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Student-led Public Engagement Event: Increasing Audience Diversity and Impact in a Non-Science Space

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Abstract
There is a wealth of innovation in microbiology outreach events globally, including in the setting where the public engagement is hosted. Previous data indicates underrepresentation of marginalised ethnic groups attending UK science-based public engagement events. This project engaged our student cohort, encompassing a diverse range of ethnic groups, to create an integrated art and science event within an existing series of adult education evenings. The study's objectives were to increase the proportion of visitors from marginalised ethnic groups and to gain a greater understanding of the impact of the event on the visitors' reported science capital. The participants' demographics, links to our students and University, and detailed impact on participants' science capital of the event were determined through analysis of exit questionnaires. There was an increase in the proportion of marginalised ethnic group visitors compared to similar previous events. A higher proportion of visitors from marginalised ethnic groups had links with our students and University compared to white/white British visitors. Elements of the exit-questionnaire were mapped to the science capital framework and participants' science capital determined. Both ethnically marginalised participants and white/white British visitors showed an increase in science capital, specifically dimensions of science-related social capital and science-related cultural capital, after the event. In conclusion, our study suggests that a student-led blended art and science public engagement can increase the ethnic diversity of those attending and can contribute towards creating more inclusive public engagement events.

Key words: public engagement, science capital, marginalised ethnic groups, student led, impact, science art

Introduction

The publics' engagement in science, trust in scientists, and trust in scientists' work, has individual and societal benefits (Llorente et al., 2019, Stilgoe et al., 2014). The increasing narrative to take public engagement out into the community has led to the establishment of creative and innovative events with reported success in reaching audiences who typically would not engage with science activities (Dallas, 2006, Duckett et al., 2021, Leão & Castro, 2012, Paul & Motskin, 2016).

The public engaging with science allows individuals to make informed decisions around their own lives, and more widely this decision-making impacts society as a whole. When sections of the community do not trust scientists there is often a negative impact for that group of society. For example, vaccine hesitancy amongst subgroups within the population, including ethnic minority communities during the Covid-19 pandemic (Ala et al., 2021), is a significant health threat globally (WHO). Whilst the science-societal relationship is complex, public engagement events give science a platform to create a dialogue between scientists and the public; however, we must ensure that events are accessible to all.

Public engagement strategies aspires to engage with groups that fully represent society (Canfield et al., 2020, Canovan, 2019). Race and ethnicity-based inaccessibility and misrepresentation is reported to be an important barrier in engagement with science events (Dawson, 2018). Communities that scientists find difficult to engage are consistently underrepresented in the visitor demographics at such events, including marginalised ethnic groups (Duckett et al., 2021, Nielsen et al., 2019). This highlights the importance of culturally appropriate platforms. Inclusive science communication can help progress addressing the inequitable distribution of and engagement in science (Canfield et al., 2020) and the development of successful models could allow practitioners to rethink approaches to public engagement activities.

Being engaged with science – the science capital framework

How well an individual feels connected with science and their feelings towards science can be explored through the science capital framework. Derived from the social theory of capital, science capital is described as the "science-related resources" to which an individual has access (Archer et al., 2015). Dimensions of science capital include science-related cultural capital, an individual's engagement and participation in science, and science-related social capital, such as who you know that works in science. With positive attitudes towards science being related to higher levels of science capital, using the lens of science capital can help to explain variable rates of participation in science across society including ethnically marginalised and socioeconomically disadvantaged communities (DeWitt & Archer, 2017).

There is a drive to build and enhance science capital amongst the public to allow continued societal support for science and widened engagement across the breadth of society (PAS 2019). Previously we have reported that both community (Duckett et al., 2021) and university-hosted (Rawlinson et al., 2021) events can increase knowledge and elements of science capital amongst participants, with significantly higher reported knowledge gain in visitors from low progression to higher education postcode areas (Rawlinson et al., 2021). These findings are mirrored within the literature, with several studies showing that through engaging with informal science activities many participants report an increase in their science capital and more positive attitudes towards science (Bryan et al., 2022, Roberts & Hughes, 2022). Unfortunately, we, and much of the science community, are still failing to attract audiences to events which are ethnically diverse and representative of society and thus those communities we find harder to reach often have lower science capital (Archer et al., 2016, Duckett et al., 2021, Nielsen et al., 2019, Rawlinson et al., 2021).

A sense of belonging

People with a strong science identity, such as those who identify themselves as a "science person", are more likely to feel a sense of belonging in and/or amongst science (Chen et al., 2021, Rainey et al., 2018). A person's sense of belonging is key to their likelihood to seek out, stay, and succeed in a space. This holds for scientific communities, where people's perception of themselves as valued community members affects their attainment and retention (Lacey et al., 2022, Lewis et al., 2016). People from underrepresented groups tend to feel a lower sense of belonging in science (Mooney & Becker, 2020, O'Brien et al., 2020, Rainey et al., 2018) and report increased accessibility barriers leading to social exclusion from engagement with science public engagement events (Dawson, 2018). Interventions which increase the sense of belonging in a member of an underrepresented or disadvantaged group can increase engagement and attainment in science (Chen et al., 2021, LaCosse et al., 2020, Murphy et al., 2020).

Role models can play key roles in establishing a sense of belonging in members of underrepresented groups (Lewis et al., 2016). Exposure to similar role models in science helps members of underrepresented groups overcome stereotypes that science is not "for them", and thus helps develop their science identity (Dennehy & Dasgupta, 2017, Schinske et al., 2016, Shin et al., 2016). While role models can be a factor in a person's sense of belonging, this effect varies depending on the similarity of the role model, with role models perceived as relevant and compatible with a person's identity more likely to have a positive impact on that person (Rosenthal et al., 2013, Shin et al., 2016, Stout et al., 2011).

Aim

Building on our previous work undertaking public engagement of science in a non-science space, this study aims to evaluate the impact of using a diverse body of student organisers and presenters in a blended science and art event hosted in a public gallery on the impact of the resulting audience demographic. Through evaluation of exit questionnaires, we wanted to gain a greater understanding of the impact of attending the event across different groups of visitors through a science capital lens.

Research Question 1: Can a student-led public engagement event attract an ethnically diverse audience, which is representative of the local regional demographic?

Research Question 2: Does the perceived learning gain and immediate reported impact on science capital differ between visitors from marginalised ethnic group and white/white British visitors?

Methods

Event

The "Art in Science" event was hosted at the Millenium Galleries in Sheffield City Centre. The event was a collaboration between Sheffield Hallam University and Sheffield Museums Trust. As with previous collaborative projects (Duckett et al., 2021) the Art in Science was a multifaceted, informal science and art event (Figure 1).

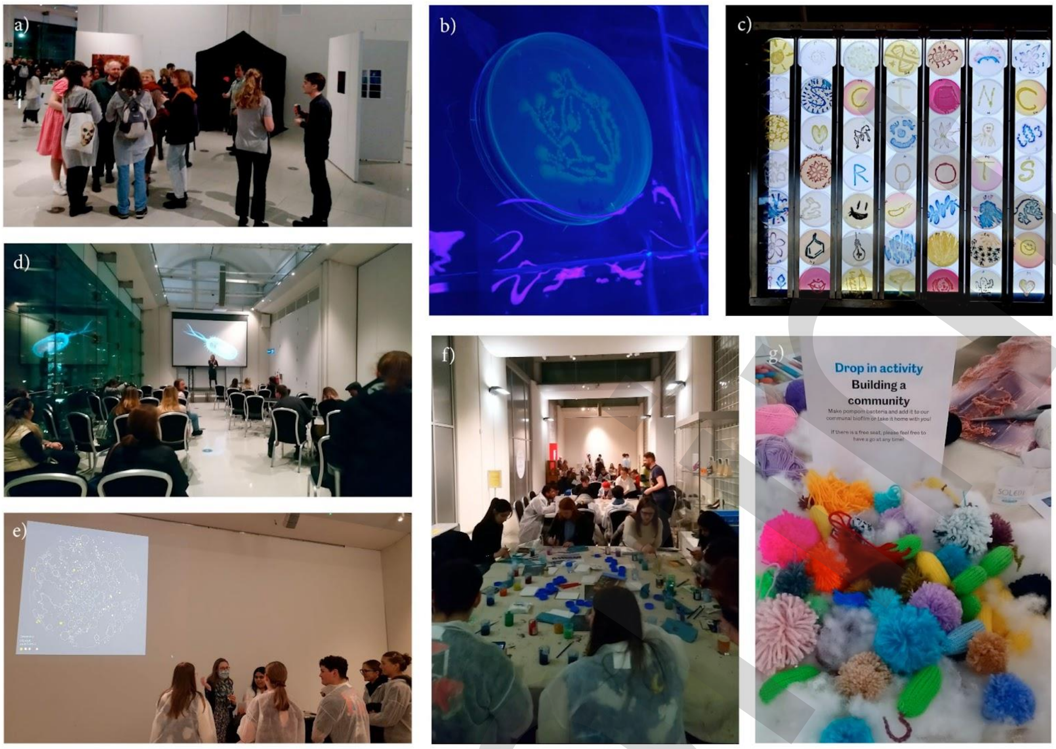

Figure 1: Elements of Art in Science event. (a) Science image exhibition area with visitors discussing research topics with doctoral students, (b) student designed fluorescent bacteria agar art housed in the blackout tent, (c) "Science Roots" light box exhibition where undergraduate students created agar art with the theme of what inspires them to study science, (d) mini-lecture series which ran throughout evening, (e) the artist in residence created a visual projection on the main wall of the exhibition after shadowing student researchers undertaking microbiology research (f) multiple hands-on creative art activities based around microbiology research and (g) visitor-created piece of individually crafted bacteria forming a biofilm.

An art gallery was created where researchers presented a single, striking image of their research to catalyse conversations with the public (Figure 1a). Agar art was presented both in the 'Science Roots' light box and luminescent agar art in a black-out tent (Figure 1b-c). The Artist in Residence Exhibition was the accumulation of several weeks of collaboration between the artist and several researchers at Sheffield Hallam University. Prior to the event, the artist had visited the microbiology research laboratories to find out more about and gain hands-on experience of a soil microbiome project before creating the exhibition pieces (Figure 1e).

Hands-on art in science activities (Figure 1f) included "building a community" where visitors helped to mature our microcolony of knitted and crocheted bacteria into a woolly, mature, polymicrobial biofilm (Figure 1g). The "reinventing life drawing" activity saw participants swabbing their own microbiome and then drawing onto agar plates. After incubating, this agar art was shared on social media for people to see (Instagram, @SHU.micro). The "pastel pathogens" activity allowed visitors to observe a range of pathogens under the microscope, creating a pastel picture of what they observed. Visitors explored the soil microbiome project through colour paintings of soil components and the event offered a mini-lecture series of talks from researchers (Figure 1d).

The Millennium Galleries provided exclusive tours of the exhibits and additional hands-on experiences including print making and felt crafts, inspired by the natural history collections of the museum.

Involvement of students

Final-year undergraduate students and MSc student from the Department of Biosciences and Chemistry were encouraged to make agar art for the event. Agar plates and bacterial streak plates were provided for the students in their capstone-project laboratories and then incubated and presented at the event by the project team. Masters and PhD research students presented images of their research in the art gallery and collaborated with the artist in residence. Undergraduate and postgraduate students were invited to the event both as volunteers and as visitors.

Data collection

Exit point feedback from visitors was collected using a modified version of our previously designed mixed-methods questionnaire (Duckett et al., 2021). The questionnaire (supplementary materials) was designed to be quick to complete to maximise completeness by participants. It consisted of a combination of simple profiling tick boxes, Likert-style responses, and free text comment boxes.

Data analysis: visitor demographic, enjoyment and perceived learning

Open coding was used to code free text responses of the question "Tell us something from your visit that you have found particularly interesting", followed by thematic analysis and categorization into themes (Byrne, 2022).

Visitors self-identified ethnicity within the categories of Asian/Asian British, black/black British, mixed ethnicity, other and white/white British. These categories of ethnicity were taken from the Sheffield 2011 Census (Office for National Statistics, 2011) to allow comparison of the ethnicity of visitors with the Sheffield region and previous collaborative events between the research team and Sheffield Museums Trust (Duckett et al, 2021). Ethnicity marginalised groups is defined within this piece of work as participants within black/black British, Asian/Asian British, mixed ethnicity and other categories.

As a measure of the perceived learning by visitors, participants were asked to rate their pre- and post-visit knowledge of the six key microbiology event topics: microbes in the body, microbes that cause disease, microbes in the soil, biofilms, antibiotics, and DNA. Scores were subsequently combined to create an overall individual perceived learning score for each participant. Differences between groups was determined by Wilcoxon rank sum test, statistical analysis was performed in R.

Data analysis: science capital

Participant's existing and expected-future engagement with science were used as a measure of event impact on science capital. Nine Likert-style engagement questions were designed to cover key dimensions of science-related capital, namely scientific literacy, science-related attitudes, values and dispositions, science media consumption, participation in informal science events, and talking about science in everyday life (Archer et al., 2016). Knowledge about the transferability of science was not included in this study as it focuses on the knowledge of science qualifications linking to jobs which was not touched upon in the event. In addition, participants were asked about their highest level of science qualification and whether they and/or someone close to them worked in the science industry as additional measures of science-related social capital (Archer et al., 2015) (Table 1).

Table 1: Framework for Science Capital data collection and analysis. Individual elements of science capital were mapped to question(s) on the exit questionnaire and each element analysis to give a score from 0-1. Science related social and cultural capital scores were determined from the respective elements and given a score from 0-1 and finally overall science capital score was determined from the science related social and cultural capital score and put on a 0-1 scale.

	Question(s)	Analysis. N.B. number is initial score allocated to each question response
1 Science capital	N/A	1.1 and 1.2 scores
1.1 Science related social capital	N/A	1.1.1 - 1.1.3 scores
1.1.1 Family science skills, knowledge and qualifications	a) “Do you work in science?” b) “What is your highest qualification”	a) 1 - No, 5- Yes b) 1- GSCE/O level, 2 - A level or equivalent, 3 - BSc, 4 - Masters, 5 - PhD.
1.1.2 Knowing people in science-related roles	“Do any of your family or friends work in science?”	1 - No, 5- Yes
1.1.3 Talking about science in everyday life	“I regularly discuss science with family and friends”	Likert Scale of 1- strongly disagree to 5- strongly agree: before and after event
1.2 Science related cultural capital	N/A	1.2.1-1.2.5 scores
1.2.1 Scientific literacy	a) “How much do you know about the following, before visiting and after visiting… Microbes in the body, Biofilms, DNA, Microbes that cause disease, Microbes in the soils, antibiotic resistance” b) “I feel confident talking with others about science”	a) Likert Scale of 1- nothing to 5- A lot: before and after event for each topic. b) Likert Scale of 1- strongly disagree to 5- strongly agree: before and after event
1.2.2 Science-related attitudes, values and dispositions	a) “Science is useful to me in my daily life” b) “Science is important in society” c) “I believe science is everywhere” d) “Scientists do valuable work”	a-d) Likert Scale of 1- nothing to 5- A lot: before and after event for each question.
1.2.3 Knowledge about the transferability of science	Not included in questionnaire	N/A
1.2.4 Science media consumption	“I actively engage with/look for books/magazines/TV or internet content about science”	Likert Scale of 1- nothing to 5- A lot: before and after event for each question.
1.2.5 Participation in out-of-school science learning contexts	“I regularly (at least twice a year) visit science museums, festivals and/or science-focused events”	Likert Scale of 1- nothing to 5- A lot: before and after event for each question.

Scores of each question on the questionnaire were scaled to a value between 0 and 1. The mean of the scaled scores was used where multiple questions relate to a single dimension. The score of cultural and social capital was an average of the dimensions within them. Scores of each capital and dimension were used to create a heat map, the colours of which were used to colour the hierarchy graph. Dimensions were compared before and after the event by Wilcoxon signed rank tests and between ethnicity groups at each time point by Mann-Whitney tests. Data analysis was performed in Prism.

Ethics

Ethics for this study were acquired through the Faculty of Health and Wellbeing and Life Sciences Ethics Committee following the Sheffield Hallam University Research Ethics Policy: ER10872482. Ethical approval was given after initial scrutiny as no identifiable, confidential or controversial information would be collected.

Results

To determine the impact of the Art in Science event on participants' science capital, as well as the uptake and impact of visitors from marginalised ethnic groups, exit questionnaires were undertaken. The event had 282 visitors with 123 completing an exit questionnaire, thus a 44% uptake.

An individual's learning is positively linked to their engagement and enjoyment of a topic or activity (Blumenfeld et al., 2005). The question "tell us something from your visit that you have found particularly interesting" was thematically analysed to determine aspects of the event that participants found engaging (Table 2).

Table 2: Qualitative analysis themes of participants' interest. Answers to the question "Tell us something from your visit that you have found particularly interesting" events were blinded, coded into each category and enumerated. Example comments are given for each theme (n = 104).

Themes	Example	Number of responses
Specific scientific/factual learning points	*"Bioluminescence", "background microbes", "antibiotic resistance"*	45
Talks/lectures	*"Oral cavity", "bone structure"*	7
Opportunity to learn something new	*"Excellent science communication to a non-scientist", "translating science"*	5
Opportunity to be creative/science inspiring art	*"Amazing shapes and patterns of the micro world", "thrush looks like grapes"*	25
Positive overall experience	*"Love the lady studying mine water", "passion from the presenters"*	7
Interactive activities	*"Using a microscope", "handling fossils"*	11

The responses identify specific scientific and factual learning as the most interesting element of the Art in Science event followed by the opportunity to be creative and artistic. There was no difference in the theme of response based on participants' ethnicity (data not shown).

Student involvement increased the number of visitors from marginalised ethic groups

An aim of the project was to increase the proportion of visitors from marginalised ethnic groups at the event. The ethnicity of participants of the Art in Science was compared to previous collaborative events with Sheffield Museums Trust and the Sheffield region (Table 3).

Table 3: Comparison of participant ethnicity at the Art in Science event compared to previous collaborative events and Sheffield region. Art in Science (n = 123), The Horror Within and The Science of Science Fiction with Sheffield Museums Trust (Duckett et al., 2021) and Sheffield Census (Office for National Statistics, 2011). Note where percentages do not equal 100% for an event, the absent participants chose to not disclose their ethnicity.

Ethnicity	Art of Science (2022)	The Horror Within (2017)	The Science of Science Fiction (2018)	Sheffield Census (2011)
Asian/Asian British	13.1%	4.1%	5.8%	8.0%
Black/Black British	2.5%	0.0%	0.0%	3.6%
Mixed	3.3 %	2.0%	5.8%	2.4%
Other	1.6%	0.0%	0.0%	2.2%
White/White British	77.9%	93.9%	88.5%	83.7%

The demographic of visitors at the Art of Science event was markedly different compared to previous blended art and science evenings. The Art in Science event had an increase in the proportion of all marginalised ethnic groups apart from mixed ethnic when compared to the Science of Science Fiction event. The most marked increase was the increase in Asian/Asian British participants, increasing to 13.1% compared to 4.1% and 5.8% for the previous events. There was also an increased proportion of Asian/Asian British and mixed ethnicity participants compared to the Sheffield region, although black/black British and other ethnicities were underrepresented at the Art in Science event compared to the Sheffield region.

To determine if the increase in the proportion of participants at the Art in Science event from marginalised ethnic groups was due to the social-capital impact of increased student-led participation, the “How did you hear about the event?” question was analysed (Table 4).

Table 4: Comparison of how people heard about the Art in Science event. Due to the sample size, all marginalised ethnic participants were analysed together (all responses n = 123; marginalised ethnic participant responses n= 26, white/white British n = 95).

	Museums Sheffield Trust website/poster	Sheffield Hallam website/poster	Social media	I know someone involved in the event	Friend/family	Other
Total	12 (10%)	10 (8%)	37 (30%)	23 (19%)	30 (24%)	11 (9%)
Ethnically marginalised groups	3 (12%)	5 (19%)	7 (27%)	6 (23%)	5 (19%)	0
White/white British	9 (9%)	4 (4%)	29 (31%)	17 (18%)	25 (27%)	11 (11%)

Participants from marginalised ethnic groups were slightly less likely to hear through social media than white/white British participants (27% and 31% respectively), and slightly more likely to attend the event through someone involved (23% and 18% respectively). Participants from marginalised ethnic groups were much more likely to hear from a Sheffield Hallam University website or poster than white/white British participants (19% and 4% respectively).

Impact of attending the event was seen across all visitors, with differences observed between white/white British and marginalised ethnic group participants

The main scientific content for the Art in Science event was broadly categorised into six themes: microbes in the body, biofilms, DNA, microbes that cause disease, microbes in the soils, and antibiotic resistance. To determine perceived learning at the event, participants were asked “How much do you know about the following” for each theme, before and after the event on a scale of 1 (nothing) to 5 (a lot) (Figure 2).

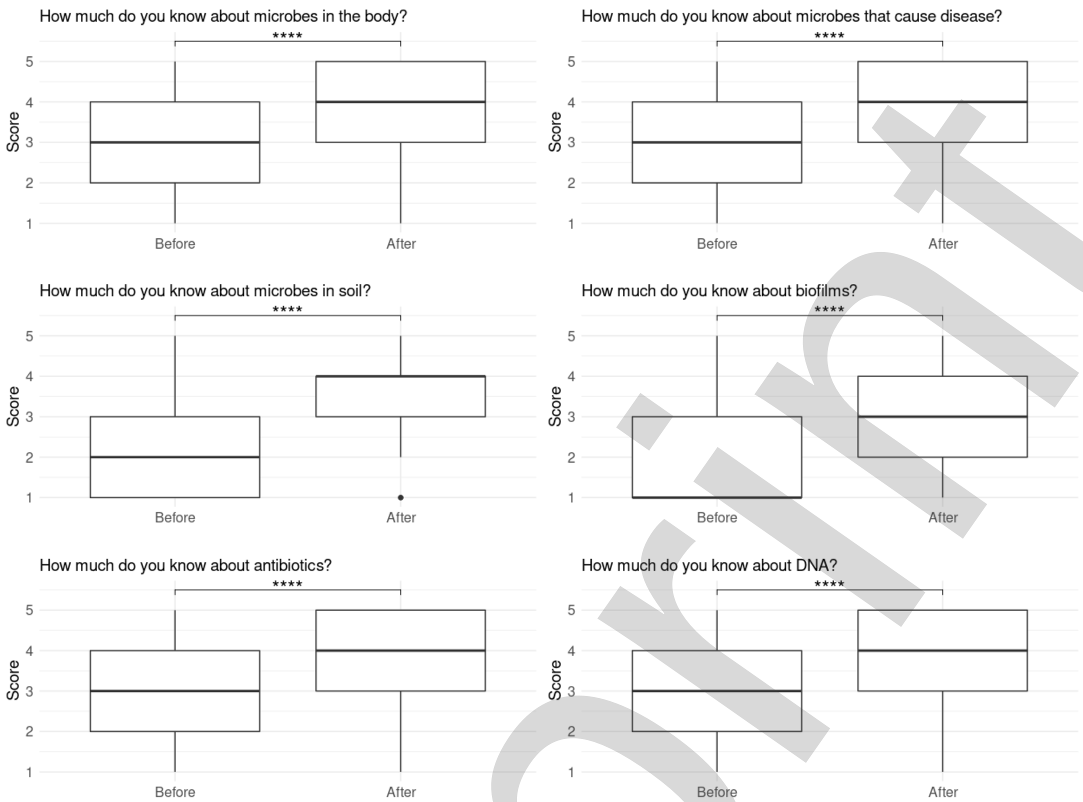

Figure 2: Perceived knowledge before and after of different areas. The amount of perceived knowledge participants gained during the Art of Science event in the six science content areas was ranked from 1 (nothing) to 5 (a lot). Data shown in median values at the centre of the plot, first and third quartiles complete the plot and the whiskers represent 1.5*IQR from quartiles. Outlying points are represented as individual points (n = 123). **** indicates $p \leq 0.0001$ in a Wilcox signed rank test.

Exit questionnaire analysis showed an increase in perceived learning by participants in all main themes of the Art in Science event. There was no difference in the perceived learning of participants from marginalised ethnic groups compared to their white/white British counterparts (data not shown).

Perceived learning forms part of the science capital framework. Using the framework outlined in Table 1, participants' exit questionnaires were analysed to determine differences between marginalised ethnic participants and white/white British participants' science capital. The framework allows investigation of two elements of science capital, firstly, participants pre-existing science capital and secondly, the impact of the event on participants science capital (Figure 3).

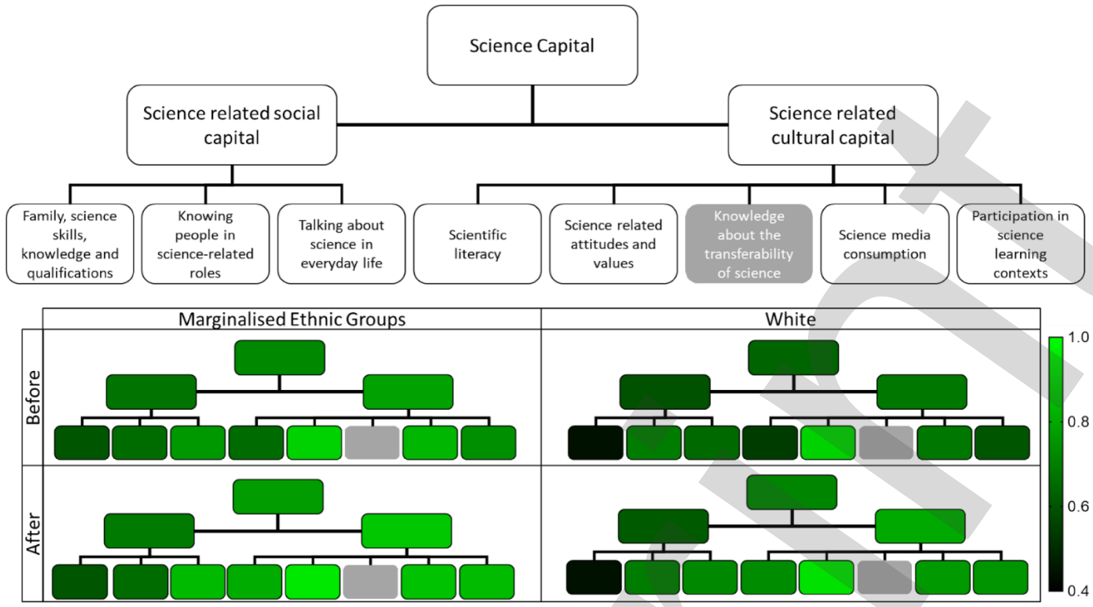

Figure 3: Impact of attendance at the Art of Science event on science capital and related dimensions. The mean score of each dimension was grouped by ethnicity and before/after attendance at the event higher dimensions were an average of sub-dimensions. The range of results was between 0.44 and 0.94, indicated by a gradient scale from black to green. Hierarchy plots mimic the layout of the top plot of science capital dimensions (n = 123).

Participants' pre-existing science capital: No difference in pre-existing overall science capital and science-related social capital was observed between marginalised ethnic participants and white/white British participants. Participants from marginalised ethnic groups had a higher pre-existing science-related cultural capital score than those from white/white British backgrounds ($p < 0.05$, Mann Whitney test). Within the individual elements of science related social capital, participants from marginalised ethnic groups had a higher score in "family, science skills, knowledge and qualifications" than those from white/white British backgrounds ($p < 0.05$, Mann Whitney test). There was no statistically significant difference in the remaining individual elements. Within the individual elements of science related cultural capital, participants from marginalised ethnic groups had a higher score in "scientific literacy", "science related attitudes and values", and "participation in science learning context" than those from white/white British backgrounds ($p < 0.05$, Mann-Whitney test). There was no statistically significant difference in "science related attitudes and values" and it is worth noting that this element scored the highest across the framework analysis.

Impact of the event on participants' science capital: Participants from both marginalised ethnic backgrounds and white/white British backgrounds reported an increase in their overall science capital after the event. They also reported an increase in both its components, science-related social capital, and science-related cultural capital ($p < 0.05$, Wilcoxon matched pairs signed rank test). Within the individual elements of science-related social capital, both groups of participants had a higher score in "talking about science in everyday life" after the event ($p < 0.05$, Wilcoxon matched pairs' signed rank test). There was no statistically significant difference in the remaining individual elements between elements based on relationships. Within the individual elements of science-related cultural capital, both groups of participants had an increase in "scientific literacy" and "participation in science learning contexts" ($p < 0.01$, Wilcoxon matched pairs signed rank test).

Finally, white/white British participants reported an increase in “science-related attitudes, values and dispositions” and “science-media consumption” ($p < 0.01$, Wilcoxon matched pairs signed rank test) due to the event, whereas no difference was seen for marginalised ethnic groups. There was no statistically significant difference in “science-related attitudes and values”.

Discussion

Drawing on the previous success of blended arts and science events hosted in a non-science space (Duckett et al., 2021), this student-led Art in Science event aimed to increase the ethnic diversity of those attending. Through exit questionnaires and qualitative data analysis our study also explored event impact on visitors from marginalised ethnic communities and white/white British communities.

With continued underrepresentation of visitors from marginalised ethic groups at science public engagement events, inequality in science communication remains (Canfield et al., 2020). Key barriers to marginalised and minoritised individuals and communities are reported as a lack of a sense of belonging, accessible role models, and low levels of existing science capital (Chen et al., 2021, DeWitt & Archer, 2017, Lewis et al., 2016). The student body in the Department of Biosciences and Chemistry at Sheffield Hallam University has a higher representation of individuals from marginalised ethnic groups (~30%) than the Sheffield City Region population (16.3%) (Duckett et al., 2021). Our approach was to engage these students in the organisation, preparation and delivery to increase the ethnic diversity of those attending the Art in Science event. Briefly, this approach draws upon existing literature around relatable role models increasing the sense of belonging and engagement in science amongst minoritised and marginalised individuals and groups (Chen et al., 2021, Lewis et al., 2016, Shin et al., 2016).

Exit questionnaires were used to capture the demographics of participants and the immediate impact of the event. Previous similar events undertaken by the research team have echoed the national picture, which sees white individuals more likely to visit museums and science spaces than those from marginalised ethnic groups (Archer et al., 2012, Department of Digital Culture, 2016, Duckett et al., 2021). The Art in Science event observed an increase in the proportion of visitors from marginalised ethic groups (20.5%) in comparison to our previous bended art and science events (6.1% in 2017 and 11.6% in 2018) (Duckett et al., 2021). This was also above that of the Sheffield City region at 16.3% for marginalised ethnic citizens (Office of National Statistics, 2011). Overall, social media led as the most common way visitors had heard about the event. However, participants from marginalised ethnic groups were more likely than white/white British participants to have heard about the event through someone involved or via Sheffield Hallam advertising. The increase in ethnic diversity was not equivalent across all ethnic groups, with Asian/Asian British having the higher representation at the event compared to the Sheffield Census. Interestingly, there is a higher proportion of Asian/Asian British students within our department than black/black British. Whether the increase in Asian/Asian British visitors is a direct result of this can only be speculated.

Others have reported that there can be barriers to engagement within event exhibits for minority ethnic visitors, for example due to language, which ultimately lead to the feeling of not belonging and unease (Dawson, 2018).There was no difference observed at this event in the reported knowledge gain or interests between the Art in Science minoritised ethnic and white/white British visitors. It is acknowledged our minoritised ethnic group visitors had higher existing science education, which potentially impacted on the responses to these questions. However, working with our diverse student organisers to prepare and deliver the event could have contributed towards making an inclusive accessible event and minimised any implicit biases in design which may be hindering rather than aiding in promoting inclusivity.

An individual's relationship with and attitude towards science is influenced by their science capital (Archer et al., 2015). Understanding levels of science capital amongst different groups of the population can help explain social inequalities in science participation (Archer et al., 2015, DeWitt & Archer, 2017). Through participant exit questionnaire responses we found no difference in the overall existing (pre-event) science capital scores between marginalised ethnic groups and white/white British visitors. Further analysis of the dimensions of science capital explored in the questionnaire did identify higher cultural capital scores (across all elements) in marginalised ethnic visitors when compared to white/white British visitors. Visitors from marginalised ethnic groups also reported knowing more people working in science and holding higher level science qualifications than white/white British visitors. It is encouraging that our study suggests that students, as a diverse organisation and presenting body, can increase ethnic diversity at a science-based event, however the resulting participants from marginalised ethnic groups have a higher existing level of some elements of science capital before attending than white/white British visitors. We have previously shown that hosting a blended science and art event in a non-science space can attract and engage visitors who typically do not engage with science (Ducket et al 2021) and whilst our current study suggests an approach which can also increase ethnic diversity, these visitors are already more engaged science through their existing reported science capital. Dawson (2016) argues that science communication is not open to everyone due to social advantage and structural inequalities, meaning that events remain invisible to some groups in society. Our study suggests that whilst involving diverse multiple voices in planning and delivery through recruitment of our student body could broaden the reach of science public engagement events in non-science spaces such as museums, additional barriers are preventing societal groups of minority ethnic citizens with low levels of existing science engagement from participating.

Collective science capital scores for participants of both marginalised and white ethnic backgrounds reported as being increased after visiting the event. With participants reporting that they were more likely to talk about science in everyday life and participate in future science events, the Art in Science event successfully increased accessibility of science to all visitors. This equal impact gain across both white/white British and marginalised ethnic group participants, together with the knowledge gain and interest discussed earlier, suggests that our student-led event model is a move in the right direction of inclusive science communication.

Conclusion

A student-led Art in Science event was evaluated via exit-questionnaires. Ethnic diversity was increased amongst visitors compared to previous events by the group as well as the Sheffield region. A sizeable minority of participants, higher in ethnically marginalised groups, at the event reported attending due someone they knew was involved of through the university or through a university poster or website. Thus, it is tempting to speculate that the increase in ethnicity was in part due to an increase in the ethnic diversity of those involved in planning and organisation.

A science capital framework was used to gain a better understanding of the impact of the event on participants. Several pre-existing elements of science capital were higher in participants from marginalised ethnic groups than white/white British visitors. Overall reported science capital was increased in visitors irrespective of ethnicity and this increase was seen in discrete elements of science capital.

This student-led blended art and science outreach contributes towards creating a more inclusive science communication approach. However, complex barriers are still in place surrounding participants from ethnicity marginalised groups attending outreach events, and a greater understanding of the rich diversity within ethnicity marginalised groups will allow future events to engage more fully with diverse communities.

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Conflicts of interest

The authors declare that there are no conflicts of interest.

Data Availability Statement

The data presented in this study may be available on request from the corresponding author. The data are not publicly available due to ethical restrictions.

References

Ala, A., Edge, C., Zumla, A., & Shafi, S. (2021). Specific COVID-19 messaging targeting ethnic minority communities. EClinicalMedicine, 35, 100862. https://doi.org/10.1016/j.eclinm.2021.100862

Archer, L., Dawson, E., DeWitt, J., Seakins, A., & Wong, B. (2015). “Science capital”: A conceptual, methodological, and empirical argument for extending bourdieusian notions of capital beyond the arts. Journal of Research in Science Teaching, 52(7). https://doi.org/10.1002/tea.21227

Archer, L., Dawson, E., Seakins, A., & Wong, B. (2016). Disorientating, fun or meaningful? Disadvantaged families’ experiences of a science museum visit. Cultural Studies of Science Education, 11(4), 917–939. https://doi.org/10.1007/s11422-015-9667-7

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2012). Science Aspirations, Capital, and Family Habitus. American Educational Research Journal, 49(5), 881–908. https://doi.org/10.3102/0002831211433290

Blumenfeld, P. C., Kempler, T. M., & Krajcik, J. S. (2005). Motivation and Cognitive Engagement in Learning Environments. In The Cambridge Handbook of the Learning Sciences (pp. 475–488). Cambridge University Press. https://doi.org/10.1017/CBO9780511816833.029

Bryan, R., Gagen, M. H., Bryan, W. A., Wilson, G. I., & Gagen, E. (2022). Reaching out to the hard-to-reach: mixed methods reflections of a pilot Welsh STEM engagement project. SN Social Sciences, 2(2), 10. https://doi.org/10.1007/s43545-021-00311-6

Byrne, D. (2022). A worked example of Braun and Clarke’s approach to reflexive thematic analysis. Quality & Quantity, 56(3), 1391–1412. https://doi.org/10.1007/s11135-021-01182-y

Canfield, K. N., Menezes, S., Matsuda, S. B., Moore, A., Mosley Austin, A. N., Dewsbury, B. M., Feliú-Mójer, M. I., McDuffie, K. W. B., Moore, K., Reich, C. A., Smith, H. M., & Taylor, C. (2020). Science Communication Demands a Critical Approach That Centers Inclusion, Equity, and Intersectionality. Frontiers in Communication, 5. https://doi.org/10.3389/fcomm.2020.00002

Canovan, C. (2019). “Going to these events truly opens your eyes”. Perceptions of science and science careers following a family visit to a science festival. Journal of Science Communication, 18(02), A01. https://doi.org/10.22323/2.18020201

Chen, S., Binning, K. R., Manke, K. J., Brady, S. T., McGreevy, E. M., Betancur, L., Limeri, L. B., & Kaufmann, N. (2021). Am I a Science Person? A Strong Science Identity Bolsters Minority Students’ Sense of Belonging and Performance in College. Personality and Social Psychology Bulletin, 47(4), 593–606. https://doi.org/10.1177/0146167220936480

Dallas, D. (2006). Café Scientifique—Déjà Vu. Cell, 126(2), 227–229. https://doi.org/10.1016/j.cell.2006.07.006

Dawson, E. (2018). Reimagining publics and (non) participation: Exploring exclusion from science communication through the experiences of low-income, minority ethnic groups. Public Understanding of Science, 27(7), 772–786. https://doi.org/10.1177/0963662517750072

Dennehy, T. C., & Dasgupta, N. (2017). Female peer mentors early in college increase women's positive academic experiences and retention in engineering. Proceedings of the National Academy of Sciences, 114(23), 5964–5969. https://doi.org/10.1073/pnas.1613117114

Department for Digital, Culture, Media & Sport Taking Part Survey 2016; Retrieved from. https://www.gov.uk/guidance/taking-part-survey#how-to-access-survey-data. Last accessed 22.11.22

DeWitt, J., & Archer, L. (2017). Participation in informal science learning experiences: the rich get richer? International Journal of Science Education, Part B, 7(4), 356–373. https://doi.org/10.1080/21548455.2017.1360531

Duckett, C. J., Hargreaves, K. E., Rawson, K. M., Allen, K. E., Forbes, S., Rawlinson, K. E., Shaw, H., & Lacey, M. (2021). Nights at the museum: integrated arts and microbiology public engagement events enhance understanding of science whilst increasing community diversity and inclusion. Access Microbiology, 3(5), 000231. https://doi.org/10.1099/acmi.0.000231

Instagram, @SHU.micro, https://www.instagram.com/shu.micro/, last accessed 22.11.22

Lacey, M. M., Shaw. H, Abbott. N, Dalton. C, Smith, D (2022). How students' inspirations and aspirations impact motivation and engagement in the first year of study. Education Sciences, in press

LaCosse, J., Canning, E. A., Bowman, N. A., Murphy, M. C., & Logel, C. (2020). A social-belonging intervention improves STEM outcomes for students who speak English as a second language. Science Advances, 6(40). https://doi.org/10.1126/sciadv.abb6543

Leão, M. J., & Castro, S. (2012). Science and rock. EMBO Reports, 13(11), 954–958. https://doi.org/10.1038/embor.2012.151

Lewis, K. L., Stout, J. G., Pollock, S. J., Finkelstein, N. D., & Ito, T. A. (2016). Fitting in or opting out: A review of key social-psychological factors influencing a sense of belonging for women in physics. Physical Review Physics Education Research, 12(2), 020110. https://doi.org/10.1103/PhysRevPhysEducRes.12.020110

Llorente, C., Revuelta, G., Carrió, M., & Porta, M. (2019). Scientists' opinions and attitudes towards citizens' understanding of science and their role in public engagement activities. PLOS ONE, 14(11), e0224262. https://doi.org/10.1371/journal.pone.0224262

Mooney, C., & Becker, B. A. (2020). Sense of Belonging: The Intersectionality of Self-Identified Minority Status and Gender in Undergraduate Computer Science Students. United Kingdom & Ireland Computing Education Research Conference., 24–30. https://doi.org/10.1145/3416465.3416476

Murphy, M. C., Gopalan, M., Carter, E. R., Emerson, K. T. U., Bottoms, B. L., & Walton, G. M. (2020). A customized belonging intervention improves retention of socially disadvantaged students at a broad-access university. https://www.science.org

Nielsen, K., Gathings, M. J., & Peterman, K. (2019). New, Not Different: Data-Driven Perspectives on Science Festival Audiences. Science Communication, 41(2), 254–264. https://doi.org/10.1177/1075547019832312

O'Brien, L. T., Bart, H. L., & Garcia, D. M. (2020). Why are there so few ethnic minorities in ecology and evolutionary biology? Challenges to inclusion and the role of sense of belonging. Social Psychology of Education, 23(2), 449–477. https://doi.org/10.1007/s11218-019-09538-x

Office for National Statistics 2011 UK Census. https://www.ons.gov.uk/census/2011census/2011ukcensuses Last accessed 22.11.22

PAS 2019. Public attitudes to science 2019. https://www.gov.uk/government/publications/public-attitudes-to-science-2019 Last accessed 22.11.22

Paul, P., & Motskin, M. (2016). Engaging the Public with Your Research. Trends in Immunology, 37(4), 268–271. https://doi.org/10.1016/j.it.2016.02.007

Rainey, K., Dancy, M., Mickelson, R., Stearns, E., & Moller, S. (2018). Race and gender differences in how sense of belonging influences decisions to major in STEM. International Journal of STEM Education, 5(1), 10. https://doi.org/10.1186/s40594-018-0115-6

Rawlinson, K. E., Duckett, C. J., Shaw, H., Woodroofe, M. N., & Lacey, M. M. (2021). Family-focused campus-based university event increases perceived knowledge, science capital and aspirations across a wide demographic. International Journal of Science Education, Part B, 11(3), 273–291. https://doi.org/10.1080/21548455.2021.1971319

Roberts, K., & Hughes, R. (2022). Recognition Matters: the Role of Informal Science Education Programs in Developing Girls' Science Identity. Journal for STEM Education Research, 5(2), 214–232. https://doi.org/10.1007/s41979-022-00069-3

Rosenthal, L., Levy, S. R., London, B., Lobel, M., & Bazile, C. (2013). In Pursuit of the MD: The Impact of Role Models, Identity Compatibility, and Belonging Among Undergraduate Women. Sex Roles, 68(7–8), 464–473. https://doi.org/10.1007/s11199-012-0257-9

Schinske, J. N., Perkins, H., Snyder, A., & Wyer, M. (2016). Scientist Spotlight Homework Assignments Shift Students' Stereotypes of Scientists and Enhance Science Identity in a Diverse Introductory Science Class. CBE—Life Sciences Education, 15(3), ar47. https://doi.org/10.1187/cbe.16-01-0002

Shin, J. E. L., Levy, S. R., & London, B. (2016). Effects of role model exposure on STEM and non-STEM student engagement. Journal of Applied Social Psychology, 46(7), 410–427. https://doi.org/10.1111/jasp.12371

Stilgoe, J., Lock, S. J., & Wilsdon, J. (2014). Why should we promote public engagement with science? Public Understanding of Science, 23(1), 4–15. https://doi.org/10.1177/0963662513518154

Stout, J. G., Dasgupta, N., Hunsinger, M., & McManus, M. A. (2011). STEMing the tide: Using ingroup experts to inoculate women's self-concept in science, technology, engineering, and mathematics (STEM). Journal of Personality and Social Psychology, 100(2), 255–270. https://doi.org/10.1037/a0021385

WHO World Health Organisation https://www.who.int/news-room/spotlight/ten-threats-to-global-health-in-2019 Last accessed 22.11.22