

Science Hunters: an inclusive approach to engaging with science through Minecraft

Laura Hobbs, Carly Stevens, Jackie Hartley and Calum Hartley

Abstract

Science Hunters is an outreach project which employs the computer game Minecraft to engage children with scientific learning and research through school visits, events, and extracurricular clubs. We principally target children who may experience barriers to accessing Higher Education, including low socioeconomic status, being the first in their family to attend university, and disability (including Special Educational Needs). The Minecraft platform encourages teamwork and makes science learning accessible and entertaining for children, irrespective of background. We employ a flexible approach that adapts to the needs of the users. More than 8000 children have been engaged in the first four years, with overwhelmingly positive feedback.

Keywords

Representations of science and technology; Science education; Social inclusion

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Context

Computer games have long been used to enhance education [e.g. Betz, 1995; Amory et al., 1999; Jayakanthan, 2002], and we know that learning is more effective when it is fun [Lepper and Cordova, 1992]. Minecraft, “a game about placing blocks and going on adventures” [Mojang and Microsoft, 2018], rapidly became one of the most popular video games in the world following its release in 2011 — within five years it was second in sales only to Tetris, released in 1984 [Peckham, 2016]. Lane and Yi [2017] described Minecraft as one of the most widely used and important games of the current generation. It is also ideal for communicating scientific concepts, as it has features which correspond to real-world processes and is relevant to a variety of natural and physical sciences [Lane and Yi, 2017; Short, 2012].

Minecraft is an open-world, exploratory and generative video game [Lane and Yi, 2017]. Players move around freely, building with and mining a wide range of cubic blocks with varying properties, in a range of ecological and physical

settings. Ecologically representative biomes and complex systems can be modified by the player, enabling them to change and interact with the environment [Nebel, Schneider and Rey, 2016]; an example is shown in Figure 1. Detailed description of Minecraft's features and its use in educational settings can be found in Nebel, Schneider and Rey [2016] and Lane and Yi [2017]. In the U.K., 69% of 6–10 year olds and 81% of 11–14 year olds play video games [U.K. Entertainment Association, 2018], and many children are hugely experienced with Minecraft, giving them a sense of expertise and ownership. And so, in 2014, Science Hunters was created, pulling together the huge popularity and potential for enhancing scientific literacy of Minecraft by using the game to engage children with learning about science.



Figure 1. During a Science Hunters session, a Minecraft player has planted virtual seeds, in an enclosure constructed in the pre-existing landscape, and supported them to grow by strategic placement of water trenches. All features are comprised of cubic blocks with varying properties and appearances.

Project rationale

Science Hunters is delivered within the remit of 'Widening Participation', targeting children who may face barriers to accessing Higher Education [Higher Education Funding Council for England, 2017]. These may include, for example, low family income, being the first in their family to go to university, being in care, disability, or being of a Black, Asian, and Minority Ethnic (BAME) background [Lancaster University, 2019]. It is also particularly important for girls to see science as for 'people like them' [MacDonald, 2014]. A range of often intersecting factors may affect children's opportunities to access informal science learning [Atkinson, Siddal and Mason, 2014]; an overarching aim of Science Hunters is to raise science capital — science-related knowledge, experiences, attitudes and resources — and aspirations [Archer, DeWitt, Osborne et al., 2012] in these groups. A strong focus on reaching and benefitting children with Special Educational Needs (SEN) has developed, enhanced by collaboration with the National Autistic Society, the leading U.K. charity for people affected by autism [<http://www.autism.org.uk/>].

The intention, in using Minecraft, is to allow children to explore science topics by comparing processes that occur in the real and virtual worlds, with the aim of

helping children to understand and remember the processes involved. For example, one topic covered is 'Volcanoes'. The volcanic glass obsidian can form when lava cools instantly in contact with water. In Minecraft, obsidian forms when the source block of a lava flow — its hottest part, which has not begun to cool in the air — touches water. Other parts of the lava flow, which have begun cooling in the virtual air, solidify in contact with water, but do not form obsidian. Another example is that crop seeds in the Minecraft world require correctly prepared soil and adequate light to grow. Growth rates also respond to sources of water and fertiliser. Participants can design their own farms to approach the problem of feeding a growing population, and build them.

The opportunity to engage with such interactions in Minecraft, alongside handling real samples and interacting with scientists, is offered in the hope of raising students' awareness of, and interest in, scientific concepts. These both link to content within the National Curriculum [Department for Education, 2014], complementing school-based learning, but are not usually covered in such detail within their formal education unless they choose to study specific subjects at a higher level.

Project delivery and approach

Science topics are mainly centred around research undertaken at Lancaster Environment Centre, an interdisciplinary research centre at Lancaster University, U.K. where the project is based.

Science Hunters currently reaches children through a variety of free-to-access activities:

- School visits (mainly taking activities to schools, and also working with school groups visiting the university campus);
- Public events, such as providing activities at festivals;
- Minecraft Clubs for specific groups: (1) an established club on Lancaster University campus for children with autism, (2) a newly established club for children in care developed in collaboration with Worcestershire County Council (a local authority in England) which is delivered in the county and local university jointly operated main library, and (3) a newly established group for children in residential care in Cumbria, U.K., also delivered on Lancaster University campus.

Project staff have research backgrounds in Environmental Science plus extensive skills and experience in learning delivery and engagement. Additional staffing is provided by volunteers, who include other researchers with similar backgrounds and students from a range of faculties and departments at Lancaster University. Student volunteers gain valuable skills and experience relevant to work in psychology, education, and engaging the public with research, with some undertaking structured placements with the project designed to enhance their employability post-graduation.

During Science Hunters activities, Minecraft is typically operated in 'creative' mode, giving players an unlimited number and diverse range of blocks with which

to build. A version of Minecraft specifically designed for educational delivery is used, ensuring children play in a safe environment by preventing connections outside the classroom and restricting access to certain game features that could interfere with the learning experience (such as use of virtual items that could damage others' builds).

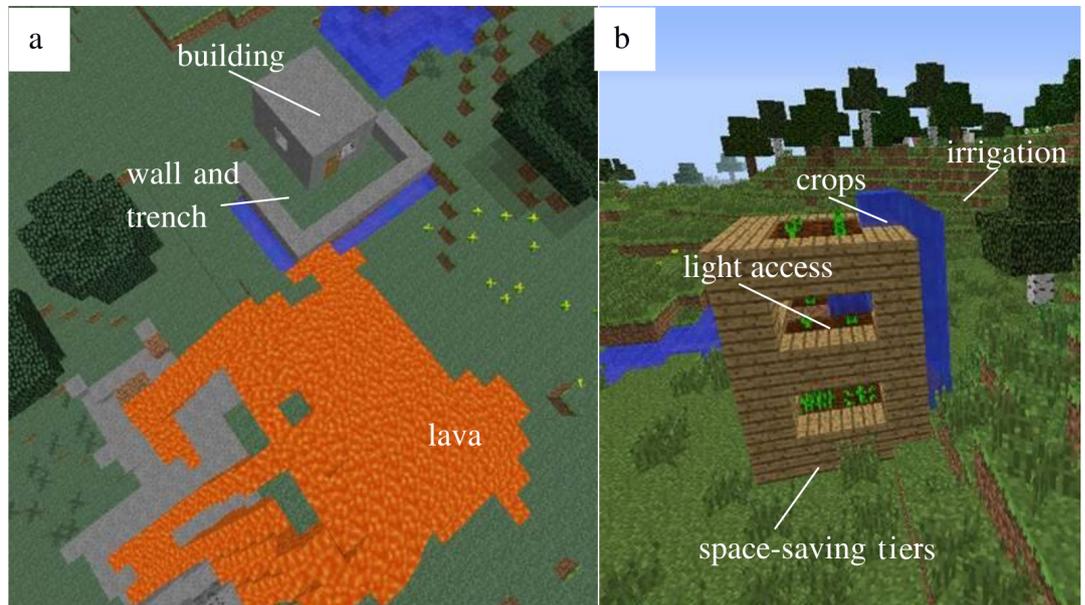


Figure 2. Examples of (a) an erupting volcano and management of resulting hazards (a wall and water-filled trench have been constructed to prevent lava reaching the building) and (b) space-saving farm with light access and an irrigation system, designed to produce food in within a limited surface area, both constructed in Minecraft under the framework of Science Hunters sessions.

Science Hunters delivers activities for children of all ages, typically up to the age of 16 years. During sessions, a science topic is briefly introduced at an accessible level appropriate to the ages and needs of the audience, enhanced with hands-on, practical demonstrations and interactive discussions which can be referred to later. Children are then set a task or challenge which demonstrates a real-world process or solves a real-world problem, such as a hazard-generating volcano needing management or a space-saving farm suitable for feeding a growing population in the future (Figure 2). For example, the structure of the 'Food Security' session is broadly:

- Food security topic introduced by session leader: finding out what students think this means, leading them to work this out by means of targeted questions and exploration and expansion of existing knowledge;
- Food-related hands-on samples found in Minecraft used to support and elaborate on this: demonstrate how much space needed to produce food, provide opportunity for children to see food sources in unprocessed states (for example, carrots with uncut leaves, sugar cane, cocoa beans and wheat seeds) and initiate relation of the topic to the Minecraft world;
- Challenge of healthily feeding a growing population whilst having increasingly less space in which to produce food thus raised: students set task of designing a space-saving farm that could be used to resolve this difficulty in future;

- Students direct play: decide how to approach task and what form and function their farms take;
- Learning can be further reinforced over time: leaving an activity, such as growing seeds in a transparent bag, which demonstrates germination and then plant development in a small space.

Science Hunters activities employ a learner-centred constructivist approach [Brooks and Brooks, 2001; Rovai, 2004] characterised by a teaching environment that has a positive impact on learning [Rosen and Salomon, 2007]. As outlined above, focus is on students directing their learning in line with their interests and solving problems through use of Minecraft, with a clear emphasis on constructing understanding and meaning from the information given, within the context of the game. Session staff support children to use their imagination and creativity, exploring the concepts discussed and developing their learning and understanding by creating related builds in Minecraft. Whilst the topic under consideration provides a framework for construction within the virtual world, activity undertaken within the game is directed by the children. In practice this means that the session leader sets a building task or challenge related to a specified theme considering a real-world problem or demonstrating a real-world process, and children then decide how they address this in Minecraft. This enables children to test and explore concepts in a way that is not possible in reality and pursue their own interests by focusing on aspects of the topic that they find most engaging. Thus, anchored instruction [The cognition and technology group at Vanderbilt, 1990] and constructionism [Papert and Harel, 1991] are applied by contextualising the themed building challenge in a real-world situation and building upon existing knowledge to explore the topic and advance understanding.

Children typically attend in small groups; most commonly 10–20 participate in each session. As Minecraft presents valuable opportunities for developing peer collaboration and mentoring skills [Kervin, Verenikina and Rivera, 2015], students often work in pairs, with further collaboration and assistance between pairs encouraged. The needs of the participants are paramount in the practical arrangements for sessions, which are decided on an individual basis with each hosting organisation to ensure that these needs are met. For example, the session length may be altered or group sized reduced as adjustments in consideration of particular needs. The pedagogical approach of the sessions and use in botanical contexts are discussed further in Hobbs, Stevens and Hartley [2018a], while geoscience topics in particular are addressed in Hobbs, Stevens and Hartley [2018b].

Topics for delivery in one-off school and public event sessions are based in Environmental Science; topics covered include ‘Volcanoes’, ‘Food Security’, ‘Animal Habitats’, ‘Flowers’ and ‘Biomes’, which link both to areas of the National Curriculum in England and research expertise at Lancaster Environment Centre. New topics are added annually to add value and variety to the schools programme, with some developed in direct collaboration with schools.

The established Minecraft Club runs fortnightly on Lancaster University campus for children with Autism Spectrum Disorder (ASD) — a neurodevelopmental disorder characterised by profound impairments in communication and interaction — who often have difficulty engaging in “real life” social situations

[American Psychiatric Association, 2013]. Although Minecraft can be a single-player game, many children use shared virtual worlds in which they interact and communicate with each other. Minecraft is a shared interest of many children with ASD, and countless anecdotal reports suggest that the social-interactive aspect of Minecraft has great benefits for children's confidence, social motivation, and communication skills. As children attend multiple sessions, topics change regularly and are wider ranging than those in the schools programme, from pollination and renewable energy to neuroscience and virtual reality technology, to provide variety and avoid repetition. These often link to wider events and themes, with delivery tailored to accommodate the diverse range of ages, backgrounds, and needs of attendees. An associated programme of sessions has also been delivered in libraries in areas with high levels of urban and rural deprivation, with support from an external funding grant. Feedback for all strands of the project is gathered through a variety of media, including comments on Post-It notes, 'smiley face' feedback cards, word walls, verbal reporting, questionnaires, and observational records.

The project so far

From the start of the 2015–2016 school year to the end of the 2017–2018 academic year, school sessions were delivered in over 100 primary, secondary and specialist schools across England, with more than 5000 child engagements covering school years from Reception (starting age 4) to Year 13 (ending age 18), spanning the full range of statutory education in the U.K.

In the first three years of the project, 19 external events have been delivered, reaching more than 2500 children. These are held in a variety of locations, such as in local libraries and at science and community festivals, and range from short sessions working with small groups of around ten children, to multi-day events engaging hundreds of participants. Where appropriate, topics have been developed to reflect the nature of the venue in which the session takes place and/or wider events (for example, a session on minibeasts was designed to align with the theme of British Science Week 2018 and link with provision at Lakeland Wildlife Oasis [<https://wildlifeoasis.co.uk/>] where the event was hosted and has now been incorporated into the schools offer). Children of all ages attend these events (Figure 3).

The established Science Hunters Minecraft Club for children with ASD has been running since 2015 and reaches around 30 children per year. There is space for 16 children in the club at any one time, with children attending for as long as they wish. A waiting list is in operation so that vacated spaces can be filled immediately. The success of the club for children with ASD has led to the initiation of two new Minecraft Clubs in the 2018–2019 academic year. One, in collaboration with Worcestershire County Council, will benefit local children who are or have been placed in the care of someone other than their parents, or adopted, and face the challenges that this brings, and was initiated during the school mid-term break of Autumn 2018. The club reached 25 children during this week and will continue through the 2018–2019 school year. A second Minecraft Club for children in residential care has been initiated with a care facility in Cumbria, U.K., beginning in early 2019.

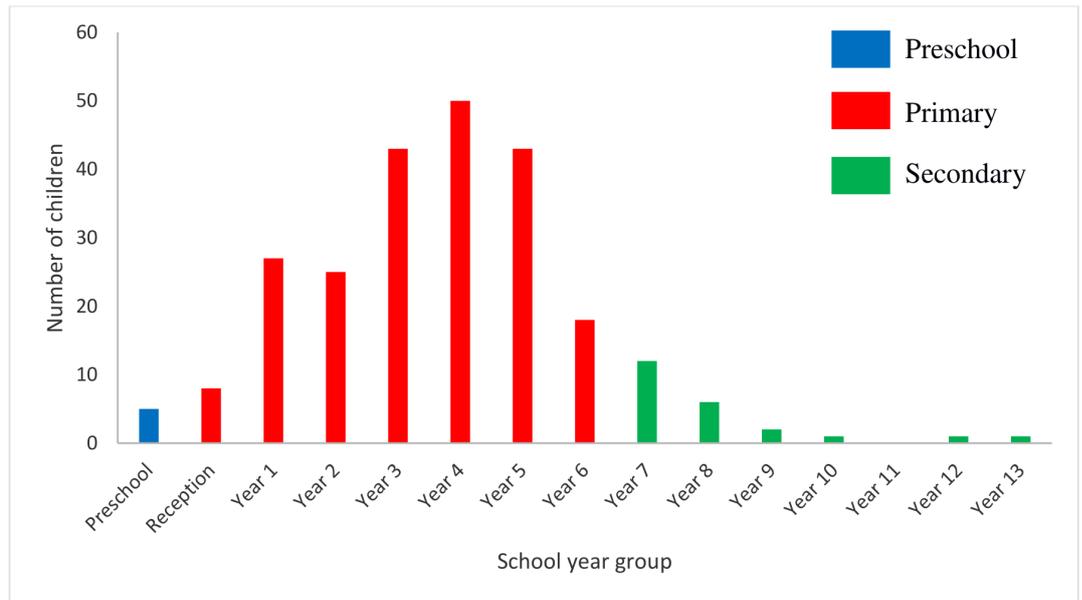
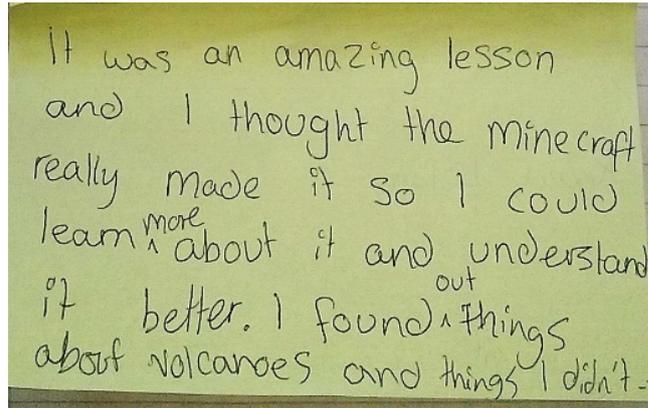


Figure 3. Age by school year group of children who chose to attend Science Hunters public events in the 2016–2017 academic year. Ages range from preschool (0–4 years) through primary school (4–11 years) to secondary school (11–18 years) and broadly reflect the distribution of ages worked with in schools.

Impacts on participants

Feedback has been overwhelmingly positive; in the project’s first three years of school visits, all attending children reported that they enjoyed the session and could relay something they had learnt. In particular, they tell us that using Minecraft makes the session “fun, enjoyable and different” to their standard school lessons, and that it helps them to understand the content being discussed. For example, a secondary school student reported anonymously via written feedback that “*It was an amazing lesson and I thought the Minecraft made it so I could learn more about it and understand it better*” (Figure 4). Children and teachers appreciate being able to explore novel research areas that link to their teaching and learning curriculum in greater depth than they would usually be able to do and with access to relevant expertise, and being able to participate in related hands-on demonstrations and ask in-depth questions about them. For example, secondary school teachers told us via email “*I am very grateful for the support that you have shown me and the insight to my pupils that science is more than just Biology, Chemistry and Physics*” and “[Staff member] was so engaging, the students loved her approachable and enthusiastic delivery linking rock specimens with personal stories of field work and then using Minecraft to model the making of the different rocks. . . I have been privileged to work with [staff member] to bring science to life, out of the classroom and encourage students to think about STEM qualifications and jobs in this field. [Some of our] students are interested in a career in the sciences and will hopefully be first generation in their families to attend university.”

Children also value reassurance and confirmation that potential barriers to attending university or achieving academically can be overcome, and that science can be “for them”, with teachers noting that the strong representation of female scientists on the team “*will hopefully inspire some of the girls too*” and has prompted “*several of our girls say that they now want to be scientists too and discover something new*” (primary and secondary school teachers, verbal feedback).



It was an amazing lesson
and I thought the minecraft
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it better. I found ^{out} things
about volcanoes and things I didn't ->

Figure 4. Anonymous written feedback from a secondary school student participating in a Science Hunters school session.

Teachers report multiple benefits, often noting that concentration levels are higher than they would typically expect, and that children who would usually find it difficult to participate in lessons are engaged and absorbed throughout. In many cases, they comment that children who would generally exhibit lower levels of social-communication are interacting and collaborating with their peers (e.g. *"It was great to see our students engaged and interacting with each other during the workshop. Not only were they learning about volcanic processes but they were socialising and having fun! These students find it hard to join in many of the activities in a mainstream setting so it was amazing to see them confidently working with you"*; email feedback from a secondary school teacher supporting a group with SEN) and *"This is great, it just works for them. It's allowing them to explore on their own terms at whatever level they need, it's a great leveller. It's great to see them all engaged at the same time and getting into something like this, and it's relevant as well because of what they've been hearing about on the news"* (verbal feedback from a teacher observing a session in a school for children with SEN).

In some cases, children who would not typically be expected to collaborate with others (including those who have previously exhibited aggressive behaviour when asked to) have happily worked in partnership on a shared laptop, because they *"want to play Minecraft and the topic interests them"* (primary school teacher, verbal feedback). Additionally, the use of Minecraft means that children can both demonstrate what they've learnt within the session and by consolidating their learning through the game, remember it later. For example, comments such as *"The session was a great success and the pupils really enjoyed it. They still talk about it now months afterwards which is a testament to the way the session was delivered"* and *"They have remembered the experience and therefore have remembered the content"* have been submitted through anonymous online questionnaires which are sent to participating teachers each school year. These questionnaires have an average response rate of 50% and thus far, 100% of respondents have stated that they would participate again; schools often request repeat visits and the project has supported several to set up their own Minecraft Clubs to build on their participation in the project. Parents have contacted the project following school visits to express their appreciation of the impact on their child, for example *"It's a confidence boost for kids like [name of child] who struggle with their self-esteem"* (sent via social media direct messaging).

Children participating in public events often report through anonymous written feedback cards that they think the sessions are “cool”, “awesome” and the best or their favourite part of the wider event. Other typical feedback includes comments such as “*my children learnt about the connection between real life and games well*”; “*excellent for mixing playing with the curriculum*”; “*amazingly wonderful, engaging and educational*”; “*I love the idea. It engrosses children while teaching science*”; “*my daughter really enjoyed the Minecraft... great idea to include kids in the Uni and help teach them — wonderful idea*”; “*It is very good for kids to be creative — it is a good opportunity to learn*”; and “*my son loved it and came back on all three days to try something new*”.

Of all anonymous written comments collected by the project between 2015 and 2018, only two (< 1%) could be considered negative; one of these (“it was OK but I wish there was more learning to it”) did not expand further and was inconsistent with other reported experiences, and the other was contradictory, for example stating that the session was both fun and no fun, and not coherent [Hobbs, Stevens, Hartley et al., 2019, in review]. Externally collected feedback is also overwhelmingly positive, consistent with feedback collected directly, and the project is now an invited feature and recurring activity at several shows and events.

Parents/carers attending Minecraft Clubs appreciate the inclusive nature of the project. They acknowledge that it benefits their children by facilitating social-communication, placing accommodation of their additional needs paramount and presenting science in a novel way that promotes their learning more effectively than standard school lessons, which do not always engage their children for various reasons. Typical feedback includes comments such as “*He has given up every other extracurricular activity he has tried, as everything else puts him under some kind of pressure and he gets enough of that at school*” and “*It has been great for him to be doing an out-of-school activity in a setting where he can be an expert, with other people who enjoy the same things*” (both reported via anonymous parent/carer questionnaires). We also receive detailed feedback through personal communication, such as news that a child who would previously not communicate in writing would now send instant messages (as is possible in the game) and that another child has been able to improve communication in other social contexts and reduce specialist support needed in school, progress which parents/carers attributed to the confidence and social-communication skills their children developed at Minecraft Club.

Across all areas of Science Hunters, interest in the project has elevated to such a level that a significant number of requests for delivery cannot be met due to logistical constraints. This high demand has grown year on year and as such the project has had to expand its funding and team accordingly.

Discussion and conclusions

Minecraft has proved a valuable tool in visualising, exploring and interacting with a range of scientific concepts through the Science Hunters approach to science engagement. The game allows safe experimentation in a way that isn't possible in a real life situation. There are a huge range of topics to which this can be applied, and learning opportunities to be engaged with, which we are continuing to explore.

Children seeing science as “for them” is particularly relevant for the groups targeted by the project; for example, girls and working-class boys tend to have

particularly low scientific aspirations [Archer, DeWitt and Willis, 2014; MacDonald, 2014] and are core audiences for Science Hunters. “Traditional” career expectations are further challenged by the fact that a significant proportion of Science Hunters staff would be categorised as coming from ‘Widening Participation backgrounds’ themselves, with especially strong representation of female scientists.

Quality of delivery and impact has been exceptionally high; every child participant surveyed after participating in a Science Hunters school visit has been able to relay something they had learnt, and all teachers responding to anonymous surveys have done so positively. Feedback from public events and the project’s Minecraft Club is also exceptionally positive. These comments reflect the educational aspects of the activity and links between Minecraft and real world processes, indicating that the aim of engaging people with science through the game has been met, and the inclusive and accessible ethos of the project as a whole. At our long-running Minecraft Club, local children with ASD can play together on a dedicated server, naturally eliciting social behaviour both within and outside the virtual world; these benefits can now be extended to new groups in our additional clubs. Importantly, Minecraft Clubs on campus and in university facilities provide excellent opportunities for children to become familiar with university environments while providing positive experiences associated with science and social interaction. The strongly positive feedback and necessary expansion of the project due to demand, while not quantitative measures, are an indication of the success and appeal of the Science Hunters approach to science communication with children who may not usually engage with such activities.

Feedback from participants, parents/carers, teachers and external collaborators demonstrates that Science Hunters’ accessible and inclusive approach and structured use of Minecraft provide an effective and appealing method for engaging children with science, research, learning, and participation in Higher Education. This is applicable to work with schools and groups of children with Special Educational Needs in particular, at small and large public events and in dedicated extracurricular clubs supporting underserved groups. The project is highly successful and its novel approach to communicating and raising enthusiasm for science presents a valuable resource in the fields of widening access to and participation in further study and appreciation of science subjects at school and beyond.

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Authors

Laura Hobbs has a PhD in Environmental Science; with a research background in both volcanology and science communication, she coordinates the Science Hunters project at Lancaster University. She also runs Science from the Start, specialising in science communication for underserved audiences, and is a Research Fellow in Science Communication at the University of the West of England. E-mail: l.hobbs@lancaster.ac.uk.

Carly Stevens has a PhD in plant ecology and is a senior lecturer in ecology and Director of Postgraduate Research Students at Lancaster Environment Centre, Lancaster University. She initiated the Science Hunters project in 2014 after realizing that computer games had great potential to enthuse and inspire students who were less engaged with their education. Her own research is into how global change impacts on plants and soils. E-mail: c.stevens@lancaster.ac.uk.

Jackie Hartley has a PhD in Animal Behaviour and a BSc in Zoology. After completing her PGCE in Secondary Science teaching, she taught for over 15 years in school and college. She is now a Science Hunters project assistant at Lancaster University, developing and delivering Science Hunters sessions and works as an education officer in the energy industry. E-mail: j.hartley7@lancaster.ac.uk.

Calum Hartley has a PhD in Psychology and is a lecturer in the Department of Psychology at Lancaster University. He is a collaborator on the Science Hunters project and is particularly involved in Minecraft Club. He conducts research with children with autism spectrum disorder focusing on symbolic communication, word learning, and understanding of ownership. E-mail: c.hartley@lancaster.ac.uk.

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