Using Minecraft to engage children with science at public events

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Abstract

Engagement with science and scientific skills are an important aspect of children's ability to navigate the world around them, however engagement with science is low in comparison to other subjects. The Lancaster University outreach project Science Hunters takes a novel approach to engaging children with environmental science research, through a constructivist pedagogical approach using the popular computer game Minecraft. While Minecraft is extensively used in formal education settings, few data are available on its use in public engagement with scientific research, and the relationship between children's and adults' attitudes to science and computer games are complex. Through motivational surveys conducted as part of the project evaluation, we analysed feedback from participants attending sessions as part of a programme at public events, to explore basic demographics of children attending our events, and whether it is the prospect of learning about science, or the opportunity to play Minecraft that leads them to choose our activity. We also present evaluation of general feedback from participants at public events over four years to give a broader view of participants' response to the activities.

Key learning points

- General feedback is highly positive; children are having fun and engaging with the scientific research and learning presented
- Minecraft is a driver behind the decision to attend the activity; while many participants are also interested in science, more choose this activity because Minecraft, rather than science, is involved
- The Science Hunters approach is effective at attracting and engaging people to engage with scientific research and is transferable to other fields

Keywords

Science communication; informal learning; Minecraft; environmental science

Introduction and background

As part of their education, children need to develop a range of skills and knowledge that enable them to understand scientific and technological aspects of the world around them, including evidence-based reasoning, inquiry-based skills and understanding the nature of science and how scientific knowledge is developed (‘scientific literacy’) (Harlen, 2018). This is important not only for future scientists, but for everyone, as the basic principles of scientific understanding are extremely valuable tools in navigating the world and everyday life, and a scientifically literate population is beneficial for society as a whole (e.g. Czerski, 2016; Science and Technology Committee, 2017; Harlen, 2018).

However, there is abundant evidence that, in comparison to other school subjects, science is failing to engage children and young people (e.g. Archer et al., 2012 and references therein). For example, while children commonly enjoy science (Murphy and Beggs, 2005; Kerr and Murphy, 2012) and many adults think science is important in everyday life and that young people’s interest in science is essential for future prosperity (Castell et al., 2014), there is a substantial body of evidence indicating that children’s interest in science are formed by age 14 (Archer et al., 2012 and references therein) with decline in interest beginning at around age 10 (Murphy and Beggs, 2005). This decline is less apparent when children are involved in practical, investigative activities (Murphy et al., 2004), and teachers suggest that making science more relevant to pupils’ experience is the best way to improve science teaching and learning (Murphy and Beggs, 2005). Cultural biases such as perceptions of scientists as ‘brainy’ also lead to people feeling that science is not ‘for them’ outside of formal education settings (e.g. Archer et al., 2013; Science and Technology Committee, 2017). Therefore, initiatives which encourage young people to engage with science, and complement science learning in formal education, are vital for increasing our science capital (science-related knowledge, experiences, attitudes and resources; Archer et al., 2012) (Science and Technology Committee, 2017).

With this is mind, Science Hunters was initiated in 2014 as a small project, aiming to use the computer game Minecraft to communicate scientific concepts and inspire interest in and enthusiasm for science in children. This approach draws on the knowledge of the increased efficacy of learning when it is fun (Lepper and Cordova, 1992) and long history of using computer games to enhance education (e.g. Betz, 1995; Amory et al., 1999; Jayakanthan, 2002, Hobbs et al., 2019). . Now in its fifth year, the project has grown substantially and currently engages around 6000 children each academic year. Science Hunters activities are open to children of all ages and include visits to schools, Minecraft Clubs for children in specific groups (such as children who are in care, or have autism) and attendance at public events and festivals, along with other sub-projects such as production of home packs and online resources to enable families to undertake activities at home.

Minecraft is an extremely popular game, particularly with children; Lane and Yi (2017) described it as one of the most important, and widely used, computer games of the current generation. Minecraft is a construction-based, open-world game in which players are able to create an infinite variety of structures by utilising blocks with a wide range of appearances and properties. The Minecraft worlds within which each player operates emulate ecologically realistic environments and physical processes, making the game an ideal teaching tool for increasing scientific literacy amongst children (Lane and Yi, 2017; Short, 2012; Hobbs et al., 2018a). Science Hunters uses an educational version of Minecraft set within 'creative' mode to ensure a safe play environment and unlimited access to building blocks.

Minecraft is used extensively in educational contexts, from literacy (e.g. Litcraft; Lancaster University, 2019a) to geography (e.g. Short, 2012) and chemistry (e.g. Molcraft; Hullcraft, 2016). A Minecraft educator online community provides resources and support via the Minecraft Education Edition website (Mojang, 2019). The simplicity and relative affordability of the game make it a viable option for classroom use for both students and teachers and its accessibility facilitates active construction of knowledge and children can collaborate and engage with questions within its interactive environment (Nebel et al., 2016). Detailed accounts of Minecraft's features and its use in a variety of formal educational settings and research contexts are given in Nebel et al. (2016) and Lane and Yi (2017) and include its application to arts, computing, physics, chemistry, geology, storytelling and social skills education. However, while there is a growing body of work on the use of Minecraft in education and learning research (Nebel et al., 2016 and references therein), there is relatively limited information available about its use in facilitating informal science learning and public engagement with science more broadly

While children in schools are selected for participation in Science Hunters activities by their teachers, children attending sessions at public events do so by choice, with the agreement of their parents/carers. Therefore, in order to explore the appeal of the project's activities, we investigate the efficacy of the project's use of Minecraft to engage children with science and research at public events as part of our project evaluation. In this paper, we evaluate general feedback from public events to assess attendees' experience of the sessions, and where Science Hunters sessions are part of a larger programme of activities, we look at what motivates people to choose our particular activity. Who is choosing to attend our sessions; for example, do they appeal to a particular age range? Are the sessions only appealing to people who are strongly interested in science or Minecraft, or a broader audience? Minecraft is an extremely popular game (Lane and Yi, 2017) yet many adults struggle with the amount of time their children spend on computer games (Nebel et al., 2016), and children and adults often enjoy and see the value of science (e.g. Murphy and Beggs, 2005; Castell et al., 2014) but engagement with and attitudes towards science are not always positive (e.g. Archer et al., 2013; Science and Technology Committee, 2017), therefore, which element most drives people to attend, the science or the Minecraft?

Methods

Project approach and delivery

As a Widening Participation project, Science Hunters particularly aims to reach children who face one or more barriers to accessing Higher Education, such as disability, low family income, being of the first generation in their family to attend university, being of Black, Asian and Minority Ethnic background, or being in care/a care leaver (Lancaster University, 2019b). While it is more difficult to monitor uptake in these groups at public events than in schools and at Minecraft Clubs where attendees are known to the school or project, activities are always designed to be relaxed, informal and accessible to all (Hobbs et al., 2019). For example, we readily adapt delivery and the Minecraft challenges set to cater for a range of ages, abilities and needs. We do not charge for our activities and ensure that there is no pressure on children to participate, complete their challenges or execute them in a particular way. We choose to take our activities to community-based venues such as libraries which are familiar and appropriate to family-based audiences, or to family-oriented festivals, so that the educational aspects of the activity are non-intrusive and the research involved is accessible and inclusive (Hobbs et al., 2019).

Research areas that have been covered include food security, volcanology, animal adaptations, parasite ecology, plant biology, insect ecology, coral reef ecosystems, flood management and bioluminescence. Pedagogically, we employ a learner-centred constructivist approach (Brooks and Brooks, 2001; Rovai, 2004), using anchored instruction (The Cognition And Technology Group At Vanderbilt, 1990) and constructionism (Papert and Harel, 1991), which is facilitated by the accessibility of Minecraft and its capability to support transformational play (changing their play environment; Barab et al., 2012) by allowing interaction with and modification of the virtual environment (e.g. development of farms) and creation of almost any structure using blocks (Nebel et al., 2016). Through this approach, we encourage inquiry-based learning by supporting children to develop their understanding through their own ideas and efforts alongside collaboration with others, an approach endorsed by a growing body of empirical evidence and professional knowledge (e.g. Loyens and Gijbels, 2008; Harlen, 2018). We first introduce a scientific topic via interactive discussions, hands-on activities and demonstrations, and then set children a related problem to solve in Minecraft. The approach children choose to solve this problem is guided by their own imagination and the aspect of the topic they find most interesting, with guidance from session staff (Figure 1a). This focus on the students directing their own learning and solving problems through use of Minecraft, with a clear emphasis on constructing understanding and meaning from the information they've been given, was chosen as it ensures that children can find and maintain interest in and understanding of scientific topics and feel a sense of ownership and that science is 'for them', whilst consolidating their learning (Hobbs et al., 2018a). As an example, a 'volcanoes' session might include (depending on ages, abilities and needs of the group attending) an interactive discussion and demonstrations about volcanic hazards and hands-on activities introducing different types of volcanic rocks. This would be followed by a related challenge which could be to build a volcano, create a particular rock type using interactions in Minecraft that are analogous to processes occurring in the real world, or build features in order to manage a volcanic hazard (Figure 1b, 1c). Detailed descriptions of session structures can be found in Hobbs et al., 2018a; 2018b; 2019).

Figure 1. (a) Children participating in Science Hunters sessions undertake creative challenges in Minecraft related to the science topic introduced during interactive discussion and demonstrations, directing their building according to their interests and with guidance and support from session deliverers. Children here are building parasites at Campus in the City

(2018) with support from Science Hunters volunteer Amber Drinkwater. (b) A five-year-old child explores lava and water interactions in Minecraft at a Science Hunters public event. (c) Lava (orange) from a volcano built by a child in Minecraft during a Science Hunters Minecraft Club session is prevented from reaching other constructions using walls (black) and water (blue) to impede its flow.

Evaluation data collection and analysis

The evaluation data analysed here were gathered from a range of public events between 2015 and 2018, as detailed in Table 1. These events were both small (attended by ≤ 50 children) and large (attended ≥ 100 children). It should be noted that at the larger events, due to limitations imposed by physical space and numbers of computers available, the largest number of children involved at any one time was under 50 and was most commonly 10-20, so that participant numbers at any one time were broadly consistent.

Table 1. Public events at which evaluation data used in this analysis was collected for Science Hunters. Participant numbers refer only to the number of children attending the Science Hunters activity. General evaluation data refers to feedback about the activity; motivational evaluation data is information about what prompted people to choose the Science Hunters activity out of all those on offer at the event.

Year	Location	Number of children	Part of a larger event?	If yes, a science event?	General or Motivational evaluation data used	Number of other activities on offer and total event attendees
2015	Lancaster Central Library, Lancaster, Lancashire	28	No	N/A	General	0 other activities, 28 total attendees
2016	Lancaster Central Library, Lancaster, Lancashire	25	No	N/A	General	0 other activities, 25 total attendees
2016	Heron Corn Mill, Beetham, Cumbria	44	No	N/A	General	0 activities, 44 total attendees
2017	Lancaster University Community Day, Lancaster, Lancashire	212	Yes	No	Motivational	80 other activities, 2000 total attendees.
2017	Lancashire Science Festival,	194	Yes	Yes	Motivational	8 other workshops/approx. 200 other

	Preston, Lancashire					activities available. Total attendance 13000 across three-day festival.
2018	Lakeland Wildlife Oasis, Milnthorpe, Cumbria	22	No	N/A	Motivational General	1 other activity available, 28 total attendees.
2018	Campus in the City, Lancaster, Lancashire	190	Yes	No	General	0 other activities available, 190 total attendees.
2018	Geronimo Children's Festival, Arley Hall, Cheshire	554	Yes	No	Motivational General	Approx. 100 other activities,
2018	Lancashire Science Festival, Preston, Lancashire	403	Yes	Yes	General	7 other workshops/approx. 200 other activities available, 13000 attendees across three-day festival.

At five of these events other activities were available. For context:

- At Lancaster Community Day 2017 these included activities based in art and music, Science Technology Engineering and Maths showcasing and experiments, sport and wellness, play, food, and community and emergency services. More information is available at https://www.lancaster.ac.uk/events/community-day/.
- At Lancashire Science Festival 2017 and 2018, a large programme of science-related events was available, including workshops (of which the Science Hunters activity was one), stage shows and demos, hands-on drop-in activities, and activities with community and emergency services. More information is available at https://lancashiresciencefestival.co.uk/archive/. It should be noted that in both years, attendance figures for Science Hunters workshops were capped by availability of facilities with attendance via advance booking only. All were full to capacity.
- At Lakeland Wildlife Oasis in 2018, the wildlife centre (a small, all-weather zoo) itself was also open to visitors. There were a total of 88 visitors to the zoo, of whom 28 were children, on the day of the event. The zoo is a fee-charging visitor attraction; entry to the Science Hunters activity only was free of charge.
- At Geronimo Children’s Festival in 2018, a wide programme of children’s activities was available across three days. These included stage shows, music, circus and theatre workshops, sport and wellbeing activities, children’s entertainers, and a funfair.

General feedback was collected during small events at which there were no alternative activities on offer between 2015 and 2016 (Lancaster Library (2015), Lancaster Library (2016) and Heron Corn Mill (2016)) through ‘word wall’ feedback in which adults and children could leave their comments. This method was chosen as an anonymous, fun method of collecting feedback that did not intrude on engagement with the activity as it could be completed outside active participation in the session, for example at the point of leaving.

During 2018, general feedback for Science Hunters sessions was collected using feedback cards inviting 'smiley face' negative/neutral/positive feedback responses and comments at Campus in the City, Lakeland Wildlife Oasis, Geronimo Children's Festival and Lancashire Science Festival. This method was developed as the project progressed and expanded over several years, with changing evaluation needs, and moved from delivering exclusively at small, localised events to participating in larger multi-activity events with wider reach. Using rating scales such as the smiley face scheme allows efficient assessment of attendees' opinions of the activity as a quantifiable measure of success, and is more accessible to children with lower levels of literacy than a word wall. Examples of both methods of feedback collection are shown in Figure 3.

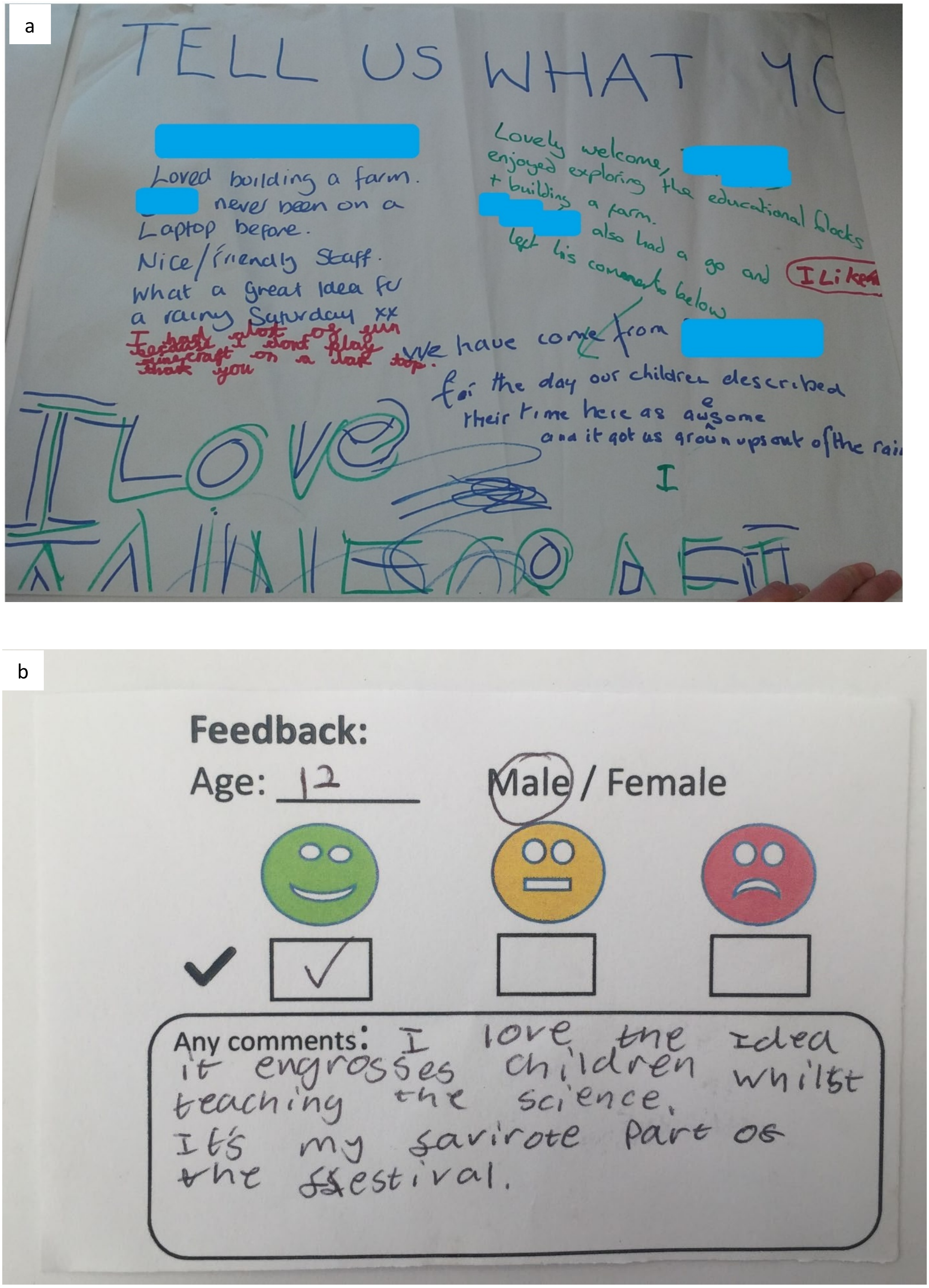


Figure 3. (a) A portion of the 'word wall' feedback left at Lancaster Library in 2015. Some

identifying details have been redacted for privacy. (b) An example of a feedback card returned at Geronimo Children's Festival in 2018.

The contents of all comments given were grouped into the following categories: (i) indication of fun/enjoyment, (ii) activity location, (iii) reference to the science topic, (iv) educational elements, (v) staff and atmosphere, (vi) mention of Minecraft, (vii) excitement, (viii) experiencing technology and (ix) negative comments. Responses given via 'smiley faces' have been translated into positive, neutral and negative feedback. Evaluation information collected centrally by main event organisers is not included here.

As the reasons behind the project's successful attraction of participants at public events (Hobbs et al., 2019) cannot intuitively be linked to either the use of Minecraft or communication of science, as part of project evaluation for Science Hunters, we asked people attending public events through their own choice to tell us (i) how often the child participating plays Minecraft, (ii) whether the child participating or the adult accompanying them decided to attend the session and (iii) how interested that person is in science and in Minecraft and which element most strongly influenced their decision to take part in the session. All data were gathered using self-completed paper questionnaires handed to accompanying adults at the following public events (see table 1): Lancaster University Community Day (2017), Lancashire Science Festival (2017), Science Hunters at Lakeland Wildlife Oasis (2018) and Geronimo Children's Festival (2018). Adults were asked to complete the questionnaires rather than children so that data collection did not interfere with children's participation in the activity, and to minimise bias towards opinions of children with higher literacy levels. Children as well as adults had to consent to the data collection as they would be asked for their input in cases where they had chosen to come to the session themselves. Although this information was collected for evaluation rather than research purposes, data collection nevertheless conformed to the standards of the British Educational Research Association Ethical Guidelines for Educational Research (2014) and this secondary analysis of the data has been approved by the Lancaster University Faculty of Science and Technology Ethics Team.

Respondents reported, along with basic demographic information, whether adults or children made the decision to attend via tick boxes, in order to ensure that the attitudes of the person most influential in choosing the activity were captured. Likert and semantic differential scales were used to indicate (i) frequency of children's Minecraft play, (ii) interest in science, (iii) interest in Minecraft and (iv) balance between science and Minecraft as the factor behind their decision to attend. These scales ranged from 1 (never/very uninterested/science as appropriate) to 5 (frequently/very interested/Minecraft as appropriate).

At Geronimo Children's Festival, a three-day event, different project sessions were delivered on each day. Responses were collected during one of these days, on which 217 children attended. At other events, all attendees were offered the opportunity to give feedback.

Where responses indicated that the child was the decision maker and therefore provider of information on interests and play frequency, these quantitative indicators were compared to children's school year group (covering preschool (age 4 years and younger) to Year 13 (age 18 years) and whether they were male or female. The resulting data were not normally distributed, and therefore non-parametric statistical tests were used to investigate the relationships between participants' interests and reasons for choosing the activity.

Spearman's correlations (giving correlation coefficient r_s) were used to explore whether there were significant relationships between these factors, for example whether there is a correlation between interest in science and interest in Minecraft, or between interest in science and reason for coming to the activity. Mann-Whitney U tests were used to check whether there were significant differences between respondent groups, e.g. whether children were more interested in science than adults. The level of significance for these tests was set to 0.05, and therefore tests returning a p-value lower than this were considered to have found a statistically significant relationship (i.e. there is more than a 95% chance that the relationship actually exists).

Box 1. Notes on statistics used

Normal distribution of data: Data are described as 'normally distributed' when they are centred around a mean (average value) and decrease equally towards the lower and higher ends of the range of values present. An example of this would be information about the heights of people in a population. Most people will be close to average height. The numbers of people who are shorter and taller than average height will be approximately equal, and only a small number of people will be either very short or very tall. Some statistical tests ('parametric tests') assume that data is normally distributed in order to work, however this is not always the case. For example, if a large group of people were asked to choose a number between 1 and 100, there could be peaks of results at several points along the scale, including at either end.

Non-parametric tests: These are statistical tests which do not assume that data are 'normally distributed'. Statistical software can be used to confirm whether or not data are normally distributed, and therefore which statistical test is most appropriate to use when analysing the dataset.

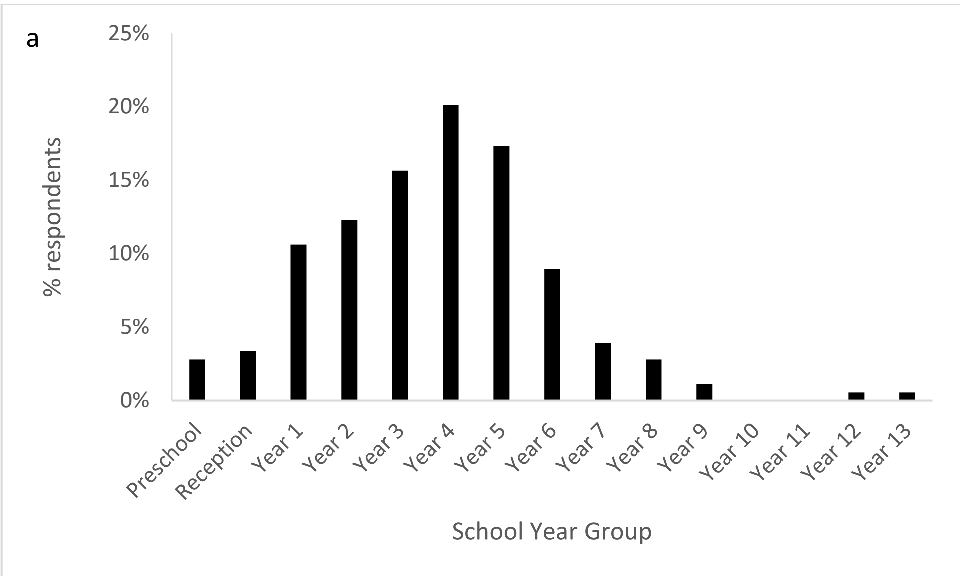
Correlation co-efficients: a correlation coefficient has a value between -1 and 1, and tells you how strong the relationship between two variables (e.g. characteristics) is. A coefficient of -1 indicates a strong positive relationship, while a coefficient of 1 marks a strong positive relationship. A coefficient of 0 would indicate no relationship between the variables. For example, when looking at data about ages and heights of children, we would expect to see a positive correlation coefficient as we know that children's heights increase as their ages increase, and therefore a correlation coefficient closer to 1 than 0.

p-values: a p-value is a 'calculated probability'. It is a value between 0 and 1 that tells you the probability that your results could have happened by chance. For example, if a correlation were found between hours spent in extracurricular activities and exam results, the p-value would tell you whether or not this correlation was significant (should be accepted), and how likely it is that you could have obtained these results if there was no genuine correlation between extracurricular hours and exam performance. Generally, 0.05 (5% probability) is used as a threshold, and therefore a p-value of less than 0.05 indicates that a result is significant (less than 5% probability that it happened by chance).

Results

Age range of children attending public events

Figure 2a demonstrates that the majority of children attending public events through choice are primary school aged (aged 4-11 years), with a core audience in school years 3 to 5 (age 7 to 9 years). These year groups sit within Key Stage 2 in the National Curriculum in England (Department for Education, 2014). This information was gathered from participants in our sessions at Lancashire Science Festival (2017) and Lakeland Wildlife Oasis (2018), two public family-based events at which we obtained demographic data from a high proportion of attendees (82% and 91% respectively) using questionnaires. Figure 2b includes age information from a larger cohort, collected at events at which age data were collected from lower proportions of the attending children (35% of the total across all five events); the core audience remains primary school-aged, falling within Years 1 to 6 (Key Stages 1 and 2).



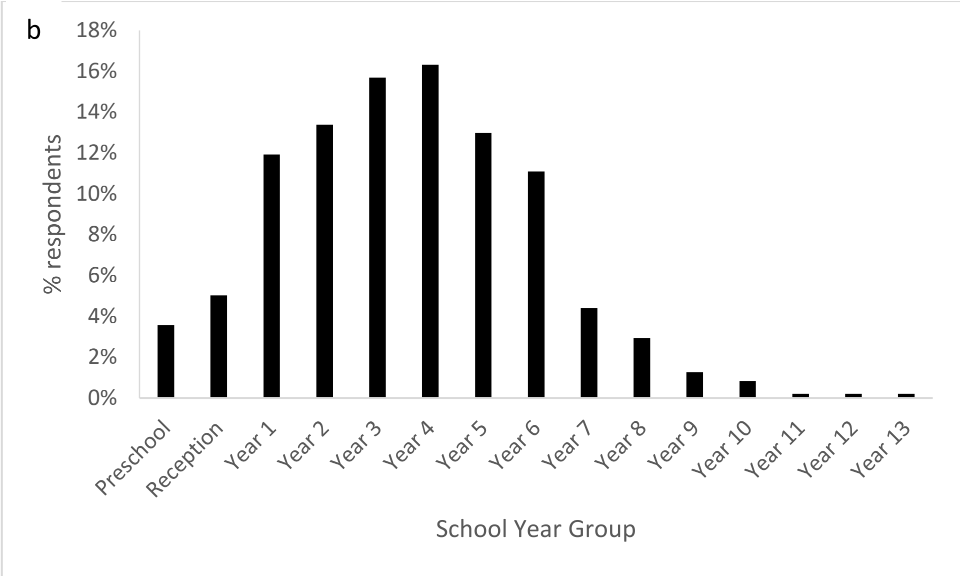


Figure 2. (a) School year groups of 179 children attending Science Hunters public events at Lancashire Science Festival (2017) and Lakeland Wildlife Oasis (2018), at which demographic data were collected from a high proportion (84%) of attending children. (b) School year groups of 478 children attending Science Hunters public events at Lancaster University Community Day (2017), Lancashire Science Festival (2017), Lakeland Wildlife Oasis (2018), Geronimo Children's Festival (2018) and Lancashire Science Festival (2018), where demographic information was collected from a combined total of 35% of attending children.

General event feedback

In total, 43 pieces of feedback containing 64 pieces of categorised content were collected using word wall feedback, and 371 'smiley face' feedback cards were returned. Feedback was highly positive, with 90% of 'smiley face' feedback cards giving a positive response. In addition, only 0.3% were negative. Most of the neutral feedback and one negative response came from sessions at Lancashire Science Festival (2018); feedback from the other two events was around 3% more positive for both (table 2).

Feedback cards contained a further 271 instances of written feedback, containing 534 pieces of categorised content. Therefore, in total 314 comments containing 598 pieces of content were categorised in total (figure 4). Only comments relating to the Science Hunters activity itself, rather than logistics of the main event, such as timings and set-up, were included. Figure 4 shows distribution of comments between categories, while Table 2 shows the feedback given using ‘smiley faces’ on feedback cards at events in 2018.

Table 2. Feedback given in 2018 via cards (n=371).

Event	Positive (happy)	Neutral	Negative (unhappy)
Campus in the City (2018)	49 (92.5%)	4 (7.5%)	0 (0.0%)
Geronimo Children’s Festival (2018)	105 (92.9%)	8 (7.1%)	1 (0.3%)
Lancashire Science Festival (2018)	178 (87.3%)	25 (12.3%)	1 (0.3%)
Total / % of overall total	332 (89.5%)	37 (10.0%)	2 (0.5%)

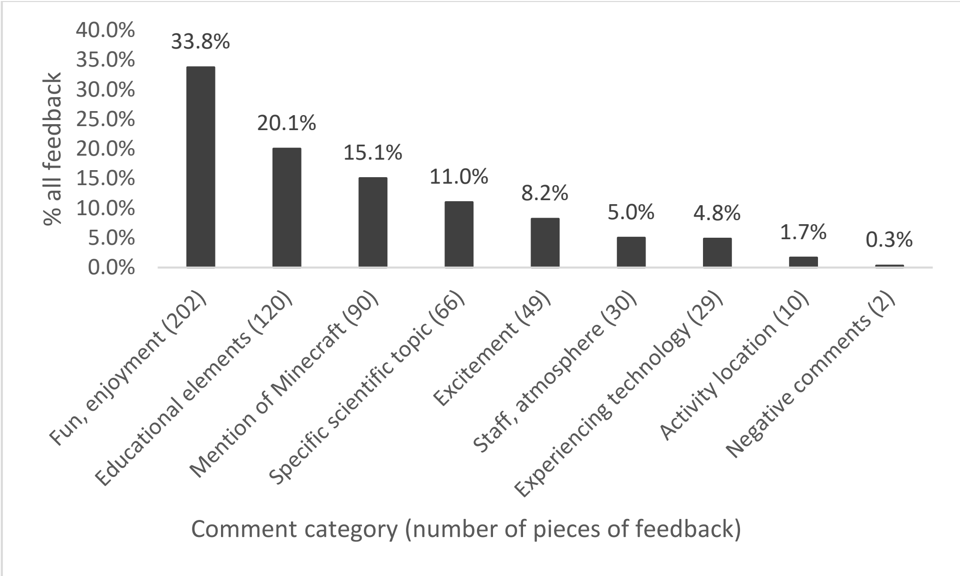


Figure 4. Distribution of comments between categories for feedback given via word walls and feedback cards.

Correlation of children's demographics and interests

In total, 289 responses to the motivational questionnaire were collected, giving a response rate of 44.8%. Of attending children, 213 (74.2%) were reported as male and 74 (25.8%) as female. The only significant relationship that was found between children's characteristics and interests in science and Minecraft was a moderate positive correlation ($r_s = 0.340$, $p = <0.001$) between school year group (age) and how frequently a child plays Minecraft; as children get older, their Minecraft play frequency tends to increase, although there were also some frequent players in the younger year groups with some children playing regularly from Reception (age 4 or 5 years). For the children who responded, overall play frequency increases around Year 5, then continues to increase to Year 9 where it remains high until a slight decline at Year 13.

Interests in science, Minecraft and reasons for coming

Of the 289 responses collected, 287 reported whether the child or the accompanying adult made the decision to come to the Science Hunters activity. In 178 cases (62.0%), the child made this decision. Adults made the decision in 87 instances (30.3%) and the decision was made jointly for a further 22 (7.7%). Table 3 shows mean and modal values for interest in science, interest in Minecraft and reason for coming, for all attendees at all events, along with further breakdown for adults and children where a significant difference was found between these two groups. The distribution of reasons for coming is shown in Table 4.

Table 3. Mean and modal values for interest in science, interest in Minecraft and reason for coming, for all attendees at all events, along with further breakdown for adults and children where a significant difference was found between these two cohorts.

	Mean	**Mode**	**Significant difference between children and adults? (Mann-Whitney U test)**
Interest in science (1 = very uninterested, 5 = very interested)	4.39 ± 0.04	5	No ($p > 0.05$)

Interest in Minecraft (1 = very uninterested, 5 = very interested)	4.04 ± 0.06	5	Yes ($p < 0.0001$) Children: mean = 4.37 ± 0.07, mode = 5 Adults: mean = 3.29 ± 0.11, mode = 3
Reason for coming (1 = science, 5 = Minecraft)	3.53 ± 0.07	3	No ($p > 0.05$)

Table 4. Distribution of responses for driving factor behind choosing the Science Hunters activity from the programme of activities available. The balance between science and Minecraft was indicated on a Likert scale of 1 (science) to 5 (Minecraft).

Reason	Scale	Responses
Science	1	25 (8.7%)
	2	27 (9.4%)
	3	92 (32.2%)
	4	55 (19.2%)
Minecraft	5	87 (30.4%)

A small majority of people said that science and Minecraft were equal (a score of 3 in table 4) in influencing their decision to choose the activity; of those who indicated either science or Minecraft (scores other than 3), 18.2% chose science and 49.7% chose Minecraft. Interest in science in children, and interest in Minecraft in both children and adults, ranged from 1 to 5 (very uninterested to very interested). Interest in science in adults ranged from 2 to 5 (uninterested to very interested).

Statistically significant correlations were found between:

- Interest in science and interest in Minecraft ($r_s = 0.244$, $p < 0.001$; weak positive correlation)
- Children's interest in Minecraft and the frequency of their play on Minecraft ($r_s = 0.243$, $p < 0.001$; weak positive correlation)
- Children's interest in Minecraft and Minecraft driving the decision to attend ($r_s = 0.255$, $p < 0.001$; weak positive correlation)

Comparison of data from science and non-science events

When data collected from attendees at activities which were part of wider science events (Lancashire Science Festival 2017) and non-science events (Lancaster University Community Day 2017, Lakeland Wildlife Oasis 2018 and Geronimo Children's Festival 2018) were considered separately, there were no significant differences ($p > 0.05$) between interest in science or interest in Minecraft in participants across these two types of event. Adults were again less interested than children in Minecraft, with no significant difference in interest in science between children and adults.

There was no significant difference ($p > 0.05$) in reason for coming between attendees at science and non-science based events. The mean overall 'reason for coming' score was slightly weighted towards Minecraft for both; 3.56 ± 0.11 (n=127) for non-science events and 3.51 ± 0.10 (n=159) for the science event, with no significant difference between responses from adults and children.

At the non-science events, the following statistically significant correlations were found:

- interest in science and science driving choice to attend (r_s = 0.209, p = 0.018; weak positive correlation);
- interest in Minecraft and Minecraft driving choice of activity (r_s = 0.276, p 0.002; moderate positive correlation);

These relationships were not statistically significant for responses from the science event. Frequency of the child's play on Minecraft and reason for coming were also compared for the science event, as no significant correlation could be found between reason for coming and interest in science or interest in Minecraft for this event. For all attendees (n=158), there was a significant weak positive relationship (r_s = 0.171, $p < 0.031$); for children (n=80) this relationship was slightly stronger (r_s = 0.241, $p < 0.031$) and for adults (n=64), there was no significant relationship.

Discussion

Ages of children attending Science Hunters activities through choice

Based on data collected at public family events, the core body of children attending Science Hunters activities by choice are of primary school age, i.e. aged 11 years or younger. Given the onset of decline in interests in science around age 10 (Murphy and Beggs, 2005), children of primary school age are ideal as beneficiaries of outreach and engagement with science and research, particularly given the positive influence on this decline of practical, investigative activities (Murphy et al., 2004); this evaluation indicates that Science Hunters activities naturally appeal to this core group.

General event feedback

Results from general feedback are clearly positive, although slightly less so for Lancashire Science Festival (2018). It is unclear why activities at this event were less well received here than at the other events; it could be that the physical set-up (fixed computers on lines of desks compared to portable laptops around tables) was less appealing as an informal learning environment and took longer to navigate at the start of sessions, encroaching on activity time, or that the sessions were less enjoyable because Lancashire Science Festival took place on uncomfortably hot days in 2018. There was one negative (red face) response with a comment; while this has been categorised as one of the two 'negative' pieces of feedback content as the smiley face response was negative, the comment was difficult to read and was contradictory. For example, it starts with "It was OK" despite the negative response and says "a little bit no fun it was fun". Another comment of "It was OK but I wish there was more learning to it" was left with a neutral (yellow face) response and contains the other piece of 'negative' content recorded. It is unclear why the respondent felt learning was lacking as they have not elaborated, and this is not consistent with other feedback which strongly recognises the educational and learning elements of the sessions.

At Geronimo Festival, the one negative response was given by a 6-year-old child, with no comment. This therefore makes it difficult to interpret; one learning point from this exercise was that while colours were used to aid interpretation and accessibility for children completing the cards, we were told that some children were more drawn to their preferred colours than the emotions expressed by the faces, needing adult assistance to complete them correctly. Others were unhappy at the point of completing the cards as they had been told it was time to leave the activity, and again needed adult help to enable them to relate their feedback to how they found the activity itself. Therefore, the 'negative' comments left are difficult to interpret, and do not provide any insights into why the sessions at Lancashire Science Festival received slightly less positive feedback than those at other events. As these 'non-positive' comments made up a very small (< 0.5%) proportion of all feedback analysed, it appears that most participants are receiving a positive experience by attending the activities.

Comments most commonly related to fun and enjoyment of the activity (34%), the educational aspects (20%), and Minecraft (15%). Specific scientific elements were mentioned in 11% of comments. This indicates that children are relating to both the scientific aspects of the activity, and the use of Minecraft, and are aware that they are learning as they play. They are also having fun, which is important both for creating positive associations with science and learning about science and therefore counteracting cultural biases which lead children to see science as 'not for them' (e.g. Archer et al., 2013), and for efficacy of learning (Lepper and Cordova, 1992).

Motivation information

Feedback revealed that the majority of children attending (74%) were boys; video gaming has been problematically stereotyped as a male domain (Shaw, 2010 and references therein) which may be influencing who attends activities involving computer games. There was, however, no significant difference in interest in science, interest in Minecraft or frequency of Minecraft play between boys and girls attending. The tendency of Minecraft play frequency to increase with age is not unexpected, as children become more able to complete complex tasks as they get older.

On average, people attending our activities had high interest in science, with no significant difference between children and adults. Average interest in Minecraft was also high, with children having high interest and adults having moderate interest.

The reason for choosing the Science Hunters activity out of all those on offer was consistently weighted slightly towards Minecraft, across all events. There was no correlation between interest in science and interest in Minecraft and the reason for choosing the activity at the science event, which could be explained by the fact that everybody present had already chosen to attend the main event because of the science on offer, and because there were other activities utilising Minecraft available; some other factor, such as the specific science topics available or the timing of the activity within the day, may have had more influence so that there was no strong preference towards either science or Minecraft. There was, however, a weak correlation between frequency of Minecraft play, which was also shown to correlate to interest in Minecraft, and Minecraft driving this choice.

At the non-science events, there was a weak correlation between interest in science and science driving the choice of activity, and a moderate correlation between interest in Minecraft and Minecraft driving the choice to attend. These outcomes suggest that (i) Science Hunters activities are attracting both children and adults (who are choosing the activity for their children, and facilitating their attendance and participation) with a broad range of interests; while average interest in both science and Minecraft were high, there were some attendees who described their interest in one of these elements as low and (ii) that Minecraft is effective as a tool for drawing people to an activity, in which they can then be engaged with research topics. In addition to the existing use of Minecraft in a wide range of formal education and learning research settings, the scope of the Minecraft virtual environment is so wide that there are many and varied possibilities for using to engage children with a range of research fields, both within and outside of science; this approach could be transferred to engagement with a multitude of topics, using Minecraft and a creative, supportive ethos to both attract and facilitate engagement.

Conclusions

Primary school aged children are a core audience for Science Hunters activities, and while these are mainly attended by boys, there is no difference between interest in science or interest in Minecraft between the boys and girls who take part. Feedback is highly positive, with fun, enjoyment and the educational aspect of the activities making the most impact on attendees, indicating effective engagement. As well as being an effective engagement tool used within our approach during the sessions, at all events there are indications that Minecraft is the most influential feature of the activity when people are choosing which session to attend from a programme of activities, with around three times as many people choosing to attend due to Minecraft being involved rather than because science is featured. Therefore, the Science Hunters approach to using Minecraft to engage children with scientific research is effective both at attracting participants, and having a positive impact on them. It is important to note that it is not only the use of Minecraft that makes the Science Hunters approach effective; the inclusive nature of the sessions (e.g. all ages and abilities are welcomed and adjustments are made for additional needs with tolerance for all needs emphasised) and pedagogical strategy of combining creative, child-driven gameplay with practical anchoring in an informal manner are fundamental to the project's success (Hobbs et al., 2019) and are learning points to be considered alongside the findings presented here. As Minecraft is an open-ended game, this approach is transferable to engagement with other research areas, both within and outside the scientific arena.

Acknowledgements

Science Hunters is funded by Lancaster University. We would like to thank our student volunteers and supporting staff from Lancaster University, the venues that have supported our sessions and all of the adults and children who have attended our events and made them a success; particularly those who have responded to our requests for feedback and enabled us to conduct our evaluation.

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