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Environmental science exploration days: breaking the barriers, and widening participation in the Scottish capital

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1 Introduction

Widening participation, in the context of higher education, has many definitions (Burke, 2017). Here, we define widening participation as: encouraging a more representative cross-section of students across higher education institutions and subjects, and encouraging the success of students from underrepresented or disadvantaged backgrounds (e.g., Tonks and Farr, 2003; Weedon and Riddell, 2016). In the UK, widening participation has been a long-standing concept, with the 1963 Robbins Report publicly identifying a need to raise aspirations and improve ties between schools and universities (The Committee on Higher Education, 1963). Since then, there have been some successes. For example, the proportion of low socioeconomic status learners in England accessing higher education increased by 50% over the 15 years up to 2009 (Higher Education Council for England, 2010). However, further progress is still needed. In the 2023/24 academic year, the progression rate from secondary to higher education for disadvantaged pupils fell for the second year in a row, compared to that of all other pupils in the UK (United Kingdom Department of Statistics, 2025). In particular, there remains a clear lack of diversity in students choosing science subjects (e.g., Smith and White, 2011).

The lack of a diverse pool of students who participate in science is of particular concern, given current complex global environmental problems. Collaboration and interdisciplinary approaches between natural, social and applied sciences, as well as

the humanities, will be necessary to overcome these global environmental problems (Focht and Abramson, 2009; MacLeod and Nagatsu, 2018). Pupils from poorer areas have been found to obtain lower average test scores in science at ages 7–14 (Smith and Gorard, 2011). Those who continue to study mathematics or science after the age of 16 tend to have higher prior attainment scores, whereas disadvantaged pupils are less likely to pursue science, or be supported in obtaining the grades in these subjects that would encourage further study (Gorard and See, 2009). Hence, if disadvantaged students are disproportionately more unlikely to perform well in the sciences at an early age, they are unlikely to study them further. Beyond grades, pupils' science aspirations are also influenced by their science capital; that is, their access to and availability of science (e.g., Archer et al., 2015). This is influenced by social inequalities, including class, gender, and ethnicity. It is therefore imperative to engage pupils from underprivileged backgrounds in the sciences in as many contexts as possible from an early age.

In order to design impactful outreach and engagement initiatives, it is essential to implement effective strategies. The impact of an outreach initiative is influenced by the methods of delivery, its setting, and the persona of the facilitator, amongst other factors. An example of an effective educational method to promote learning in children is using active learning, that is, "learning which engages and challenges children's thinking using real-life and imaginary situations" (e.g., Bonwell and Eison, 1991; Audain and Shoolbread, 2015). By encouraging children to actively engage in learning, the material becomes more memorable, than it would through traditional "passive" methods (e.g., Prince, 2004). An example of impactful settings and personae for outreach is utilising the higher education infrastructures. For example, an initiative in a university setting, in which pupils engage with university staff and students, can increase the pupil's science capital (DeWitt et al., 2016; Baines et al., 2024). In particular, Murphy (2002) found that disadvantaged students reported that their perceptions of studying at university changed positively by meeting staff and students.

Here we reflect on a widening participation initiative, Environmental Science Exploration (ESE) Days, carried out in Edinburgh, United Kingdom. Through this initiative, we trained PhD students to develop outreach activities about environmental science, centred on active learning, and deliver them to widening participation pupils during a campus visit. We will briefly outline the set-up of the day, reflect on the lessons learned and unintended outcomes of our initiative, and suggest best practice for future actions.

2 Creating the environmental science exploration days

To inspire pupils from underrepresented backgrounds to engage with environmental science before subject selection in secondary school, we designed ESE Days hosted at The University of Edinburgh. We selected state schools associated with the Scottish widening participation programme, LEAPS, (https://www.leapsonline.org). In particular, we engaged with schools located within four miles of our science campus, and schools where rates of progression to higher education from the school are below the national average. All schools were in areas in the lower quintiles of the Scottish Index of Multiple Deprivation (SIMD; Scottish Government, 2020). Groups of up to 90 pupils (ages 9–14) visited The University of Edinburgh's King's Buildings campus, home to the College of Science and Engineering, during 3-h morning sessions across four events over 2 years 2024–2025.

In advance of the ESE days we designed 11 outreach activities, which spanned the following subjects; geosciences, biology, chemistry, engineering, and mathematics (Supplementary Table S1). Activities were designed to be hands-on and question-driven, following the principles of active-learning (e.g., Bonwell and Eison, 1991; Prince, 2004; Audain and Shoolbread, 2015), and required a clear scientific hook (e.g., Tarrant, 2018) and interdisciplinary connections (e.g., Focht and Abramson, 2009; MacLeod and Nagatsu, 2018). We also ensured the content aligned with the Scottish curriculum (Education Scotland, 2013). The activities were refined through iterative testing to validate timing and ensure feasibility.

Each day consisted of four 20-minute activities, bookended by plenary sessions, with a mid-morning snack-break. Activities were provided to groups of 7–15 pupils at a time. The 20-min duration emerged from our teaching experience and teacher consultation, balancing sufficient time for meaningful engagement (e.g., Grossman and Rhodes, 2002; DuBois et al., 2011), against the risk of losing pupil's attention through cognitive overload (e.g., Bligh, 2000; Prince, 2004; Wilson and Korn, 2007; Fortenbaugh et al., 2015). The group sizes were chosen by host teachers to ensure pupil safety and guarantee sufficient supervision. This format thus attempted to balance attention span limitations with breadth of scientific exposure.

To provide relatable role models, we recruited PhD students as activity facilitators rather than academic staff. Near-peer role models are particularly effective for aspiration-raising, as PhD students represent more attainable career stages than professors while demonstrating diverse pathways into science (e.g., Bandura, 1997; Ten Cate and Durning, 2007; Stout et al., 2011; Morgenroth et al., 2015). We provided paid professional development opportunities for the PhD students involved, recognising that unpaid outreach work can exclude students from lower socioeconomic backgrounds. This allowed for the possibility of increasing the diversity of role models available to students, and thus widening the participation for both the outreach receiver and facilitator (e.g., Stout et al., 2011; Dennehy and Dasgupta, 2017).

To estimate the impact of the initiative on the day, we held an informal, plenary multiple-choice pop quiz during the closing plenary session, with questions chosen from each of the activities facilitated. This provided group summative assessment in a playful manner, shown to be beneficial for learning (e.g., Roediger and Karpicke, 2006; Adesope et al., 2017). More formally, the pupils were then asked to fill out an anonymous survey evaluating their experience once back in school, and were also encouraged to send letters to the PhD students. Survey questions included multiple choice questions; "Did you enjoy your visit?", "Did you learn what environmental sciences are during your visit?", "Do you think you will want to study and learn more about environmental sciences?", as well as open-ended questions; "What did you enjoy most about your visit?". Although we are aware of the potential limitations of such methods (e.g., Borgers et al., 2000), this feedback was used to informally, and continuously, evaluate each event throughout the initiative.

Finally, to expand the impact of the ESE Days, each activity was designed to become an Open Educational Resource (OER). OERs are open-access resources that are intended to be used by teachers and educators, and should be freely accessible (UNESCO, 2022). This approach gives us the opportunity to expand participation beyond our geographical limitations, as subject-specific OERs are highly valuable to educators of early education (e.g., Makokotlela, 2022; Kuo et al., 2024). Similarly, OERs are found to be used by a wide range of audiences, beyond mandatory education, thereby further increasing the reach of the resources beyond their intended audience (e.g., LeMire, 2024). We published our OERs on https://www.tes.com/teaching-resources/shop/OpenEd.

3 Discussion

3.1 The value of funded outreach for postgraduate researchers

A lack of funding is a key barrier to science outreach participation (Woitowich et al., 2022), which is often time-intensive. Additionally, it may facilitate participation from a more diverse group of postgraduate researchers, particularly those who might otherwise be excluded due to limited social or financial capital (e.g., Stout et al., 2011; Dennehy and Dasgupta, 2017). Funding outreach initiatives therefore has potential to widen participation in outreach facilitation, as well as access to higher education. This was true in the case of the ESE Days, where several of the authors in this article would not have participated in the initiative, had it not been for the additional funding.

We saw this improved access for postgraduate facilitators as an unintended additional impact of the organisation of the ESE Days. Outreach and public engagement are often strongly encouraged, if not mandatory, components of doctoral training programmes (e.g., Economic and Social Research Council, 2015). However, these initiatives are not always supported with dedicated time or financial resources, and therefore limit participation to only a fraction of the landscape of doctoral candidates. Crucially, funding supports sustained long-term engagement with outreach initiatives. Over time, this enables facilitators to reflect upon, and refine their activities, as well as improve their communication skills. This transforms postgraduate outreach engagement into a valuable opportunity for professional development.

3.2 Pupil and PhD student engagement

PhD students found that the most meaningful conversations arose after the activity was over. During this time, pupils had the opportunity to ask more questions about the activity and initiate conversations about the life of a scientist. The PhD students additionally prompted the pupils to share topics that they enjoy the most at school, helping the pupils to feel more at ease and linking the presented material with their day-to-day life. The novel university environment helped to facilitate these conversations. Allowing time for these student-led conversations helped the pupils see science as relevant to their everyday life and relate to the PhD students, again improving their science capital (e.g., Archer et al., 2015; DeWitt et al., 2016).

Finally, the impact of the ESE Days went beyond that of the pupils who attended. PhD facilitators reported they found value in communicating complex concepts in an accessible way–a skill that will be required in academic careers when sharing their work with various audiences. In addition, the PhD students reported that the activities were most effective when they could flexibly adapt their approach to accommodate the different energy levels, age, and interests of participant groups; by doing so, they developed valuable skills in communicating these complex concepts both accessibly and flexibly. The ESE Days were therefore not only beneficial to the receivers of the outreach activities, but also to those who delivered it.

3.3 Concluding remarks

To summarise, we designed the ESE Days as a widening participation initiative that blends active learning, relationship building, and inclusive outreach. Through four 20-minute, hands-on, interdisciplinary activities on a university campus, we offered a breadth of environmental sciences and created space for informal conversations between school-age pupils and PhD facilitators, encouraging aspirations for higher education. We encourage future outreach facilitators to design outreach for engagement with underrepresented local communities in mind, in agreement with DeWitt and Archer (2017) and Woitowich et al. (2022). Particularly, we advocate for outreach activities to be pupil-centred, interdisciplinary, and with active learning as the pillar of the activity. We also encourage sharing outreach activities as OERs for improved access. We recognise here that funding was pivotal: by removing participation barriers for postgraduate facilitators, the provision of funding enabled continuity and skill development, thereby strengthening the representation which pupils encountered. Funding also allowed the facilitators to publish their activities as OERs, further extending the impact of the ESE Days beyond the local geography. We recommend future outreach initiatives to incorporate financial support for activity facilitators to widen the participation of outreach facilitators, not just outreach receivers.

The OERs developed are freely accessible through https://www.tes.com/teaching-resources/shop/OpenEd.

Author contributions

FM: Data curation, Writing – original draft, Supervision, Writing – review and editing, Conceptualization, Funding acquisition. OF: Data curation, Writing – original draft, Writing – review and editing, Visualization. AB: Writing – original draft. NG: Writing – original draft. CP: Writing – original draft. EC-F: Funding acquisition, Writing – original draft, Conceptualization, Writing – review and editing. KT: Writing – original draft. FF: Writing – original draft. AM: Writing – original draft. EP: Writing – review and editing. FE: Writing – review and editing. JM: Writing – review and editing. LJ: Writing – review and editing. GL: Writing – review and editing, Funding acquisition, Visualization, Conceptualization. RE: Writing – review and editing, Funding acquisition, Conceptualization. KD: Supervision, Funding

acquisition, Writing – review and editing, Project administration, Conceptualization. SR: Resources, Project administration, Funding acquisition, Conceptualization, Supervision, Writing – review and editing. NF: Resources, Writing – review and editing, Supervision. NH: Supervision, Writing – review and editing, Resources, Data curation, Project administration.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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