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Interested but not being served: mapping young people's participation in informal STEM education through an equity lens

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ABSTRACT

It is commonly assumed that the reason many young people do not participate in informal STEM education (ISE) is because they lack interest in STEM. This paper draws on survey (n = 1,624) and qualitative data (n = 36) with young people aged 11–14 to examine the ways in which science dispositions, demographic characteristics, 'consumption' of cultural practices and exclusion interact to produce unequal forms of STEM participation. Latent class analysis generated six groups within our quantitative dataset: three groups who infrequently participated in designed and community ISE practices (*Underserved Tech Enthusiasts, Underserved Creatives* and *Underserved Scientists)*, one group who only participated in specific forms of ISE practices (*Partly Served Generalists*) and two groups who frequently participated across a broad range of ISE practices (*Served Cultural Omnivores* and *Served STEMnivores)*. Participation in ISE did not necessarily reflect young people's STEM interests; many minoritised young people reported being interested in STEM, yet rarely took part in designed and community ISE, while others from more socially advantaged backgrounds regularly participated regardless of their STEM interest. We conclude that ISE settings are excluding and failing to serve young people from minoritised backgrounds and there is a need to support these young people better.

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Informal STEM participation; equity; cultural consumption; science capital; latent class analysis

Equity and informal STEM education

Informal STEM education (ISE) is a growing field and potentially encompasses a wide range of activities. As a result, although ISE research typically focuses on 'out of school' experiences, ISE has been framed in a number of different ways in the literature (Dawson 2014a, 2019; Bell et al. 2009). A key definitional difference within ISE research is about whether ISE is understood to include *all* experiences of engaging with STEM 'everyday' at home, online and through popular culture, i.e. anywhere outside school science classrooms, or whether ISE is framed as encompassing institutional activities, such as visits to science museums and zoos, or taking part in community coding clubs. In this paper, we take a broad view of what constitutes ISE from the perspective of young people and

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explore how young people aged 11 to 14 engage (or not) with in 'everyday' *and* 'institutional' (designed and community) ISE. Taking an equity perspective, we examine the ways in which science dispositions, demographic characteristics, 'consumption' of cultural and STEM-related activities and exclusion interact to produce different forms of STEM participation.

Research has suggested that ISE experiences can provide valuable opportunities for science, technology, engineering and mathematics (STEM) engagement and are of high societal significance. For instance, in the UK and across Europe, around a fifth of all young people visit science museums and centres annually (Hamlyn, Matthews, and Shanahan 2017; Ecsite-UK 2008). The benefits of ISE participation are widely recognised. Research has found that such experiences contribute to learning and interest in STEM – and have been regarded as a potential 'on-ramp' that can mitigate persistent inequalities in formal science education (Bell et al. 2009; Bevan, Calabrese Barton, and Garibay 2018; The Association for Science and Discovery Centres 2010). Research, however, has also suggested that most ISE settings tend to better serve more privileged communities and in response, equity concerns have been raised across Europe and the US (Dawson 2014b, 2019; Feinstein 2017; Massarani and Merzagora 2014). The visitor demographics of designed, institutional spaces, such as science museums and science centres, zoos and botanic gardens, tend not to be representative of the general population; participation is the highest among White, middle-class communities living in urban areas, while people from lower socioeconomic and minoritised[1] backgrounds are less likely to take part (DeWitt and Archer 2017; Garibay 2009; Hamlyn, Matthews, and Shanahan 2017; Ipsos MORI 2011, 2014).

Moreover, while a lot is known about how typical, self-selecting participants experience ISE settings and activities, relatively little research has been done with young people who do not take part (cf. Dawson 2019). In other words, ISE research has predominantly focused on those within the system, at the expense of understanding more about people who do not, cannot or will not participate in ISE. There is a common and persistent assumption that 'non-participation' in ISE is due to a lack of interest and/or exposure, or access barriers like distance and costs (Bell et al. 2009). This assumption is evident in the foci of many ISE interventions on raising or inspiring interest in STEM, a strategy that has been critiqued for assimilationist tendencies. This strategy presupposes that if only people knew about the opportunities available within ISE spaces and were able to access these, they would be able to participate and benefit from such experiences. As previous work has shown, deficit perspectives (and putting the blame for 'non-participation' on the visitors) are unhelpful and risk reproducing the status quo (Dawson 2014c, 2019).

Recent research has also pointed out that simply getting people through the door does not suffice in terms of achieving the goal of providing opportunities that are equitable for all. Many people, young and adult, feel out-of-place in both science and high-status cultural institutions like museums (Archer, Dawson, Seakins, and Wong 2016; Dawson et al. 2020; Garcia-Luis and Dancstep 2019; Gonsalves, Rahm, and Carvalho 2013; Lynch and Alberti 2010; Sandell 2007). Young people from minoritised backgrounds might therefore reap fewer benefits, even when they do take part, in comparison with 'typical' visitors (Archer, Dawson, Seakins, DeWitt, et al. 2016; Dawson 2019; Feinstein 2017). This situation manifests in a so-called 'Matthew effect', where those who are already more privileged benefit in greater amounts than those who are less, which reproduces the existing patterns of inequalities (see also Bourdieu and Passeron 1990; DeWitt and Archer 2017). Although some small-scale studies have convincingly demonstrated that ISE participation (in particular, long-term involvement in science/STEM-focused programmes) can support and empower young people from minoritised backgrounds (Calabrese Barton and Tan 2010; Gonsalves, Rahm, and Carvalho 2013; Rahm 2010), the benefits of the ISE sector at large appear to remain limited.

In this paper, we explore how participation varies across different forms of ISE and different demographics of young people aged 11–14 from two cities in the UK (Bristol and London). Specifically, we are interested in exploring different 'types' of ISE participation within our sample. By 'demographics', we refer to stratifications by gender, ethnicity, social class (which we explore through the proxy of cultural capital) and science capital (science-related resources and dispositions; see below). After introducing our theoretical framework and methodological approach, we present the six groups generated by the latent class analysis of our quantitative dataset, which we then discuss by drawing across quantitative and qualitative datasets collected as part of the same study. The groupings are considered using an asset-based approach (what we refer to as an 'equity lens'), turning our focus to what young people are doing and are interested in, rather than what they are not. Using an original dataset and applying a latent class analysis (a form of statistical analysis that has to date not been extensively used within ISE research), we aim to contribute a new and nuanced understanding of the challenges of ISE participation and provide recommendations for more equitable informal STEM learning opportunities.

Cultural consumption and science capital

In this paper, we use the theories of cultural consumption and science capital to analyse young people's ISE participation. In drawing on cultural consumption work, we find it useful to consider Bourdieu's thesis that 'taste' for cultural practices and their consumption is often not the product of individual preferences, but rather a manifestation of social status, upbringing and education. In his seminal work *Distinction*, Bourdieu wrote

> Taste classifies, and it classifies the classifier. Social subjects, classified by their classifications, distinguish themselves by the distinctions they make, between the beautiful and the ugly, the distinguished and the vulgar, in which their position in the objective classifications is expressed or betrayed. (Bourdieu 1984, 6)

Bourdieu argued that unequal power relations between dominant and dominated cultures are reproduced and sustained through an uneven attribution and valuing of particular cultural preferences and practices, which could be relationally defined through binary oppositions such as 'high' versus 'low' culture. The cultural consumption patterns of more socially privileged people tend to be valorised and regarded as 'tasteful' or 'highbrow', while those of less powerful people are accorded less value within the dominant culture and are disparaged as 'lowbrow'. A typical example of a 'highbrow' cultural practice (associated with middle-class 'taste') would be a visit to an opera house or a museum, or having a 'taste' for modern art, while watching a popular TV show would be seen as an example of a ‘lowbrow’ cultural practice (associated with working-class ‘taste’, or there lack of).

More recently, scholars have looked at how patterns of consumption have become increasingly complex in modern society (e.g. Bennett et al. 2009). The original cultural consumption work has been critiqued for disregarding some forms of popular, 'everyday' culture and insufficiently recognising the breadth of people’s activities, interests and resources (Lamont and Lareau 1988; Miles and Gibson 2016). Newer work has argued that, for instance, the elite forms of cultural consumption might actually involve consuming across a wide range of ‘lowbrow’ and ‘highbrow’ practices, not simply being limited to the ‘highbrow’ ones (a type of cultural consumption that has been labelled ‘omnivorous’; see Peterson and Kern 1996). As much of the existing cultural consumption research has to date focused on the arts, we considered it valuable to apply this theoretical work to the consumption of STEM-related activities, and consider how ‘consumption’ of different forms of ISE varies among different demographics and provide differential value for young people.

Along with the work on cultural consumption, we also employ the Bourdieusian-derived concept of ‘science capital’ (Archer et al. 2015). Science capital encompasses science-specific forms of social and cultural capital, such as what people know about science, how they think about it, what they do and whom they know. Importantly, science capital does not necessarily have value in itself. Rather, following Bourdieu’s (1986) work on capital, the value of capital is determined by the ‘field’ – the specific context with its rules and norms. For instance, skills to fix a motorbike (arguably, STEM-related skills) are valuable in a specific context, but might be difficult to activate and use in the classroom, where they might have little recognition and value (see also Yosso 2005). However, depending on the rules and regularities of the field (for instance, the teacher adopting a practice where they recognised wider range of students’ skills and experiences as legitimate), more diverse resources might be deemed valuable. The concept of science capital has previously been found to predict young people’s likelihood of participating in post-16 science education and employment. We thereby find it compelling to consider what role science capital plays in how young people participate in ISE.

Research design

In this paper, we draw on qualitative and quantitative data collected as part of the Youth Equity and STEM (YESTEM) project seeking to understand and support ISE participation among young people.

Quantitative data collection

We were interested in what young people were participating in outside their school time and what influenced their participation, with a particular interest in STEM-related activities. The survey instrument adopted items from established questionnaires (Archer et al. 2015; Falk et al. 2016) and included demographic data (e.g. gender, ethnicity), science capital items (a set of 14 items, see Archer et al. 2015), cultural capital items (a set of four items), participation items, reasons for (non-)participation, and identity and aspiration items. We recognise a common limitation of survey methodology that by providing a specified list of options (e.g. a list of defined activities with a 5-point Likert frequency scale), we might miss the breadth and complexity of what young people actually do. We also acknowledge that our project's focus on designed and community ISE settings aligned with dominantly valued practices. Elitist, classed assumptions of the value of dominant cultural activities like visits to a science museum have, in previous work, made some other practices associated with different modes of science learning and engagement largely invisible (Dawson 2019). In our study, we sought to mediate these limitations by including an extended list of questions about 'everyday' science participation and adding several open-ended questions (e.g. 'What other activities do you do in your spare time that we haven't included in the list above?').

After designing a questionnaire, we carried out cognitive testing (Beatty and Willis 2007) with five Year 7 students (aged 11–12), which resulted in adding a few additional items. We then piloted the questionnaire with 547 students from four London secondary schools and used exploratory factor analyses and measures of internal consistency (e.g. Cronbach's alpha) to test and further refine the instrument. The piloting was carried out with the same age group as planned for the main study. We initially aimed for a sample of at least 300 in order to check for reliability and validity of the instrument (Field 2013). The recruitment of participants for the pilot study was done by the project team using existing school contacts. Mindful of the challenges of making arrangements with schools to complete computer-based surveys, we over-recruited and ended up with higher pilot sample size than initially aimed for, which we decided to consider in full for survey validation.

Schools for the main study were recruited in London and Bristol (which were the cities where the qualitative aspects of the study were also taking place), aiming to include young people who regularly participated in ISE as well as those who did not. Using EduBase, the Department for Education's public register of educational establishments in England and Wales, a sample frame of secondary schools in London and Bristol was designed, which specified the criteria against which schools would be recruited. The sample was broadly representative at school level of secondary schools in the two cities, considering the following criteria: percentage of students who spoke English as an additional language, percentage of students who were eligible for Free School Meals and students' attainment. Schools were then recruited along those criteria; they were offered a school-specific report and a voucher as an incentive to participate and help recruit students. When a school declined to participate or was non-responsive, another school that broadly fitted the sample quotas was approached as a replacement. There was an even spread of students across Years 7, 8 and 9.

Students from 10 London and four Bristol state schools completed the surveys via an online link during school time. Between March and June 2018, we collected 1,873 responses. After data preparation and cleaning, 1,624 individuals remained in the dataset for the analysis reported in this paper. 1,019 (62.7%) were from London and 605 (37.3%) from Bristol. 41.4% were boys, 50.1% were girls, and the remaining young people selected 'prefer not to say' or 'other'. 38.8% of respondents self-identified as White, 19.9% South Asian, 15.9% Black, 16.1% other ethnicities (including mixed backgrounds) and 9.4% declined to answer. As per previous research conducted with school-aged young people (DeWitt and Archer 2017), a measure of cultural capital was used as a good enough reliable proxy for social class given that it is not feasible or desirable to obtain income data from children this age and given the considerable challenges of obtaining classifiable and valid parental occupation data from samples of this age and size. 33.4% of participants recorded low/very low cultural capital, 22.8% medium, and 43.7% high/very high cultural capital. We also calculated each participant's science capital score; 30.5% had low science capital, 64.0% medium and 5.5% high science capital, which is comparable to the national average (Archer et al. 2015).

Qualitative data collection

In parallel to the survey study, we worked with 36 young people across four ISE settings in the two study cities (Bristol and London, UK). These young people were involved with us over the course of one year. While the wider research work was multimodal and ethnographic, in this paper, we draw only on the specific data on involvement in STEM-related activities, their reasons for participating (or not), along with STEM-related dispositions, aspirations and resources young people had available. Data were captured through one-to-one interviews and discussion groups. All names are pseudonyms, which the young people chose themselves. The aim of including the relevant parts of qualitative dataset was to be able to provide depth and context and to help illustrate and exemplify further insights about the groups. It is important to highlight here that the paper foregrounds quantitative data and statistical analysis. Including qualitative data were deemed valuable to enriching our work and interpretation of the quantitative results and starting to bring the qualitative and quantitative datasets into conversation with one another.

Data analysis

Guided by an interest in how participation vary within and across different forms of ISE and different demographics of young people, we performed a latent class analysis (LCA), a statistical technique for analysing multivariate categorical data and identifying subgroups within a population. The latent class analysis is a statistical approach that finds the most parsimonious way to group respondents into classes by probabilistically grouping each observation into a 'latent class', which 'produces expectations about how that observation will respond on each manifest variable' (Linzer and Lewis 2011, 2). Latent class analysis has previously been used for influential academic studies, such as developing a new model of social class from the BBC's Great British Class Survey experiment (Savage et al. 2013). Although inferential statistical tests and pattern-finding (grouping) techniques, such as LCA, are designed for use with random samples, their use on non-random samples is not unusual in social research. Indeed, the Great British Class Survey involved a non-random, self-selecting sample. Despite the limitations on interpretations that can be drawn from our sample (which, while broadly representative at school level, was not random), we believe that the insight provided by using LCA was richer and more interesting than what could be done with descriptive statistics alone.

We used 40 closed-ended survey items relating to participation and dispositions for the LCA (see Appendix 1 for the list of items). We first carried out principal component analysis (PCA) to reduce the number of variables, and entered 13 composite variables into R. We then used a poLCA package for the estimation of the latent class models. We generated four separate models containing four, five, six and seven groups. The Bayesian Information Criterion (BIC) was minimised for a four-group solution, meaning that this was mathematically the most efficient model (Schwartz 1978). However, we considered this solution to be limited in nuance (e.g. one of the classes included 36% of the sample). After investigating all the solutions by examining the groups' characteristics of interest to the research questions and the number of respondents in each group, we decided to pursue a seven-group solution. The summary of the model results: number of observations = 1,624; maximum log-likelihood = −28,422.15; BIC = 59424.34; AIC = 57,542.31; number of estimated parameters = 349; square of the likelihood = 32,846.85; residual degrees of freedom = 1,275. Examining the seven groups further, we decided to combine two groups, which were comparable to each other on all the key items of interest to this study (the two groups differed on items not related to STEM), into a single class (we later labelled this group *Underserved Tech Enthusiasts*). This process resulted in the six final classes/groups, which are presented below. Although the classes that emerged from the analyses are perhaps not entirely surprising in light of existing research on participation in informal STEM education (e.g. Ipsos MORI 2011), they were derived from the data and not determined in advance.

The labels of the six classes were given after the analysis was completed and reflect the authors' interpretations. To identify the key features of each group, we began by looking at the item-response probabilities (Collins and Lanza 2010), which indicate the proportion of young people giving a specific response to the survey question (e.g. probability that a young person in a group would visit a science centre, science museum or planetarium at least once a year). The first part of the latent class label indicates the extent to which young people were served, or not, by the designed and community ISE settings (e.g. *Underserved, Partly Served, Served*). The second part of the label reflects young people's predominant interests and activities (e.g. *Tech Enthusiasts* label is intended to capture the young people's interest in technology) or in some cases, an overall type of participation in out-of-school activities (e.g. *Cultural Omnivores* label is intended to highlight broad and varied cultural consumption; see a more detailed description of the label below). We use the term 'non-participants' cautiously, as we think it might suggest that young people made a choice to not take part, rather than being differently served by the ISE sector.

After establishing the six latent classes, we explored the characteristics of each class through a series of cross-tabulations, using Chi-square and adjusted residuals to test significance (at significance level $p < 0.001$). As the contingency tables were all larger than 2x2, we evaluated the statistical contribution of each cell to any statistically significant Chi-square results through an adjusted residual analysis. Adjusted residuals are z-values, which can be evaluated against a cut-off point of 1.96. However, as the Chi-square analysis involved multiple tests, the significance values were Bonferroni-corrected to control type I error rate (Beasley and Schumacker 1995; Sharpe 2015).

Results are presented in Table 1 (demographic characteristics of each latent class, with further details presented in Appendix 2) and Table 2 (participation, disposition, identity and aspiration items for each latent class). We do not present item-response probabilities matrix, which included over a thousand cells in total – we considered this to be too lengthy and complex to present in the paper. The same information (i.e. how responses to individual items relate to latent classes) can be gained by profiling the groups against the

Table 1. Summary of the six latent classes.

Latent class label	N (%)	Young people who were statistically over-represented in this class
Underserved Tech Enthusiasts	369 (22.7%)	Young people who identified as Black, as boys, who were in Year 9 and who recorded low science and cultural capital
Underserved Creatives	337 (20.8%)	Young people who identified as girls and young people who recorded low cultural capital (no significant science capital, ethnicity or age trends)
Underserved Scientists	179 (11.0%)	Young people who identified as South Asian and young people who recorded medium science capital (no significant cultural capital, gender or age trends)
Partly Served Generalists	153 (9.4%)	Young people who recorded low science capital (no significant cultural capital, ethnicity, gender or age trends)
Served Cultural Omnivores	369 (22.7%)	Young people who identified as White, who were in Year 7 and who recorded medium science and high cultural capital (no significant gender trends)
Served STEMnivores	218 (13.4%)	Young people who were in Year 7 and who recorded high science and cultural capital (no significant ethnicity or gender trends)

Table 2. Selected participation and disposition characteristics of the six latent classes.

	Underserved Tech Enthusiasts	Underserved Creatives	Underserved Scientists	Partly Served Generalists	Served Cultural Omnivores	Served STEMni-vores	Full sample
Out-of-school activities **							
Go for a walk in the nature once a week or more	19.7%*	19.9%*	41.7%	76.2%*	46.8%	76.9%*	41.4%
Play video games once a week or more	75.9%	48.8%*	67.2%	65.8%	62.3%	57.1%	62.6%
Make or create things (e.g. drawing, writing, music, videos) once a week or more	23.8%*	48.9%	49.4%	80.9%*	62.2%*	80.6%*	53.8%
Attend cultural events and festivals (e.g. theatre, cinema, concert) once a month or more	46.1%*	30.5%*	55.7%	90.2%*	65.2%*	85.8%*	58.0%
Visit a museum or gallery once a year or more	14.8%*	33.6%*	45.8%	50.0%	81.8%*	88.0%*	50.5%
Visiting designed/community ISE settings **							
Visit a science or STEM club at school once a year or more	2.2%*	6.8%*	19.0%	2.0%*	25.2%*	61.9%*	18.2%
Visit science centres, science museums or planetaria once a year or more	6.3%*	15.1%*	28.5%*	34.6%	69.1%*	89.0%*	38.6%
Visit zoos or aquaria once a year or more	28.0%*	38.6%*	44.7%	69.3%*	73.4%*	85.8%*	54.0%
Visit clubs or places where you do science, technology, engineering and mathematics with other people once a year or more	10.6%*	11.6%*	30.2%	20.3%*	43.1%*	83.9%*	31.1%
Visit a city farm once a year or more	6.5%*	14.8%*	13.4%*	35.9%*	41.5%*	58.3%*	26.7%
'Everyday' STEM learning **							
Read books or magazines about science once a month or more	9.2%*	25.5%*	54.7%*	32.0%	48.8%*	90.8%*	39.7%
Watch something related to science or technology online (e.g. YouTube, Instagram, Snapchat) once a month or more	40.5%*	58.2%*	77.1%*	62.1%	81.0%*	94.5%*	66.7%
Do experiments or use science kits once a month or more	9.8%*	15.4%*	29.6%	25.5%	30.6%	68.8%*	27.3%
Make, build and/or fix things once a month or more	28.8%*	37.7%*	64.8%*	62.1%	61.8%*	90.8%*	53.6%
Talk about science with other people once a month or more	13.9%*	35.6%*	71.5%*	33.3%*	66.9%*	88.5%*	48.6%
Science-related dispositions and support (agreeing with the statements) **							
A science qualification can help you get many different types of jobs.	56.5%*	75.4%	97.2%*	55.6%*	88.3%*	88.5%*	76.4%
My teachers have specifically encouraged me to continue with science after GCSE.[2]	14.4%*	22.6%*	81.0%*	21.6%*	28.7%	63.8%*	34.0%
One or both of my parents/carers think science is very interesting.	24.7%*	43.9%*	88.8%*	28.1%*	68.0%*	82.6%*	53.7%
It is important to study science, even if you don't want a science job in the future.	35.9%*	58.8%	89.4%*	43.1%*	72.1%*	85.3%*	62.1%
I feel at home in my science classroom.	5.4%*	11.3%*	62.6%*	2.6%*	20.6%	52.3%*	22.4%
I feel comfortable in out of school science and technology settings.	7.1%*	20.8%*	58.7%*	11.8%*	43.1%*	72.5%*	33.0%
STEM identity ***							
I see myself as a science person.	9.6%*	16.5%*	54.3%*	10.1%*	32.8%	63.1%*	28.4%
I see myself as a tech person.	25.1%*	26.4%	43.4%*	24.2%	33.1%	46.3%*	31.9%

(*Continued*)

Table 2. (Continued).

	Underserved Tech Enthusiasts	Underserved Creatives	Underserved Scientists	Partly Served Generalists	Served Cultural Omnivores	Served STEMni-vores	Full sample
I see myself as an engineer person.	15.2%*	13.8%*	32.0%*	21.5%	23.1%	46.7%)	23.4%
I see myself as a maths person.	31.4%*	36.9%	54.3%*	26.2%*	47.1%	62.6%*	42.3%
Aspirations*							
I would like to study a science subject at university.	7.5%*	9.7%*	32.6%*	6.7%*	17.1	25.9%*	15.3%
Interested in having a job like these one day*							
Physical scientist (e.g.chemist, physicist, astronomer)	12.0%*	25.9%*	53.2%*	16.9%*	44.7%*	63.5%*	34.1%
Engineer (e.g. civil, electrical, mechanical, chemical engineer)	30.9%*	28.6%*	51.7%*	29.6%	44.3%	63.1%*	39.9%
Architect, designer	37.9%*	54.9%	60.7%	58.0%	67.3%*	71.7%*	57.0%
Computer programmer, website or games designer	36.9%*	40.0%	46.2%	45.5%	48.2%	57.9%*	44.7%
Doctor, veterinarian, pharmacist, dentist, nurse, nutritionist, physiotherapist	25.1%*	44.4%	57.8%*	43.4%	49.7%	69.8%*	46.0%
Mechanic, electrician or working in construction	28.5%	23.1%*	38.6%	25.2%	28.4%	51.5%*	31.2%

*Significance of Chi-square tests at the Bonferroni-corrected significance level (p <.001) to control for multiple tests.
** Items under these headings were entered into the latent class analysis.
*** Items under these headings were additionally explored after the latent classes were established.

original items and providing the corresponding percentages. We present selected examples that we found to be most meaningful in characterising the latent classes in Table 2. Table 2 combines items entered into the LCA and items explored after the latent classes were established. For clarity, we qualitatively joined responses, to present percentages of young people who 'regularly' engaged in a particular activity (informed by the existing scholarship, we configured 'regular' engagement differently for different activities).

In addition to cross-tabulation, we also carried out a logistic regression to find out which independent variables were most important in determining whether a person is in a particular group or not (the dependent variable was binary, e.g. 'not in class 6′ = 0, 'in class 6′ = 1). The logistic regression results confirmed the results of Chi-square tests and did not provide any new, additional information; hence, we do not present them here. Finally, we also coded open-ended responses and were particularly interested in any answers that suggested a STEM-orientation of the activity or aspiration.

Following an equity orientation, we were attentive to results that we considered interesting *for a specific group*, even when the results were not statistically significant when considering the adjusted residuals across the six latent classes. For example, we regarded it valuable to report that over a third of young people in the *Underserved Tech Enthusiasts* group, who were as a group the least comfortable in science and technology settings and who were the least frequently participating in ISE, actually agreed with being interested in STEM-related careers (despite this result not being significant statistically).

Qualitative data analysis was done collaboratively by the research team using a shared NVivo file. To address the questions proposed in this paper, we attended particularly to the data relating to out-of-school STEM participation, the reasons for participation, as well as demographic data in order to understand a picture of each young person (e.g. ethnicity, socioeconomic level, science capital). After we obtained and characterised the six latent classes, we examined if/whether any of the young people in the qualitative cohort might align with the key features of the latent classes. We identified one or more young people from our qualitative cohort who best characterised the latent class as illustrative examples, to provide an additional insight into understanding STEM participation.

We discuss the findings of the quantitative and qualitative parts of our study together. We begin with the survey results (i.e. characterising the specific latent class), then illustrate and explicate the characteristics of the group with qualitative data, drawing on data from young people who we interpreted as being most closely aligned with the characteristics of each latent class. Throughout the analysis and writing process, our interpretations are guided by an equity lens and informed the theoretical framework of cultural consumption and science capital that we introduced earlier in this paper.

Findings

Six classes of ISE participation

In this section, we start by presenting the overview of the six latent classes (Tables 1 and 2), which we then discuss in more details, group by group, by drawing on both quantitative and qualitative analysis. Table 1 summarises the key demographic characteristics of each latent class: the number and percentage of young people within each class and demographic trends of each class (see Appendix 2 for detailed Chi-square results of the demographic characteristics of each class).

Table 2 presents the key participation, disposition, identity and aspiration results for each latent class in a form of percentages of participants who agreed with a specific statement or who participated in a specific activity with a given frequency. We indicated with an asterisk (*) if the cell was significant at the Bonferroni-corrected alpha level to control for multiple tests. We give percentages for the overall cohort in the final column.

Underserved by ISE: Tech Enthusiasts, Creatives and Scientists

Class 1: Underserved Tech Enthusiasts

Members of this group were disproportionately more likely to self-categorise as Black, boys, and record low science and cultural capital scores. We called this group *Underserved Tech Enthusiasts* to reflect our interpretation that the young people seemed to be underserved by the ISE (i.e. low participation in designed and community ISE, with only 6.3% having visited a science museum, science centre or planetarium within the last year, compared to the cohort's average of 38.6%) and conveyed a strong interest in and high consumption of technology, digital media and gaming. The latter was evident from 75.9% of the group playing video games at least once a week, which was significantly more than other groups. Young people in this group reported feeling less comfortable in science and technology settings (only 5.4% felt comfortable in their science class and 7.1% felt comfortable in out-of-school science and technology settings). Nonetheless, many *Underserved Tech Enthusiasts* were interested in STEM-related jobs and/or held STEM-related aspirations. Around a third said they were interested in jobs such as engineers (30.9%), architects/designers (37.9%), computer programmers, website and games designers (36.9%), and mechanic, electrician or working in construction (28.5%). Although these percentages are lower than those recorded for other groups, we find it interesting that there was a notable interest. From the open-ended responses of what young people would like to do at the age of 25, nearly half (46.9%) named jobs that we interpreted as STEM-related, such as 'robotics engineer', 'bike mechanic' and 'pilot'. These young people had a stronger technology and maths than science identity, as suggested by 25.1% agreeing with being a tech person and 31.4% agreeing with being a maths person, but only 9.6% agreeing that they saw themselves as a science person.

We considered Magic (a Black African Caribbean, working-class boy in the qualitative sample) to be an illustrative example of an *Underserved Tech Enthusiast*. He described himself as a 'gamer' and in the future wanted to be involved with 'making some objects and probably new things'. Despite being interested in science, and physics specifically, he did not consider himself to be 'sciencey' because 'I don't answer a lot of questions [in the science class]'. Lulabelle, Magic's classmate who also took part in the same ISE programme, noted that 'some of my teachers, they all like pick, like, the smart kids really', which we suggest might help explain how school experiences hindered Magic's engagement with science (Magic was quiet and shy during the programme we observed). As previous research has pointed out, narrow opportunities available in the science classroom can often make it difficult for students to engage and, consequently, identify with science (Archer et al. 2017). Despite having some interest in STEM, Magic almost never visited ISE settings outside the school-led fieldtrips. When asked about ISE participation, he could not recall anything they would have visited with family and commented that his family simply would not go to places like this, unsure of the reasons why this might be.

Class 2: Underserved Creatives

Young people in this group were disproportionately more likely to be girls and have low cultural capital scores (there were no significant science capital or ethnicity trends). We labelled this group *Underserved Creatives* to reflect that, as with the *Underserved Tech Enthusiasts*, these young people rarely participated in ISE. With *Creatives*, we wanted to highlight the group's interest in and participation in creative/art-related activities. 48.9% reported making or creating things at least once a week, and the most common open-ended responses about outside school activities included music, dancing and writing. Over a third (35.8%) of those who named a specific job in response to our open-ended question about what they wanted to do at the age of 25 named one that we interpreted as arts-related, such 'artist', 'graphic designer', 'fashion designer' and 'animator'. Over half of the open-ended responses (58.3%) were interpreted as STEM-related (in some cases overlapping with the arts, e.g. 'architect'). Although not significantly more than other groups, we found it interesting to note that 75.4% of *Underserved Creatives* agreed with the statement that 'A science qualification can help you get many different types of job.' We suggest that these results indicate some interest in and dispositions towards STEM, even though this did not manifest in their ISE participation.

There were several self-identified 'arty' girls in our qualitative cohort, some of whom, we suggest, align with the characteristics of *Underserved Creatives*. Lara and Unicorn, for instance, showed an interest in science, such as displaying a willingness to attend a bi-weekly science club and reportedly enjoying their science lessons. The project participation was these girls' first time taking part in an ISE programme (both were recruited via their science teachers). Lara spoke about enjoying learning about space and wanted to take care of animals when older; Unicorn described her science lessons as 'fun'. Despite liking science, their ISE participation was not what their families did. This resonated with Magic's above response as well as with the survey results, where 'These are not the sort of places me and family/friends go to' was consistently among the top three reasons young people reported for not visiting different ISE settings (among both *Underserved Tech Enthusiasts* and *Underserved Creatives*).

Class 3: Underserved Scientists

Underserved Scientists were disproportionately more likely to be South Asian and have medium science capital scores (there were no significant cultural capital or gender trends). The label reflects our interpretation that this was the most science-keen group (recording the highest aspirations towards science education with 32.6% wanting to study a science subject at university, and being more interested in becoming physical scientists, engineers and pursue medical professions than other groups). Yet, despite a strong interest in STEM, as well as being significantly more likely to engage with 'everyday' science learning at home (especially, reading books and magazines about science, watching science-related programmes online, making, building and fixing things and talking about science with other people), *Underserved Scientists* visited ISE settings significantly less than the cohort's average. For instance, only 28.5% visited a science museum, centre or planetaria within the past year, compared to 38.6% cohort's average.

This group also reported being significantly more comfortable in science and technology settings (62.6% agreed that they felt at home in their science classroom and 58.7% agreed that they felt comfortable in designed out-of-school science and technology settings, such as science museums or science centres). Notably, however, this was the only group who felt *less* comfortable in out-of-school science and technology settings than in their science classrooms, while the opposite was observed among the other five groups (young people, on the whole, reported feeling more comfortable in out-of-school science and technology settings than their science classrooms).

Qualitative data provide some insight into the reasons for low ISE participation among some minoritised young people. Several science-keen (i.e. reporting high interest and aspiration in science/STEM), working-class young people from minoritised communities (all first or second-generation migrants in the UK) in our qualitative cohort rarely or never participated in ISE. In exploring the reasons for this, a particularly interesting theme emerged around the perceived value of ISE. Tori (a Black British, working-class girl), for instance, mentioned that ISE activities, such as science clubs, could not provide her with the level of learning she would receive through schoolwork: 'in school, you can learn new stuff. Let's just say you're going to a club ... you're going to get information but you're not going to get information more than in school.' Tori spoke about how despite having enjoyed taking part in the STEM programme as part of our project, she was unlikely to seek out other similar ISE opportunities because her focus was on 'exams and education'.

> Tori: I'd actually love to do all these things [science club] again and again, but it's just exams and education. It's really good to focus on one thing right now.
>
> I: Yeah, so your schoolwork is your main priority?
>
> Tori: When you're young, focus on study, when you've grown up, you can do whatever you want ... that's what my dad used to always tell me and my brother. [...] let's just say you were young, ruined your life, when you've grown up, you won't be able to fix that.

Innocent (a Black British, working-class girl), similarly, saw little value in repeated visits to an ISE setting: 'if we go [to science museums] every time, every month, it will just still be the same things'. While not visiting 'typical' ISE settings (as conventionally framed within science education research and practice to include places like science museums/centres and clubs), young people were involved in STEM-related activities in other ways, such as through regular evening and weekend tutoring sessions in science and mathematics.

> I:Do you do any [science] club type stuff?
>
> Innocent: Does tutoring count?
>
> I: Yes.
>
> Innocent: I do that, quite a lot.
>
> I: So, science tutoring on Saturdays?
>
> Innocent: Sundays and Mondays.
>
> I: So, Sunday and Monday. So, what is that, then, science?

Innocent: Science, maths.

Several *Underserved Scientists* in our qualitative cohort spoke at length about the tutoring, revision sessions and additional educational activities they were involved in, often on a weekly basis. Dani (a Black African girl) mentioned that 'on Saturday, I do the maths thing [university-based mathematics club], and on Sunday, I do my tutoring' and Emerald (also a Black African girl) spoke about her weekly tutoring in mathematics and English: 'I practise tests that I'm going to do.' Participation in these activities appeared to be motivated by the girls' ambition to succeed academically and as Tori put it, make sure not to 'ruin your life' by getting distracted by things not contributing to future educational and employment successes. Being aware of the competitive nature of their desirable careers in medicine and science (Tori, Innocent, Emerald and Dani all aspired to become doctors), we suggest that these girls and their families were invested in a careful 'cost-benefit analysis' of their out-of-school activities, weighing what investment would give them the best return. In this way, we considered these girls to be 'pragmatists', guided by practical considerations about how to spend their time. This, we suggest, might also have been influenced by the girls' precarious structural position and the intersecting disadvantages of ethnicity, social class, gender and migration background, where failing to succeed academically might have grave consequences. The young people perceived educational activities such as tutoring and revision to have more benefits for their academic success than ISE participation. They felt that school-related out-of-school activities offered a closer, clearer and more obvious way to generate exchange-value capital, through the symbolic capital of qualifications. In other words, the school-related experiences appeared to have been regarded as more valuable within the dominant field (school), while other informal STEM experiences were not seen as having similar value. That is, the exchange-value of some common forms of ISE participation, such as visiting science museums, was less obvious to the young people, and hence less worthy of their time.

(Partly) served by ISE: Generalists, Cultural Omnivores and STEMnivores

Class 4: Partly Served Generalists

Partly Served Generalists were disproportionately more likely to record low science capital scores (there were no significant cultural capital, ethnicity or gender trends). The group's label reflects our interpretation that the young people in this group were 'served' by some ISL settings but not others, with animal-related settings being visited particularly frequently. Young people in this group were significantly more likely than average to visit zoos, aquaria and city farms, with 69.3% visiting a zoo or an aquarium and 35.9% visiting a city farm at least once a year. They were significantly less likely to visit other ISE settings, particularly clubs. This finding resonates with previous research work reporting that animal and nature-related settings generally seem to be visited in higher numbers than other ISE settings (Hamlyn, Matthews, and Shanahan 2017; Ipsos MORI 2014). *Partly Served Generalists* also reported a high level of engagement with a range of out-of-school activities. They were significantly more likely to attend cultural events and festivals (90.2% attended at least once a month), make or create things at home (80.9% reported doing this at least once a week), and go for a walk in the nature

(76.2% went at least once a week). This group, however, was significantly less likely to want to study a science subject at university (only 6.7% wanted to do so, which is the lowest of all groups). This group was also the least comfortable in the science classroom; only four students in this group (2.6%) agreed that they felt at home in their science classroom, with slightly more reporting that they felt comfortable in out-of-school science and technology settings (11.8%). Yet, over a third (37.5%) named wanting to do a job at the age of 25 that we interpreted as STEM-related.

Several participants in our qualitative cohort remarked that going to a zoo was 'a family day out' and leisure activity. Visits to animal-related places appeared to be popular even among those young people who otherwise distanced themselves from science. Crystal (a White British, working-class girl), for instance, who told us that she 'hated' science, reported regularly going to the London Zoo with her mum ('It was fun, 'cause I got to see my favourite animal [an owl]'.) As reported elsewhere, zoos and aquaria are more closely related to fun and 'entertainment' than learning (Carr and Cohen 2011; Hyson 2004), which might partly explain the appeal of these places regardless of science interest.

Class 5: Served Cultural Omnivores

Young people in this group were disproportionately more likely to be White, and have high cultural capital scores and medium science capital scores (there were no significant gender trends). Based on their cultural capital scores, we interpreted this group to be from more advantaged/middle-class backgrounds. We called this group *Served Cultural Omnivores* to reflect our interpretation of their regular and broad cultural participation (which extended to ISE), borrowing the label of 'omnivores' from the cultural consumption scholarship (Katz-Gerro 2004; Peterson and Kern 1996). This group was significantly more likely than average to visit ISE settings (69.1% visited science centres, science museums and planetaria, and 73.4% visited zoos and aquaria at least once a year). Yet, contrary to what their high ISE participation might suggest, *Served Cultural Omnivores* did not have particularly strong science dispositions or aspirations. For instance, only 17.1% planned to study a science subject at university (just slightly above the cohort's average of 15.3%, the difference not being significant).

Rhubarb (a White British, middle-class girl), who described herself as 'arty' and 'creative' and who planned to study design, seemed to be an illustrative example of a *Served Cultural Omnivore* in our qualitative study. Despite admitting that science was not one of her main interests, she was one of the most frequent ISE participants in our study. She gave a long list of museums and other ISE settings she went to with her family on a regular basis 'I would say twice in a month'; 'I'm always with my family everywhere and I like going to museums and I like to learn about new things and learn facts'. Rhubarb's responses suggest that her family played a key role in her frequent ISE participation, which resonated with others in the study who stressed the role of their parents in driving their ISE participation, sometimes regardless of the young people's interest in STEM. Tardis (a Middle Eastern, middle-class girl), for instance, said that 'it's probably my parents who want to go [to a science museum] and then I'll be kind of reluctant at first'. Despite an ambiguous interest in science and/or participation in ISE, young people from more socially privileged backgrounds experienced a substantive amount of science activities outside school, particularly in terms of their participation in more structured, institutionalised ISE.

Class 6: Served STEMnivores

Served STEMnivores were more likely to have high cultural and science capital scores (there were no significant ethnicity or gender trends), suggesting more privileged socio-economic/middle-class status. Similar to the *Cultural Omnivores*, young people in this group regularly participated in a range of cultural activities and recorded a particularly high STEM-related participation. *Served STEMnivores* were the most regular ISE participants in our cohort, akin to 'voracious consumers' (Sullivan and Katz-Gerro 2006) given the breadth and frequency of their ISE participation. 89.0% visited science centres, museums and planetaria at least once a year, 85.8% zoos and aquaria and 83.9% clubs or places where they did STEM with other people. Their participation was high also for non-STEM settings, echoing previous research findings on the correlation between cultural and science participation (Hamlyn, Matthews, and Shanahan 2017). Unlike *Cultural Omnivores, STEMnivores* had a strong interest in STEM and high science-related aspirations (although, notably, not as high as the *Underserved Scientists*); 25.9% said they wanted to study science at University and 82.1% mentioned wanting to do a job that we interpreted as STEM-related.

We consider Ocean (a White British, middle-class boy) to exemplify a *Served STEMnivore* within our qualitative cohort. Ocean had high science capital, as indicated by both of his parents working in STEM-related jobs, and regular consumption of science books, DVDs and experiment sets he had at home. He regularly participated in a range of ISE settings and programmes, including school enrichment programmes that were exclusive to the keenest/highest attaining science students (DeWitt and Archer 2017). As he explained, 'not everyone goes' to these programmes, but it is only students like him who 'get chosen' because they 'show interest in science in their lessons'. In contrast to the above *Underserved Scientists*, Ocean also appeared to derive substantial exchange-value capital from his ISE participation; he regarded his experiences to be easily activated and of high value within the dominant field. He considered his participation to be valuable for achieving his aspiration to become an engineer, e.g. 'when I finish the [out-of-school engineering programme], they give me like a certificate saying if you want to do this in the future, you'll get a better chance of getting a job from engaging with it.'

Discussion

ISE for social good – or social reproduction?

In line with previous research (Dawson 2014a; DeWitt and Archer 2017; Garibay 2009; Hamlyn, Matthews, and Shanahan 2017; Ipsos MORI 2011, 2014), we found that ISE participation was highest among the most privileged young people, that is, among affluent, socioeconomically advantaged and White young people. High levels of participation in designed and community ISE were found among both those with and those without high interest in and dispositions towards STEM.

A particularly interesting group were *Served Cultural Omnivores*, who were frequent participants of a wide range of out of school educational activities, including STEM-related activities, despite not having particularly strong STEM interest, dispositions or aspirations. We interpret this finding as a potential example of 'concerted cultivation' within socially advantaged families (Lareau 2003), whereby intensive parent/caregiver practices are enacted to build specific forms of habitus and social and cultural capital within children as a means for supporting the social reproduction of privilege. It has previously been argued that cultural omnivorousness is a key practice in the production of 'cosmopolitan' and 'cultured' middle-class selfhood (Skeggs 2004). Following Bourdieu's (1984) cultural consumption work, we argue that the value of designed and community ISE participation for some middle-class young people may be as much the capacity to attach symbolic value to the self (through notions of 'taste' and being 'culturally rounded') as the generation of STEM-related exchange-value (in the form of STEM-specific capital). From this perspective, the alignment of many institutional ISE spaces with dominant societal values and aesthetics can be seen not as a matter of chance but rather a technology of distinction, achieved through cultural consumption.

In line with previous research (e.g. DeWitt and Archer 2017), our study also found that young people in the *Served* groups (*Served Cultural Omnivores* and *Served STEMnivores*) were more likely younger (Year 7), which could be interpreted as ISE participation decreasing as young people grow more independent, suggesting the role and importance of family support.

'Non-participation' in designed and community ISE settings not due to a lack of interest or dispositions in STEM

In both the literature and in STEM policy and practice, it has often been assumed that young people who do not participate in ISE lack interest in STEM or do not hold sufficiently positive attitudes towards it. However, the results of our analysis agree with previous research that casts doubt on such assumptions (Dawson 2019, focusing on adult participants). We found that young people who rarely participated in the ISE settings and programmes (*Underserved Tech Enthusiasts, Underserved Creatives* and *Underserved Scientists*) did not necessarily lack interest in or dispositions towards STEM. Indeed, many of these young people reported valuing science, with high percentages agreeing that science qualifications would help them get many kinds of jobs and holding STEM-related aspirations. It is significant to note, however, that young people in the *Underserved* groups were more likely to be from minoritised communities and had lower levels of dominant forms of science and cultural capital (our proxy for social class), highlighting the intersection of inequalities.

Despite infrequent participation in institutional ISE, many young people in the *Underserved* groups regularly participated in a range of 'everyday' science learning activities, such as watching science or technology online, making, building and/or fixing things. Our findings thus trouble popular assumptions that institutional ISE largely caters for the 'already interested' and that the way to engage those who do not traditionally participate is to raise their levels of interest in STEM. Rather, we interpret our findings as suggesting that ISE is currently largely only serving White and middle-class (i.e. high cultural capital) young people, irrespective of their interest in STEM, while largely failing to serve minoritised young people, including those with STEM interests (cf. Calabrese Barton and Tan 2018).

Why are minoritised young people in London and Bristol largely absent from, or excluded by, designed and community ISE settings and programmes? The wider literature has drawn attention to the issues of both access and inclusion. That is, accessing designed and community ISE settings can require considerable resources and capital (e.g. time, economic and cultural capital) and the spaces are often configured in ways that exclude and marginalise those whose knowledge and interests are not equitably reflected and represented (Dawson 2019; Dawson et al. 2020; Das and Lowe 2017; Dixon 2012; Garibay 2009; Levin 2010; Sandell 2007). In comparison, many of the 'everyday' STEM activities that young people reported engaging in may be easier to access, adapt and fit the interests and needs of the young people concerned. We suggest that this disjuncture, whereby minoritised young people who had an interest in STEM reported largely not engaging in institutional ISE, might reflect a mismatch between the young people's habitus and capital, and the field of institutional ISE (Archer et al. 2020).

The group of *Underserved Scientists* provided a particularly interesting example of how ISE settings are failing to serve some young people from minoritised communities, even when these young people report strong STEM identity and high engagement with 'everyday' science learning. We interpreted the 'pragmatists' (young people from our qualitative cohort whose characteristics resonated with *Underserved Scientists* and who spoke about making careful, pragmatic decisions about how to spend their out-of-school time to best prepare for the future) as enacting a form of a strategic response to living precarious positions of inequality. That is, we suggest that their decision not to participate in institutional ISE reflects how the investment of time, energy and resources matter, but particularly for those who are structurally disadvantaged. Hence, institutional ISE participation can be understood as entailing costs and thus representing a 'risk' that needs to be carefully weighed up (e.g. will the costs of such participation outweigh the potential benefits, especially compared to other 'known' investments, such as tutoring, which can deliver more immediately transferable forms of exchange-value capital, such as better grades in school science). As Beck (1992, 35) has argued, 'like wealth, risks adhere to the class pattern, only inversely: wealth accumulates at the top, risks at the bottom'. We, therefore, suggest that participation in institutional ISE is not an equal choice for all and might entail greater costs and risks for young people from minoritised and/or working-class backgrounds (Archer and Hutchings 2000; Dawson 2019). In this respect, it might be argued that currently, ISE is failing to offer a good enough deal and 'return on investment' of time and efforts for these young people.

To conclude, we interpret 'non-participation' in institutional ISE as a product of processes of privilege, exclusion, the effects of structural inequalities and the failure of the sector to serve minoritised communities, rather than a deficit or a lack of interest among those who do not participate. In other words, the reasons for 'non-participation' are located in structure, rather than the young people (and their families) lacking interest or the 'right' attitudes. Patterns of participation and 'non-participation' are produced through the interaction of multiple social axes of privilege and inequality (Hill Collins 2002). Intersecting social oppressions, rather than STEM interest and dispositions, shape young people's participation in informal STEM education. Following the work of Ladson-Billings (2006), we might see these patterns of exclusion as a form of 'debt' owed by the ISE sector to less privileged, minoritised groups, such that the 'size' of the debt is increased through multiple axes of inequality (Archer, Godec, and Moote Forthcoming).

Implications for research and practice

A key implication from our analyses is that efforts to broaden and diversify participation in STEM will need to be directed at changing the ISE systems, institutions and practices rather than on focusing on trying to change ('non-participating') young people. In other words, we would argue that ISE would need to critically reflect on and consider the extent to which it is prepared to challenge and change this role. Taking a Bourdieusian lens, this means a central focus on shifting dominant, inequitable power relations within the field. This would involve critically reflecting on the goals and values of ISE and current approaches to equity (e.g. is the goal to support critical agency for young people and communities, or to serve the STEM pipeline?).

We are informed here by wider research on the transformative potential of participatory, asset-based approaches in education (e.g. interests, skills, funds of knowledge, see Moll et al. 1992). We found that many of the young people in our study had STEM interests and participated in a range of 'everyday' ISE (e.g. gaming, tutoring). Yet, while these practices might reflect substantive funds of knowledge, they might not necessarily be leveraged by formal or even informal STEM learning settings. In other words, these experiences and resources may not always be recognised or leveraged as legitimised forms of STEM learning/participation within existing research and practice (Hamlyn, Matthews, and Shanahan 2017; Ipsos MORI 2011). Adopting Bourdieusian framing, we would argue that some of the young people's capital might be difficult to activate and use in productive ways within the dominant field of science/STEM education.

There is a need for the ISE sector to serve young people's interests and needs better, as well as for the wider field to reflect on the value placed on the different forms of knowledge and participation. This includes researchers, who we suggest should be careful not to disregard certain groups as 'non-participants' or 'disengaged' simply for not taking part in the narrow range of options considered by the research design and data collection, which might themselves embody and perpetuate middle-class privilege. We agree with others who have argued that there is a need to broaden what counts and revalue what young people are doing – in science learning and wider research in this area (Dawson 2019; Taylor 2016). As we move forward with our research, we will be identifying and documenting a range of ISE practices and configurations of the field that can support equitable outcomes among underserved young people.

Conclusion

This paper has presented the results of a latent class analysis, conducted on a dataset of survey responses from 1,624 young people aged 11–14 in two UK cities, London and Bristol, supplemented with qualitative data from 36 young people from the two cities who were taking part in informal STEM education programmes. We found that patterns of participation were structured by ethnicity and social class (as indicated through the proxy of cultural capital) and that 'non-participation' was not due to a lack of interest in STEM. Rather, we suggested, this was due to an injustice of the system. We offered an interpretation of participation in designed and community ISE as aligned with social reproduction and argued that if participation in ISE is to be widened and diversified, then this will require change (in values, practices and purpose) at the level of the ISE field in order that minoritised young people might be better served by ISE.

Notes

1. We use the term minoritised (rather than minority) to indicate that an individual's minoritised status is a function of how they are positioned within society, rather than an inherent characteristic. The term minoritised thus draws attention to the processes and practices of injustice and exclusion.
2. GCSE, a General Certificate of Secondary Education, is an academic qualification, generally taken in several subjects by secondary school students in England at age 16.

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Appendix 1: Survey items entered into the latent class analysis

How often do you do the following activities [Never or rarely (once a year), Occasionally (few times a year), Sometimes (once a month), Regularly (once a week), Always (every day or every other day)]

(1) go for a walk in nature (e.g. a park or the woods)
(2) do sports
(3) play video games
(4) browse the internet, watch TV or YouTube
(5) make or create things (e.g. drawing, writing, music, videos)
(6) attend cultural events and festivals (e.g. theatre, cinema, concert)
(7) have tutoring
(8) read books or magazines about science
(9) watch a science or technology programme on TV
(10) watch something related to science or technology online (e.g. YouTube, Instagram, Snapchat)
(11) do experiments or use science kits
(12) make, build and/or fix things
(13) code or design video games
(14) talk about science with other people

A score of different groups of people was calculated for the following item.

(1) If you talk about science with other people, who do you do this with? (Please tick all that apply.) [Friends, Siblings (brothers or sisters), Parents or carers, Extended family members (e.g. grandparents, aunts, uncles, cousins), Directly with scientists, Not applicable (I don't talk to anyone about science.) Other (please specify)]

How often do you visit the following [Never, At least once, more than a year ago, At least once a year, At least once a term, At least once a month]

(1) a museum or gallery
(2) a youth or community centre
(3) a science or STEM club
(4) a non-science club (e.g. sports, art, drama)
(5) science centres, science museums or planetaria (with friends and/or family)
(6) zoos or aquaria (with friends and/or family)
(7) clubs or places where you do science, technology, engineering or mathematics with other people (e.g. science club, coding club, design, tinkering)
(8) Science Museum (London)/We The Curious (Bristol)
(9) London Zoo/Bristol Zoo
(10) London Aquarium/Bristol Aquarium
(11) a local city farm
(12) a local zoo
(13) a local science or engineering museum
(14) a local coding club
(15) a local maker space or engineering club

How much do you agree with the following statements? [Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree]

(1) A science qualification can help you get many different types of job.
(2) It is useful to know about science in my daily life.
(3) I know how to use scientific evidence to make an argument.
(4) My teachers have specifically encouraged me to continue with science after GCSEs.
(5) My teachers have explained to me that science is useful for my future.
(6) One or both of my parents/carers think science is very interesting.
(7) One or both of my parents/carers have explained to me that science is useful for my future.
(8) It is important to study science even if you don't want a science job in the future.
(9) I feel at home in my science classroom.
(10) I feel comfortable in out of school science and technology settings (for example, a science museum, a science centre or a science festival).

Appendix 2: Selected demographic characteristics of the six latent classes

	Underserved Tech Enthusiasts	Underserved Creatives	Underserved Scientists	Partly Served Generalists	Served Cultural Omnivores	Served STEMnivores	Total
	n (%) Adj. Res.	n (%) Adj. Res.	n (%) Adj. Res.	n (%) Adj. Res.	n (%) Adj. Res.	n (%) Adj. Res.	n (%)
Gender x2 (15, n = 1,533) = 80.556, p < .001, Cramer's V = 0.132**							
Girl	122 (35.1) -6.4*	201 (62.2) 4.9*	77 (44.8) -1.5	79 (54.1) 1.0	187 (55.2) 2.1	102 (49.8) -0.1	768 (50.1)
Boy	184 (52.9) 4.9*	101 (31.3) -4.2*	83 (48.3) 1.9	51 (34.9) -1.7	130 (38.3) -1.3	86 (42.0) 0.2	635 (41.4)
Ethnicity* x2 (30, n = 1,529) = 104.727, p < .001, Cramer's V = 0.117**							
Asian	54 (15.6) -2.3	67 (20.8) 0.5	52 (30.2) 3.6*	20 (13.7) -2.0	58 (17.1) -1.5	53 (26.0) 2.3	304 (19.9)
Black	84 (24.3) 4.8*	60 (18.6) 1.5	33 (19.2) 1.3	12 (8.2) -2.7*	30 (8.8) -4.0*	24 (11.8) -1.7	243 (15.9)
White	130 (37.6) -0.5	121 (37.6) -0.5	38 (22.1) -4.8*	62 (42.5) 1.0	162 (47.8) 3.9*	80 (39.2) 0.1	593 (38.8)
Year group				**x2 (10, n = 1,533) = 88.609, p < .001, Cramer's V = 0.170**			
Year 7	90 (25.9) -5.0*	103 (31.9) -2.3	57 (33.1) -1.2	61 (41.8) 1.2	156 (46.0) 3.8*	105 (51.2) 4.4*	572 37.3
Year 8	115 (33.0) 0.3	123 (38.1) 2.4	47 (27.3) -1.5	35 (24.0) -2.3	125 (36.9) 2.0	52 (25.4) -2.3	497 32.4
Year 9	143 (41.1) 5.0*	97 (30.0) -0.1	68 (39.5) 2.8	50 (34.2) 1.1	58 (17.1) -6.0*	48 (23.4) -2.3	464 30.3
Science capital x2 (10, n = 1,624) = 1118.887, p < .001, Cramer's V = 0.587							
Low	294 (79.9) 23.4*	119 (35.3) 2.2	0 (0.0) -9.4*	73 (47.7) 4.9*	8 (2.2) -13.4*	1 (0.5) -10.3*	495 (30.5)
Medium	74 (20.1) -20.0*	218 (64.7) 0.3	165 (92.2) 8.3*	80 (52.3) -3.2*	360 (97.6) 15.3*	143 (65.6) 0.5	1,040 (64.0)
High	0 (0.0) -5.3*	0 (0.0) -5.0*	14 (7.8) 1.5	0 (0.0) -3.1*	1 (0.3) -5.0*	74 (33.9) 19.8*	89 (5.5)
Cultural capital x2 (10, n = 1,454) = 247.139, p < .001, Cramer's V = 0.292							
Low and very low	183 (54.8) 9.4*	126 (40.6) 3.0*	58 (35.4) 0.6	56 (40.9) 1.9	42 (13.3) -8.5*	21 (10.8) -7.2*	486 (33.4)

(*Continued*)

Appendix 2: Selected demographic characteristics of the six latent classes (Continued).

	Underserved Tech Enthusiasts	Underserved Creatives	Underserved Scientists	Partly Served Generalists	Served Cultural Omnivores	Served STEMnivores	Total
Medium	78 (23.4) 0.3	86 (27.7) 2.3	37 (22.6) -0.1	33 (24.1) 0.4	61 (19.4) -1.7	37 (19.1) -1.3	332 (22.8)
High and very high	73 (21.9) -9.2*	98 (31.6) -4.9*	69 (42.1) -0.5	48 (35.0) -2.2	212 (67.3) 9.5*	136 (70.1) 8.0*	636 (43.7)

*Significance at the Bonferroni-corrected alpha level to control for multiple tests. ** 'Other' and 'Prefer not to say' (49 and 81, respectively) are not represented in the table for ease of reading. *** 'Chinese or East Asian', 'Middle Eastern' (very small numbers; 26 and 27, respectively), 'Other' and 'Prefer not to say' (193 and 143, respectively) are not represented in the table for ease of reading.