication and presentation skills and collaborative working. Pupils also noted that through their involvement in Orbyts projects they met new people and built new friendships. Building friendships through a mutual interest in a subject is key in creating a comfortable working environment for learning and increasing pupils' sense of belonging in STEM.

A partner teacher (a non-specialist physics teacher at an all-girls school in south London) describes our impact, reporting that "it is the set of skills they are learning that really sets this apart – advanced algebra, python programming, applying neural network and artificial intelligence principles, intense teamwork and friendly cooperation". Another Orbyts partner teacher said: "...my main takeaways from the programme have been learning about the content of Issy's research and, more importantly, seeing just how much my students are capable of when given the right resources and support."

Vince, a Year 10 student from an all-girls school who presented their research at the UCL conference this year, said of their experience: "Going to the conference was a wonderful experience. When we got there, I was immediately excited to see everything. Seeing the facilities of UCL was amazing (especially the

where 95% of organisations experience skills-related challenges (up from 67% in 2020) (UK Space Agency). This particularly affects skills in software, AI/machine learning, data analysis and modelling. Almost half of employers report that the shortage of STEM graduates is a key barrier in recruitment, highlighted in a report from Luminate and the UK government Industrial Strategy in 2017. Overall, the challenges in the UK STEM landscape are broad, complex, and deeply embedded. Through the Orbyts programme we work to reduce inequity in post-16 STEM and support our partner teachers, which in the long term contributes to a more inclusive, skilled, and diverse UK STEM workforce.

#### How does Orbyts address these challenges?

Orbyts projects aim to give school students the skills and confidence to pursue STEM career pathways, should they wish to take those routes. Orbyts's structure of regular interventions, relatable role-models and active ownership of scientific research is proving transformative. Orbyts focuses on challenges specific for school students aged 13–18, and we note our work complements other high-impact and effective intervention work done by colleagues across different communities and school stages. Both qualitative and long-term quantitative evaluation shows that Orbyts measurably increases the uptake of post-16 STEM subjects, with many

*"I learned about simple computing language (python) for analysis and realised it can be used by anyone – I had no idea about coding but now I realise it's something I can actually do."*

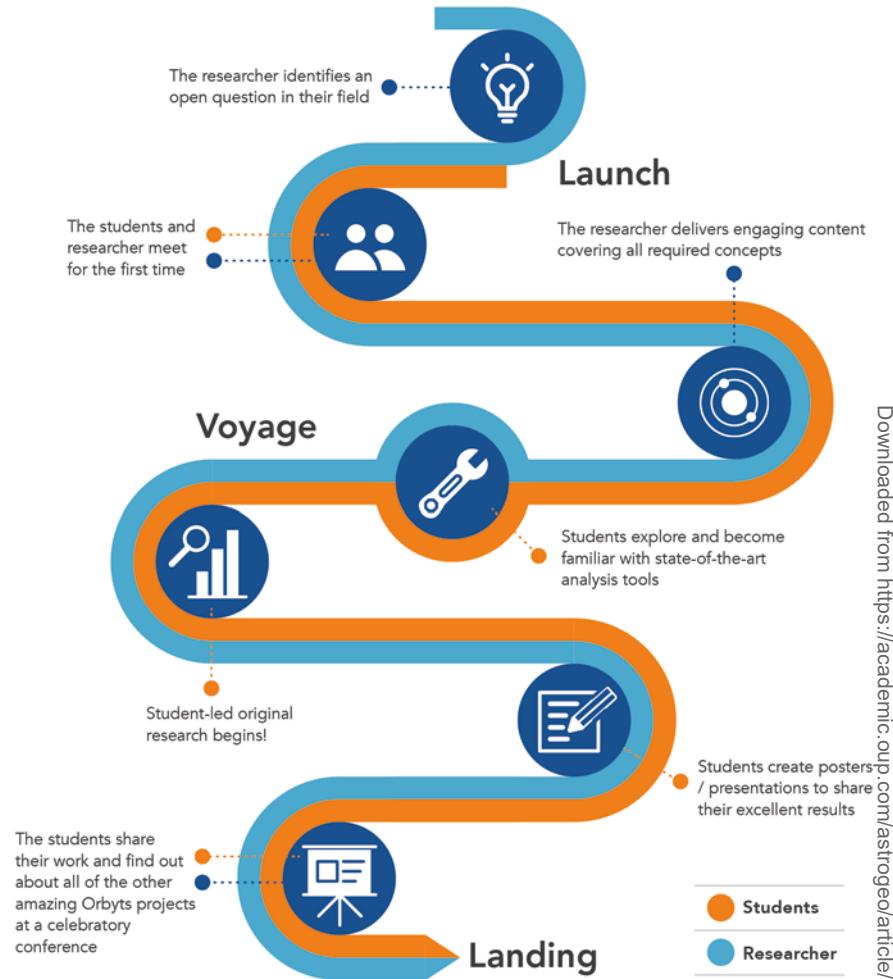
physics department) and it opened my eyes to many opportunities for the future. Speaking in front of people is a challenge for me for many reasons but speaking in front of all the people at the conference was much nicer as they were actually interested in hearing about the research that we all did. Even though I was afraid and shaking a ton beforehand and during the talk, I did well. This helped me get over the fear of public speaking a little bit and made me a little more confident.... The entire day, even though it was quite tiring, was very fun and very enjoyable and I would love to do it again." We are proud to have similarly positive feedback across conferences hosted by all hubs, including those at the University of Leicester and Northumbria University.

### Impact on scientific researchers

The benefits of Orbyts projects are not limited to school students. Orbyts partner researchers report extensive development in areas important for their own science careers and careers beyond science. The majority of Orbyts partner researchers are PhD students and early-career scientists. The aim to make science more inclusive resonates with many of the researchers on a personal level, many of whom can relate to and have personally experienced barriers to science and STEM subjects. Involvement in Orbyts projects provides early-career researchers with project and people management training beyond that typically available in a PhD programme. Researchers report that delivering Orbyts projects has led to new insights into their own research, enhancements in their specialist subject knowledge, step changes in their communication and teaching skills as well as a growth in their confidence and advances in their research profile. Orbyts projects can provide excellent examples of experience of leadership in science, project management and working as a team which are routinely asked in fellowship and post-doctoral research job applications and interviews.

"I see significant benefits to our researchers from participation in the Orbyts programme," said Prof Clare Watt of Northumbria University. "The satisfaction that Orbyts Fellows have from their research appears to increase, as they see their research practice grow from an individual endeavour, to a project where they lead an entire group and enable a shared contribution to knowledge. It is rare to have this opportunity at an early stage in the research journey; leadership of research groups tends only to be available to academics much later in their careers. In addition, researchers gain all the more general benefits from teaching activities: Orbyts Fellows develop advanced communication skills and grow in confidence and mastery of their research."

"I've been fortunate enough to have been a part of Orbyts for the last two years. The Orbyts programme has helped me gain invaluable skills and develop as a researcher in more ways than I ever expected," said Shannon Killey, Space Physics PhD student at Northumbria University. "Orbyts has enabled me to



*"Researchers report that delivering Orbyts projects has led to step changes in their communication and teaching skills as well as a growth in their confidence and advances in their research profile"*

gain confidence and ownership in my research, as well as giving me the opportunity to project manage and improve my public speaking and teaching skills in a proactive yet fun way. Working with students on an Orbyts project has been one of the most rewarding experiences I have encountered during my research career so far. By supporting students on their own development journey and providing them with positive encouragement in STEM-related subjects, it has been incredible to see the students become more confident in their work and become enthusiastic researchers themselves across the short 14-week programme."

### Impact on partner teachers

Involvement in Orbyts projects has a positive impact on partner teachers. The partnership model is critical for widening access to science. The involvement of a partner researcher removes the burden of preparing and delivering sessions from the partner teacher, which can be prohibitive for state school participation in research-style science projects. This enables Orbyts partner teachers to benefit from all the positive aspects of being involved in the project and providing them with new specialist subject knowledge that they can leverage across the school.

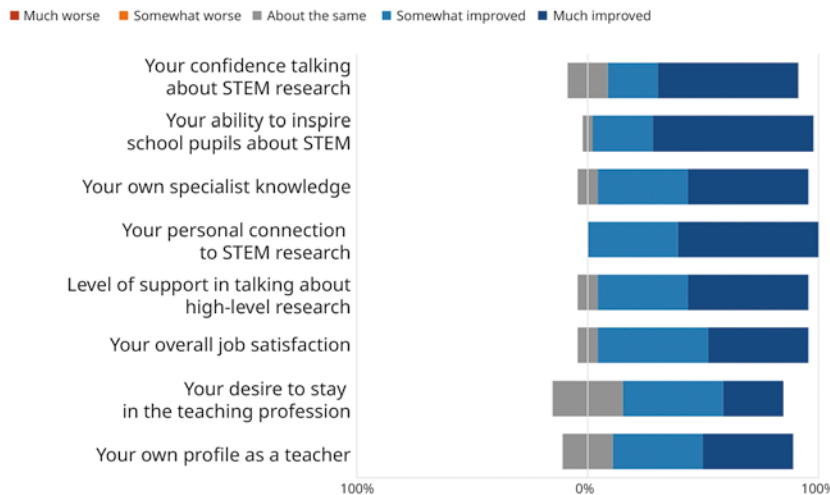
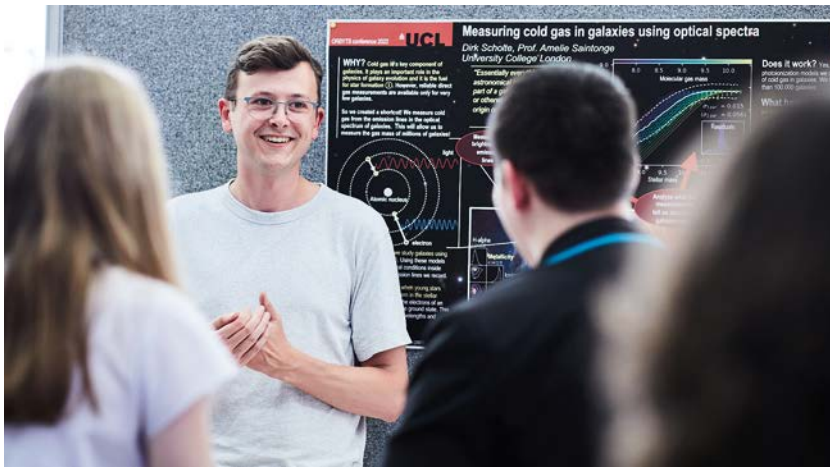
Partner teachers have reported that involvement in Orbyts projects reconnects teachers to their love of science and inspires their teaching delivery across all stages of the curriculum. Most importantly, Orbyts partner teachers report that involvement in the Orbyts project increases their desire to remain in teaching, which in turn improves teacher retention in Orbyts partner schools.

These benefits have a real and meaningful role in improving teacher retention in Orbyts partner schools, acting to counter severe shortages of

## Positive impacts on partner researchers

Positive impacts on partner researchers include:

- project and management training beyond that available in a normal PhD;
- step changes in their communication and teaching skills;
- subject knowledge enhancements;
- growth in their own confidence;
- new insights into their own research;
- advances in their research profile; and career path refinement.



specialist physics teachers in UK STEM education. For example, teacher testimony includes highlighting how “meeting the PhD students reconnected me with the excitement of studying science... and reminded me what science education can be about” (Orbyts partner teacher), and that “...in a tough year with significant professional challenges to overcome, this has been a real ‘get me out of bed in the morning’ kind of project” (Orbyts partner teacher).

Another Orbyts partner teacher said: “The project has fed back down through the school with Orbyts members giving presentations to lower year groups and it’s even changed my teaching to my 13-year-old students – all my magnetism stuff is now fed through the lens of the importance of our magnetic field and what the aurora on Earth tell us about the conditions necessary for life here... Multiple other staff have become involved and have had valuable subject knowledge gains, and through the school publications the wider school community – parents etc. – have also become enthused and are talking with their children about the project even if they’re not directly involved.”

Of the teachers surveyed at one of the Orbyts conferences this year, all teachers unanimously responded that they would recommend Orbyts to friends or colleagues. The survey responses from the teachers shown above highlight that the programme is providing substantial support in knowledge, confidence, job satisfaction and supporting the teachers’ sense of belonging in STEM.

Within the teacher survey, we also asked how teachers felt that the programme had affected their students. The most common response was ‘confidence’. We believe that this plays a significant role in the increased uptake of STEM subjects by students at our partner schools, following participation in Orbyts projects.

Top: Students presenting research at the UCL conference  
Above: Survey responses from partner teachers when asked about the impact of their involvement in Orbyts projects

### What’s next?

The past year has been an exciting time for Orbyts! We published our very first Impact Report which summarises the effects of the Orbyts programme to date. The full impact report can be found on our website at [www.orbyts.org/impact](http://www.orbyts.org/impact).

In our London and South East Hub, we have piloted our new Orbyts STAR programme in partnership with Great Ormond Street Hospital, which partners researchers with young people who have long-term medical conditions, empowering them through high-quality bespoke research projects.

At Northumbria we are exploring new avenues with industrial partnerships. Prof Rob Wicks piloted an Orbyts project in partnership with AmbaSat – a UK company based in NorthEast England that provides satellite manufacturing equipment. This project engages the students in design, electronics, operations, and programming of the CubeSat and sensor systems, enabling our North East Hub to directly engage students with a broader range of research careers within STEM and target a wider range of skill development areas.

Our Midlands Hub celebrated their first end of year Orbyts conference hosted at the University of Leicester. School students from three Leicester schools attended the conference to present their research on the variability of solar wind charge exchange at the magnetopause and auroral features observed during intervals of both quiet and active geomagnetic activity. These research projects support the upcoming SMILE mission – an international collaboration between the European Space Agency and Chinese Academy of Science – which will study the structure and dynamics of Earth’s magnetic field.

Our North East and Midlands Hubs are continuing to evolve and grow. In the coming year, we hope to continue to sustainably build all our hubs as we establish relationships with new partner teachers and local schools as well as maintaining relationships with our current partner schools. We aim to enable new partnerships outside of Northumbria University by targeting other local universities and research institutions to expand our impact across the North East. We are also excited to be welcoming new Hubs across the UK and hope to announce their progress over the next year.

Look out for our upcoming articles in future issues of A&G which will be showcasing the exciting and cutting-edge research across the Orbyts network. ●

## Teachers report involvement with Orbyts projects

- increases their desire to remain in teaching;
- inspires their teaching delivery;
- improves their specialist subject knowledge;
- re-energises and reconnects teachers to their love of science; and
- impacts the wider school community.

### AUTHORS

Jasmine Kaur Sandhu  
University of Leicester  
and Michaela  
Mooney University of  
Leicester.



With: William Dunn,  
UCL; Vicky Mason;  
Alex Thompson,  
UCL; Christian Lao, Mullard Space  
Science Laboratory, UCL; and the  
Orbyts Leadership Team.



We would like to thank all our incredible Orbyts researchers, teachers and school students for their enthusiasm and excellent research. The success of Orbyts is enabled by the partner teachers and researchers who give so much to the projects, and the school students who work so hard on them. You can also visit our website to read our impact report, follow us on X to hear all our latest news and see previous projects and read

student and teacher testimonials at [www.orbyts.org](http://www.orbyts.org). Data sources are set out in the Orbyts Impact report, which can be found at [orbyts.org/impact](http://orbyts.org/impact)

### REFERENCES

Ballard C J *et al.* 2023  
*Res. Notes AAS* 7 252  
Archer L *et al.* 2020 *ASPIRES 2: Young people's science and career aspirations, age 10-19* (London: UCL Institute of Education)