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RESEARCH ARTICLE

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Reasons for not/choosing chemistry: Why advanced level chemistry students in England do/not pursue chemistry undergraduate degrees

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Abstract

There are international concerns about decreasing rates of chemistry degree enrolment. This article seeks to understand students' reasons for not/choosing to pursue a chemistry degree, drawing on (i) open-ended survey responses from a sample of 506 students in England aged 21–22 who had studied advanced level ("A level") chemistry at age 18 (as either a full A level or a half "AS" level) and had either chosen ($n = 70$) or not chosen ($n = 436$) to pursue undergraduate chemistry and (ii) 185 interviews conducted with a subsample of 18 young people who had been longitudinally tracked from age 10 to 22 (with 17 of their parents) who took advanced level chemistry and then either did ($n = 5$), or did not ($n = 13$) go on to study for a chemistry degree. Analysis revealed four key reasons for not/choosing chemistry that were present to varying extents in both the quantitative and qualitative data (*relative interest, connection and options; experiences of chemistry A level; feeling "not/clever enough"; and views of chemistry jobs*). Four additional factors were predominantly found in the qualitative data (*associations of chemistry with masculinity; encouragement from a significant adult; views of higher education; and chemistry work experience/outreach*). Applying a sociological lens, we suggest that not/choosing chemistry was a relational process, produced through interactions of habitus, capital, and field. We identify conceptual and methodological implications and extrapolate reasons why chemistry degree enrolments may be declining, offering suggestions for how chemistry education might further support participation.

KEYWORDS

Bourdieu, chemistry, degree choice, subject choice

1 | INTRODUCTION

> *Preeti is a British South Asian young woman who was born and grew up in the East of England and lived in public housing with her mother, Geeta and sibling. Both her parents held science-related degrees from their country of origin (but had experienced downward mobility in the United Kingdom) and strongly motivated Preeti to continue with science to degree level. Throughout primary and secondary school, Preeti consistently identified chemistry as her favorite subject and remained enthusiastic in her interest and enjoyment of chemistry over time. She went on to take advanced level qualifications in chemistry, biology, physics, and maths, in which she experienced good quality teaching and obtained top grades. Yet Preeti never considered pursuing chemistry at degree level and instead went on to study biomedicine at university—a degree that she hoped would provide a "backdoor" route into her long-term aspiration for a career in medicine.*

The opening vignette from Preeti, a young woman who has participated in our longitudinal study from age 10 to 22, exemplifies the conundrum that we wish to explore in this article, namely why even sustained interest, recognition and attainment in chemistry, combined with experiences of good quality teaching and family support may not be sufficient to prompt a young person to pursue a chemistry degree trajectory. As we will go on to argue, these factors may be prerequisites for making chemistry a viable undergraduate option, but they are not what "tips the balance" of choice one way or another.

For over a decade, there has been a widespread policy concern about decreasing enrolment into chemistry degrees in the United Kingdom (e.g., Burke, 2018; Gorard & See, 2008) and internationally, including the United States (DataUSA, 2021), Australia (Lyons, 2006), Israel (Avargil et al., 2020), and Greece (Salta et al., 2012). For instance, in the United Kingdom, national figures suggest that attrition is particularly acute between advanced level (A level) chemistry and undergraduate chemistry, as noted by the Royal Society for Chemistry, who report that "in 2017, applications to study chemistry at university declined for the second year running, despite an increasing number of students taking A-level chemistry," (Burke, 2018). Accordingly, calls have been made for more attention to be given to understanding what shapes young people's chemistry degree choices, but particularly women and students from working-class and/or minoritized communities who remain underrepresented within the subject (e.g., Cooper & Berry, 2020).

Concerns about the number and representativeness of undergraduate degree students are also found within other STEM (science, technology, engineering, and mathematics) disciplines, but particularly in physics, engineering, and computing. Research has highlighted the various interconnected factors and injustices that shape participation in science and produce inequitable patterns of participation from compulsory schooling through to higher education (HE) and the science workforce. For instance, attention has been drawn to how: family dispositions, resources and capital support, or constrain school students' science participation (e.g., Archer et al., 2012, 2015; Cooper & Berry, 2020; Lyons, 2006); schools, teachers, and school science curricula and practices mitigate and/or deny student interest and/or progression in science, particularly among students from underrepresented communities (e.g., Archer et al., 2020; Chen, 2013; Joice & Tetlow, 2020; Lyons, 2006; Mcmaster, 2017); narrow, dominant, and exclusionary representations, images and practices in science make many students feel that science is "not for me" (e.g., Archer et al., 2020); engagement is shaped by science identity, being able recognize oneself, and be recognized by others as someone who is "good at science" (e.g., Carlone & Johnson, 2007).

University degree participation rates and patterns vary considerably across and between the different sciences, hence disciplinary-specific studies have also sought to understand and identify specific conditions and challenges within the areas of biology, chemistry and physics. Of these, physics has received the most attention to date, perhaps reflecting both the more acute nature of participation issues and the starkly unequal patterns of participation within the subject, with particular attention drawn to the persistent and entrenched underrepresentation of women across all educational and occupational levels (e.g., Danielsson, 2009; Francis et al., 2017; Gonsalves, 2014). For instance, it has been noted that perceptions of physics as being difficult and "hard" puts students off and Bennett and Hogarth (2009) found that students felt that they could get better grades in other subject areas compared to physics. In the United Kingdom, there is also evidence of grade severity in physics and chemistry in national school examinations, whereby these subjects are marked more harshly than others (e.g., Coe et al., 2008). This may have a negative effect on participation in physics and chemistry, since an early sense of mastery (or lack thereof) can shape expectations of success (Eccles & Wigfield, 2002).

There is a somewhat smaller literature exploring young people's reasons for choosing to study chemistry degrees. While focused on a much young, pre-degree cohort, a survey conducted by Mujtaba et al. (2018) in England with children age 11–13 found that aspirations to study chemistry were associated with perceptions of the utility of science (for skills and careers), interest in science and engagement in extracurricular activities. Research conducted more specifically on chemistry degree choices has largely involved quantitative social psychology studies of either students' intentions to study chemistry or retrospective studies of chemistry professionals, trying to identify factors that cause or relate to chemistry progression. For instance, DeBoer's (1987) study of prospective chemistry students identified the role played by a student's belief about their ability, whereby those individuals who are confident in their chemistry ability and who expect to do well at it in the future were more likely to intend to pursue the subject at degree level. Likewise, a study by Avargil et al. (2020) of Israeli chemistry professionals, chemistry teachers and chemistry HE students identified task-oriented self-efficacy as a key contributing factor to chemistry career choice. A retrospective study of chemistry teachers and professionals by Shwartz et al. (2021) suggested that high school was a significant turning point in participants' chemistry trajectories and similarly pointed to the importance of self-efficacy in chemistry as strongly related to choosing a chemistry career. These studies have focused predominantly on individual psychological factors, which from a critical perspective can be critiqued for reproducing deficit understandings of choice and failing to consider the cultural context of choice, including the role of institutional and structural factors.

There are a smaller number of qualitative studies examining the factors influencing uptake of chemistry, but these tend to surface more nuanced reasons and factors underlying choices. For instance, a study conducted by Dagogo et al. (2019) explored the degree choices of a small number of undergraduate chemistry students in South Africa and found that chemistry was a second-choice option for most of the young people, largely reflecting the university's requirement to choose a second major.

Analysis of national HE data sets (HESA 2022) shows a relatively consistent pattern between 2016 and 2021, whereby women constituted around 45% of UK chemistry degree enrolments and men around 55%. Interestingly, this gender pattern seems to be reversed among A level chemistry entries in England which, over the same time period, show a steadily increasing percentage of young women taking the subject, from 50.8% female and 49.2% male entries in 2016 to 54.5% female and 45.5% male entries in 2021 (JCQ Annual Reports, 2022). While, on the whole, chemistry records one of the most even gender balances in terms of advanced and degree level participation (e.g., compared with long-standing trends in physics, where young men predominate and biology where young women constitute the majority, see also Smith, 2011), a number of studies have drawn attention to the role of gendered inequalities and barriers to women's progression in chemistry. For instance, Miller-Friedmann et al.'s (2018) qualitative case study analysis of four successful British female chemists highlighted factors and conditions that were important to enabling the women's success within the field, such as having an effective support network, coping with financial and career instability, strategic choice of specialism and adaptation of (unconscious) bias. A quantitative study conducted by Steegh et al. (2021) with 16-year-old students in Germany who were competing in a chemistry Olympiad, found that gender-science stereotypes negatively impacted the motivation of female participants to continue in the competition. Likewise, Cousins' (2007) analysis of 30 year 12 chemistry school students found that despite overall participation rates being similar between male and female students, gender still played a part in shaping the chemistry choices (and non-choices) of young people. Notably, beyond the small number of studies focused on gender, as noted by Wilson-Kennedy et al. (2020), there is a dearth of research examining issues of race and racism in relation to chemistry participation.

In this article, we seek to add to an understanding of what shapes young people's chemistry trajectories through a mixed-methods study that tracked a cohort of young people from age 10 to 22 in England. In particular, we ask:

- What are the reasons given by students who have taken advanced level chemistry for not/pursuing a chemistry degree?
- How do reasons for choosing chemistry relate, or not, to reasons for not choosing chemistry?
- What insights can students' reasons for not/choosing chemistry offer to chemistry education policy and/or practice?

Our study is conducted in England, where all young people are required to take national school examinations at age 16 (General Certificate in Secondary Education, GCSE). Attainment in these exams then plays a part in determining their potential access to post-compulsory routes, with many students choosing to follow the academic route of advanced level (A level) qualifications at age 18. This typically involves studying 3 A level subjects, although, at the time of our data collection, many students were also able to opt to take advanced Supplementary (AS) levels (equivalent to half an A level) in one or more subjects in addition to their main A level subjects. In turn, A and AS levels constitute a key common qualification route for entry to undergraduate degrees, which in the United Kingdom are usually specialized degree routes.

2 | THEORETICAL FRAMEWORK

As discussed above, within the literature multiple factors have been found to influence young people's science—and specifically chemistry—trajectories. To help us pull these together coherently and develop an analytic frame to guide our investigation of the factors shaping advanced level chemistry students' decisions to pursue a chemistry degree, or not, we have employed the sociological conceptual framework of Bourdieu (1984, 1990). As Bourdieu's own work drew extensively on mixed methods research (combining surveys, interviews, and other methods) and sought to understand the impact of social conditions and relations on producing socially patterned educational trajectories and "choices," we considered his conceptual framework to be particularly apt.

Bourdieu's concepts of *habitus*, *capital*, and *field* have been extensively used to understand patterns of inequality in educational outcomes and trajectories, particularly classed patterns of social reproduction. Habitus refers to socialized and internalized structures of dispositions, which provide a taken-for-granted feel of what is normal, possible and/or desirable, or not, "for people like me" (Bourdieu, 1990). In the context of our focus on students (not) choosing chemistry degrees, we propose that the concept of habitus provides a way of bringing together themes of chemistry-related interest, identity, recognition, and attitudes to chemistry. As Bourdieu explains, habitus includes a person's sense of self, that is shaped by their experiences, social location through interaction with others and the field (e.g., the extent to which a person is recognized by others and enabled by the field to be seen as "good at chemistry")—it is a "present past that tends to perpetuate itself into the future by reactivation in similarly structured practices" (Bourdieu, 1990, p. 54). In other words, the habitus is both *structured* (produced through the sum of individual and collective histories and experiences) and *structuring* (guiding future choices, decisions, and outcomes (ibid.)). The habitus is thus a form of "embodied history" that is "internalized as second nature and so forgotten as history" (Bourdieu, 1990, p. 56). That is, the habitus is influenced by a person's social location and experiences and in turn can shape what is then considered "thinkable."

As feminist extensions (e.g., Adkins, 2004; Moi, 1991) of Bourdieu's theorization have noted, the habitus is gendered (and racialized, etc.) as well as classed, hence a sense of what is "for me" is structured by gender and other social axes. Hence, we extrapolate that the extent to which a young person may consider chemistry to be a desirable and possible option that fits with their sense of self, will also be shaped by the extent to which they experience the subject as aligning (or not) with their (gendered, racialized, classed) habitus.

Despite common critiques of Bourdieu's work as being overly deterministic (Fabiani, 2020; Jenkins, 1982), Bourdieu (1990) does recognize that the habitus is characterized by "the art of inventing" (p. 55), enacting "regulated improvisations" (ibid, p. 57). That is, the habitus can be spontaneous and responsive to the field, albeit within the structured and situated nature of its production. This form of structured agency is what enables the habitus "to produce an infinite number of practices that are relatively unpredictable (like the corresponding situations) but also limited in their diversity" (Bourdieu, 1990, p. 55).

Habitus operates in conjunction with capital—that is, social, cultural, economic, and symbolic resources. For instance, a young person may benefit from (or be disadvantaged by an absence of) social and cultural capital in the form of motivation and support to continue with chemistry from significant others (e.g., teachers, family members, work experience mentors). Equally, their likelihood of undertaking a chemistry degree may be mediated by their family's access to economic capital. As Bourdieu explains, capital does not have a fixed and enduring value in its own right, rather the value of capital is determined by the field. Hence, where a particular form of capital is valued and legitimated within a particular field (e.g., middle-class cultural capital within the field of schooling), this capital can be realized and translated into social advantage (e.g., educational attainment). As noted above, field—socio-spatial contexts of power and position-taking that determine the "rules of the game" and which/whose habitus and capital are valued within a particular setting—is key to both habitus and capital and the three cannot exist or make sense in isolation from one another. It is this interconnected nature of Bourdieu's framework that we find particularly helpful for making sense of existing findings and, as discussed further below, for structuring our approach to the qualitative analysis.

Bourdieu's work has been extensively applied to understanding the social reproduction of inequalities through educational practices. For instance, in the context of HE, research has demonstrated how, due to the unequal distribution of capital and the closer "fit" between middle-class habitus and the field of education, middle-class students are more likely to attend the "best" schools, attain highly and access elite universities (e.g., Reay et al., 2005; Wakeling, 2005). As a result, university is more likely to be experienced as a "normal" and "automatic" choice by the middle-classes, whereas working-class students are more likely to feel that it is "not for me." Bourdieu explains that the power of these practices lies in how some "choices" neither conscious nor actually choices in that they are experienced as "unthinkable" (Bourdieu, 1990, p. 54).

Comparatively less work has specifically used Bourdieu to examine subject choice. However, some research has explored how classed differences in habitus and capital produce patterns whereby socially privileged students are more likely to choose to study high status subjects compared with their less advantaged peers (e.g., Van de Werfhorst et al., 2003). However, Bourdieu's theoretical resources have been used to examine injustices in science participation, explicating how classed, gendered, and racialized patterns of participation (nonparticipation) in science operate through interactions between habitus, capital, and the field of school science (e.g., Archer et al., 2012; Claussen & Osborne, 2012), particularly in relation to physics (e.g., Archer et al., 2020), showing how particular practices within school physics cultivate or weed out particular forms of habitus, generating elite and narrow patterns of who "chooses" physics at A level. In this article, we employ his theoretical tools for making sense of young people's responses via surveys and interviews around their reasons for not/choosing chemistry.

3 | METHODS

We draw on a convergent parallel, mixed methods study, the ASPIRES project, a 13-year research project tracking young people's educational and career trajectories from age 10 to

23, funded by the Economic and Social Research Council (ESRC). The wider study involves (i) repeated cross-sectional surveys with a representative sample of young people from the cohort of all those in England who were born between September 1, 1998 and August 31, 1999 (with waves conducted in the final year of primary school, age 10–11, throughout secondary school, at ages 12–13, 13–14, 15–16, 17–18) and the most recent wave, reported in this article, at age 21–22 and (ii) longitudinal interviews with a sample of 50 young people and 34 of their parents, conducted at the same time points. In this article, we focus only on data from young people in the sample who studied advanced level chemistry.

3.1 | Survey sample, recruitment, and analysis

In this article, we draw on survey data from a subsample of 506 young people aged 21–22 who had taken advanced level chemistry at age 18 and who had provided open-ended, free text responses explaining why they either did or did not take the subject at university (a further 214 young people had taken A level chemistry but either declined to provide a response to this question or their answers were too unclear to code). This subsample of young people who had taken A level chemistry is drawn from a wider postal survey sample of 7635 young people (6915 of whom were excluded from the current analysis on the basis that they had not studied A level chemistry). The wider sample was recruited on the basis that they lived in England, were born between September 1, 1998 and August 31, 1999 and registered on the Open Electoral Roll. The total survey sample was not representative with regard to official government population estimates in England for 21–22 years olds based on gender, ethnicity, and index of multiple deprivation (IMD) (a national categorization that is based on home postcode/zip code—respondents provided their post code that was then matched to the national database to provide the classification, in which IMD1 represents the most deprived national quintile and 5 the least deprived national quintile of postcodes) as it oversampled populations of interest who tend to be underrepresented in STEM (namely oversampling women, racially minoritized communities, and young people from lower IMD quintiles—see Table 1).

In this article, we focus on open-ended responses from the 506 students who had taken advanced level ("A level") chemistry at age 18 and had either chosen ($n = 70$) or not chosen ($n = 426$) to pursue a chemistry degree, and who had answered the free response questions. We classified chemistry degree students as those taking undergraduate bachelors in science (BSc) and integrated undergraduate and postgraduate masters in science (MSc) chemistry degrees ($n = 50$), which included combined degrees in which the major subject is chemistry (e.g., chemistry with medicinal chemistry). We also included degrees in which chemistry is a substantial core component, namely biochemistry ($n = 16$) and chemical engineering ($n = 10$). For this article, we chose to omit students on other degrees in which chemistry may be an important element but where the extent to which it forms a core part of the degree was unclear (e.g., natural science, $n = 4$, forensic science, $n = 5$). The demographics of the students who had taken A level chemistry and either pursued, or not, a chemistry degree are provided in Table 1.

The overall questionnaire was wide-ranging and explored young people's aspirations and expectations, influences on these; destinations post-18 and numerous other areas including demographic data. It builds on previous surveys, the development and validation of which have been described elsewhere (e.g., DeWitt et al., 2011). In this article, however, we focus only on responses provided by young people who had taken A level chemistry using open-text data

TABLE 1 Demographics of A level chemistry students in the survey sample

	Self-identification	A level chemistry students who did NOT take a chemistry degree ($n = 436$)	A level chemistry students who DID take a chemistry degree ($n = 70$)	Overall survey sample ($n = 7635$)	National population data (ONS mid-year populations estimates, 2020, for 20–21 year olds)
Gender	Woman	244 (56%)	35 (50%)	4529 (59%)	48.4%
	Man	177 (41%)	35 (50%)	2739 (36%)	51.6%
	Non-binary/other/prefer not to say	5 (1%)	-	357 (5%)	N/A
Ethnicity	White	288 (66%)	42 (60%)	5974 (78%)	83.2%
	South Asian	80 (18%)	13 (19%)	706 (9%)	7.8%[a]
	Black	21 (5%)	4 (6%)	286 (4%)	4.3%
	Mixed	18 (4%)	4 (6%)	415 (5%)	4.7%[b]
	Other and prefer not to say	20 (5%)	7 (10%)	252 (3.3%)	
IMD	1 + 2	168 (39%)	29 (41%)	3626 (48%)	45.8%
	3	94 (22%)	22 (31%)	1468 (19%)	21.0%
	4 + 5	174 (40%)	19 (27%)	2541 (33%)	33.1%

[a]ONS data combine South Asian and East Asian ethnicities into a single category.
[b]ONS data combine other and mixed categories into a single other category.

explaining their decisions to not/pursue chemistry, to one of the following questions (shown according to filtering by A level and degree level subject choices): *Why did you not continue with chemistry after A level?* Or *Why did you choose to pursue chemistry?*

Open-ended responses were coded by two team members using an iterative inductive approach, with developing codes discussed and checked with a third team member. This process results in a set of codes of reasons given by students for not continuing with chemistry and a set of codes for reasons given by chemistry degree students for continuing. These codes were then mapped against one another to produce a single table of reasons for not/choosing chemistry within the survey data. This table was then mapped against the codes that had been generated in the qualitative analysis (as discussed below), to produce a final set of nine codes mapped across the qualitative and quantitative data, as detailed in Table 3.

3.2 | Interview sample and analysis

Interview data are drawn from a wider study sample of 50 students and their parents who had been longitudinally interviewed from age 10 to 21 (see supplementary material). These participants were originally recruited when the children were age 10, by approaching a stratified sample of primary schools, selected on the basis of being broadly representative of schools nationally regarding region and key pupil demographics (gender, ethnicity, eligibility for free school meals) and inviting participation. Within this sample, 20 young people went on to take chemistry A/AS level; however, we lost contact with two of these students after age 18 and their onward trajectories are unknown. Hence, this article focuses on the 18 young people in our sample who completed advanced level chemistry and who were interviewed again at age 20–21. Of these 18 students, five went on to study for a chemistry (or substantially chemistry-based biochemistry) degree, 12 took other STEM-related degrees, either in physics, maths, or engineering-related areas ($n = 5$) or biological and/or medical-related fields ($n = 7$) and one young person went straight into employment in a non-STEM job.

We conducted 108 longitudinal semi-structured interviews with the 18 young people over six time points: at the end of primary school (age 10), through compulsory secondary education (at ages 12/13, 13/14, 15/16) and at ages 17/18 and 20/21. We also draw on 77 interviews conducted with 17 of the young people's parent/s or carers at five of the same age points (excluding age 13/14). Both sets of interviews were part of a wider study that tracked the science aspirations and trajectories of 50 young people and their parents over the same time period. Most interviews were conducted face-to-face, although all interviews at age 20–21 were conducted virtually due to the COVID-19 pandemic and national lockdowns. Parental interviews and recent young person interviews typically lasted around 1.5 h but interviews were shorter when children were younger (e.g., typically around 30 min at age 10). Interviews reported in this article were conducted by 10 members of the wider project research team over the 10 years of the study, including several of the paper authors. Interviews were recorded and professionally transcribed.

Parent and child interview protocols were informed by the literature and iteratively developed over the course of the study to capture the (changing) nature and range of influences on young people's educational and occupational aspirations and trajectories. Both parent and child schedules mirrored key topics such as: favorite and least favorite school subjects, views, and experiences of school science (generally and by disciplinary area); STEM, subject experiences, preferences/dislikes; aspirations; reasons for and influences on aspirations; educational and occupational choices and reasons for these; out-of-school interests; experiences of careers advice, guidance; experiences of outreach and work experience. Parents were also additionally asked about their parenting styles and practices (e.g., Lareau, 2003).

As noted in Table 2, our sample included five young women who went on to study chemistry (and in one case, chemistry-focused biochemistry) undergraduate degrees (Davina, Demi, Hailey, Mienie, and Poppy) and 13 young people who "chose otherwise" and did not continue with chemistry after A/AS level but who had sufficient interest, opportunity and attainment levels that meant that a chemistry degree could have been a viable choice. We grouped the 13 young people who *chose otherwise* into three sub-clusters, that we termed those who *could have been* chemistry undergraduate students ($n = 10$) but who were always set on alternative STEM routes; those who *would have been* chemistry undergraduates in that they had actively considered and explored taking a chemistry degree but in the end the balance of factors tipped them toward another route ($n = 2$, Joanne, Samantha); and those who *should have been* pursuing a chemistry degree but were disadvantaged by wider social inequalities that precluded HE in general and mitigated against chemistry in particular ($n = 1$, Brittney).

Each young person's transcripts (from their six interviews) were combined with their parental interview transcripts to produce a chronologically organized, extended case study summary. We retained any instances of inconsistency within these summaries (e.g., inconsistencies within a young person's account over time and any inconsistencies between child and parent accounts) as we consider these to be normal occurrences within biographies and relationships. These

TABLE 2 Students in the longitudinal sample who took advanced level chemistry

Student (*parent/s*)	Student self-identification	A/ AS subjects	Status at age 20/21
Davina (*Dawkins*)	Mixed (White/European) middle-class woman	Chemistry, maths, physics	Chemistry degree, pre-1992 university
Demi (*Jane3*)	White middle-class woman	Chemistry, biology, maths	Chemistry degree, pre-1992 university
Hayley (*Elizabeth*)	White middle-class woman	Chemistry, biology, maths	Biochemistry degree, pre-1992 university
Mienie (*Dawn*)	Mixed (South Asian/White) middle-class woman	Chemistry, maths, physics	Chemistry degree, pre-1992 university
Poppy (*Lulu*)	White middle-class woman	Chemistry, maths, biology	Chemistry degree, pre-1992 university
Bob (*Debbie*)	Mixed (South Asian/White) middle-class man	Maths, physics, computing, AS chemistry	Computer science degree, pre-1992 university
Colin (*Ishain*)	South Asian middle-class man	Chemistry, biology, maths	Medicine degree at pre-1992 university
Hannah (*Maddison*)	White British middle-class woman	Chemistry, maths, physics, further maths	Physics degree, pre-1992 university
Josh (*Stella1*)	White British middle-class man	Maths, further maths, physics, computing, AS chemistry	Computer science degree, pre-1992 university
Kaka (*Jack & Nicola*)	South Asian middle-class man	Chemistry, biology, maths	Medicine degree, pre-1992 university
Kate (*Sue*)	White British middle-class woman	Chemistry, maths, physics, biology	Natural sciences degree, pre-1992 university
Neb (*Ruth*)	White British middle-class man	Physics, maths, further maths, AS chemistry	Maths degree, pre-1992 university
Preeti (*Geeta/ Dinesh*)	South Asian, middle-class woman	Chemistry, physics, biology, maths	Biomedical sciences degree, pre-1992 university
Rebecca (*Lucy*)	White British working-class woman	Biology, graphic design, geography, AS chemistry	Dental hygiene degree, post-1992 university
Tom4	South Asian middle-class man	Maths, further maths, physics, AS chemistry	Maths degree, pre-1992 university
Joanne (*Matthew/ Judy*)	White British, middle-class woman	Chemistry, biology, maths, history	Natural sciences degree, pre-1992 university
Samantha (*Claire*)	Mixed (South Asian/White) middle-class woman	Chemistry, English literature, biology, AS maths	Biomedical sciences degree, pre-1992 university
Brittney (*Carolyn*)	White British working-class woman	Chemistry, maths, history	Working full-time in a supermarket

Abbreviation: AS, advanced supplementary.

TABLE 3 Summary table comparing open-ended survey responses and qualitative sample responses for A level chemistry students' reasons for not/pursuing a chemistry degree

	Chemistry A level student who did NOT take chemistry degree: Reasons for not taking chemistry degree		Chemistry A level students who DID take chemistry degree: Reasons for taking chemistry degree	
Factor	Survey ($n = 436$)	Qualitative ($n = 13$)	Survey ($n = 70$)	Qualitative ($n = 5$)
Relative interest, connection, and options	Prefer other subject 48%	Prefer other subject 13/13. Personal connection other subject (8/13)	Particular interest in chemistry (29%) second choice (3%)	Personal connection with chemistry (3/5) No other options (1/5)
Experiences of A level chemistry (incl. teachers)	Negative experiences 12%	Positive experiences (13/13)	Positive experiences, favorite, A level, 7%	Positive experiences (5/5)
Identity (feeling not clever enough vs./ good at chemistry)	Feel not clever enough 21%	Feel not clever enough (8/13)	Feel good at chemistry, 20%	Feel good at chemistry (5/5)
Views of chemistry jobs	Negative views 12%	Negative views (1/13)	Positive views, 10%	Positive views 5/5
Associations of chemistry with masculinity	-	Off-putting to women (3/13)	-	Negotiate femininity 5/5
Specific encouragement/ support	<0.9%	No support for chemistry (1/13) Greater support for another area (12/13)	Parents/family, 1%	Specific support for chemistry (5/5)
Views of HE	1%	Feel cannot afford HE (1/13)	-	Family support and feel can afford HE (5/5)
Work experience and outreach	1%	Off-putting experience (1/13) Absence of experience (12/13) More engaging experience in other area (4/13)	-	Engaging chemistry outreach and/or work experience (4/5)
Other	4%	1/13	8% (plus 12% missing data and/or responses that could not be coded)	
Total	99.9%	-	100%	-

summaries were read by the team, in particular, pairing readings between researchers who had and had not directly interviewed the young person in question, to check interpretations. Following these detailed readings, we categorized young people into three subgroupings (*would* *have been*, *could have been* and *should have been* chemistry degree students), reflecting their relationships with chemistry and the extent to which they appeared to have actively considered a chemistry degree, or not. Next, coding of the case study summaries and the original transcripts was conducted by several team members, grouping the data under themes: reasons for taking chemistry at A level, experiences of chemistry teaching and learning; reasons for taking other A level subjects; experiences of other subjects; aspirations; destinations; choice processes; influences on post-18 choices; outreach experiences; work experience. These codes were refined through an inductive and deductive approach to coding that was iterated through regular team discussions that resulted in six main areas identified in Table 3 and discussed in the findings. Next, we mapped each theme by student subgroup (the *would have been*, *could have been* and *should have been* categorizations) to determine prevalence and to assess the potential "weight" of each factor. Finally, the lead author employed the concepts of habitus, capital, and field to explore the extent to which these offered explanatory power to help understanding the young people's decisions to pursue, or not, chemistry further.

3.3 | Ethics

The study received ethical approval from the University ethics committee (REC1300) and follows the ethical code of the British Educational Research Association (BERA), ensuring free and informed consent (and offering right to withdraw data) from all participants (with parents/guardians providing consent for children under the age of 18) and complying with UK data protection legislation for data treatment and storage.

4 | FINDINGS

As detailed in Table 3, comparison of the qualitative and quantitative data revealed a number of reasons for young people's decisions to not/choose to pursue a chemistry degree. We begin by discussing four key reasons that emerged across both the quantitative and qualitative data to varying extents: the relative interest, connection and option; students' experiences of chemistry A level; feeling "not clever enough" or "good" at chemistry, and chemistry jobs. We then discuss four additional reasons that were predominantly only found in the qualitative data: associations of chemistry with masculinity, receiving specific encouragement from a significant adult, views of HE, and chemistry work experience and outreach.

4.1 | Key factors (i): Relative interest, connection, and options

Comparing across the quantitative and qualitative data, the most prevalent and consistent reasons given for not/choosing chemistry to other subjects were what we termed "relational" reasons, in which chemistry was compared with another subject or option. On the survey, 48% of survey students and 13 of the *choosing otherwise* students in the qualitative sample explained their reason for not taking a chemistry degree as due to preferring another subject or option that they found "more interesting" or desirable. That is, despite liking chemistry, these students liked another area *more*, such as medicine. Typical survey responses included statement such as:

> "I enjoyed it [chemistry] and almost did [do a chemistry degree] but my love for maths was stronger" (White woman, IMD1).

> "I enjoyed maths more and I was better at it. Not to say I didn't really enjoy chemistry" (White man, IMD2).

> "I found biology more interesting" (South Asian man, IMD3).

Similarly, within the interview sample, students explained their decision as due to preferring areas like medicine (Colin, Kaka, Preeti), computer science (Josh, Bob), Maths ("I just really wanted to focus on Maths," Neb; "I just prefer Maths too much," Tom4), or Physics (Hannah). Looking across their transcripts over time, all of these young people also expressed long-term desires and interest in either medical careers (as doctors, Colin and Kaka; or in dentistry, Rebecca) or mathematics (Neb and Tom4) that, in the end, superseded their interest in chemistry.

Among students who did pursue a chemistry degree, 29% of survey respondents explained their choice in relational terms, stating that their degree choice was because they were particularly interested in chemistry, as the "subject that interested me the most" (white man, IMD3) and/or their "best" or their preferred science (e.g., "it is the best intersection of the sciences," mixed ethnicity man, IMD2) and/or as numerous young people put it, the subject that they feel they are "best" at.

A small number of respondents on the survey and in the qualitative sample explained that chemistry was actually a "second choice" option that had been taken when a preferred route had not worked out (e.g., "this was my second favourite science, white woman, IMD4"). For instance, Mienie's first choice of undergraduate degree (for which she applied initially) was in combined natural sciences. However, Mienie was not accepted on to any of the natural science courses that she applied to and, as a second choice, ended up applying for and taking a chemistry degree, a pragmatic move that remained a source of some regret for her "I would prefer to do natural sciences than chemistry," not least because she felt it would have enabled her to have more control over which areas of chemistry she studied (avoiding her least favorite areas). This theme (of chemistry being a "second choice") has also been noted in the wider literature, among students in Dagogo et al.'s (2019) study.

To note, however, examples of students taking a "second choice" degree was not solely restricted to chemistry and hence we do not propose that it is a factor that is unique to chemistry. For instance, among the non-chemistry degree students Preeti, had applied for medical degrees but, like Mienie, was not accepted on to any first-time round. Instead, she ended up studying for a biomedical degree, which she would provide a "backdoor" route into medicine. We interpret these instances as suggesting that degree subject choices are often relational choices—they are not often simply decided with respect to one subject in isolation but can be part of a wider process of negotiations and navigations.

There was insufficient detail within the survey responses to explain what it was about their chosen subject that attracted those students who did not pursue undergraduate chemistry. The reasons expressed tended to simply state a love or preference for a particular subject or occupation, such as choosing computing because "I love coding." The qualitative data offered potential further insights, with 8/13 of the *choosing otherwise* students and 3/5 chemistry degree students explaining that their choices were based on feeling a meaningful personal connection with their chosen degree area. For instance, the eight *could have* or *would have* (been able to study chemistry) students explained that personal connection with a different STEM area had significantly shifted their trajectories away from chemistry and toward another area, which in these cases was overwhelmingly biology/biological sciences. For instance, the balance of Joanne's choice of degree shifted significantly away from chemistry and toward biology after a very close family member suffered a stroke, which led Joanne to develop a strong, meaningful personal connection with neuroscience that was reinforced further through the recognition that Joanne received for her prize-winning essay on the topic. Likewise, Preeti developed a particular interest in cardiology as a result of her father's experience of heart disease ("I guess also my dad was diagnosed with like CHD [coronary heart disease] and I've kind of got more interested in it," Preeti, age 17).

Likewise, three of five young women who went on to study chemistry degrees identified a strong, meaningful personal connection with chemistry as a key factor that had influenced their choice of the subject at degree level. For instance, Mienie recounted a pivotal experience around the age of 15, when she and her mother visited the counter of a particular beauty brand in a department store, where they learned about its "natural" and sustainable ethos, which powerfully resonated with Mienie's identity and values. Mienie continued to use these products at age 21 and specifically identified this as a pivotal experience in shaping her chemistry trajectory throughout her subsequent interviews. Demi also identified a strong personal connection with chemistry in her interview at age 17, when she explained a growing fascination with the chemistry behind acne treatments, a condition that she had personal experience of, which she made the basis of an extended personal qualification:

> "Um, well like for the past I'd say like six months I've been mainly looking at cosmetic chemistry [careers], so like or like the use of organic chemistry and like skincare and like health, ...and like it links to the extended project I've been doing, which is on acne treatments. [...] I'm just interested in the Science behind it and the skin kind of conditions and stuff" (Demi, age 17).

Similarly, Hailey talked about the significant impact that her parents' serious illness had on her, which led her to develop an interest in the biochemistry of cancer. For all these three students, we noted that these deep personal connections were pivotal moments that significantly tipped the balance of their trajectories toward chemistry.

As not all the chemistry degree students recounted or experienced these deep personal connections, we are cautious as to their explanatory power for explaining chemistry degree choices. However, due to their impactful nature (influencing young people's trajectories either toward or away from chemistry, accordingly), we suggest that when personal connections with a subject or occupational area develop, these can act as potential trajectory "deal breakers," having a lasting and influential impact on the direction of choices.

4.2 | Key factors (ii): Chemistry A level experiences

Within the surveys, around 12% of young people who did not continue with chemistry pointed to some sort of negative experiences of chemistry A level as being a factor within their decision not to pursue the subject further. Most responses were relatively short and typically stated a sentiment along the lines of "I did not enjoy it." Where students provided additional detail this often reflected a more engaging and enjoyable experience in another subject area and/or, as discussed in the next section, finding chemistry hard. A number of survey participants but particularly young women conveyed that they had "lost passion due to bad A level experiences," (Asian woman, IMD4) particularly due to feeling unsupported by their chemistry teachers at A level, for example:

> "Chemistry was very challenging at A level and I did not receive any support from the teachers. This made me grow to dislike the subject whereas I had previously enjoyed it" (White woman, IMD5).

> "Not enough support" (Asian woman, IMD1).

> "Struggled in my final year of A levels due to lack of support" (White woman, IMD1).

A number of young people also drew attention to what they felt was "poor teaching" (mixed woman, IMD4), for instance:

> "I disliked my chemistry teacher, made us feel like we were worthless" (Black woman, IMD1).

> "My teachers were awful. Scraped a B grade with the help of a very good tutor. Made me hate chemistry!" (White man, IMD4).

> "I wasn't taught all the content that I should have been taught … so there were too many gaps in my knowledge. I had to self-teach" (White man, IMD4).

We did not find any such views among the qualitative sample of students who chose otherwise, who emphasized that their experiences of A level chemistry had been positive. Among the chemistry degree students, 7% of survey respondents and all of the five qualitative students expressed positive views and experiences of A level chemistry as being a contributory factor to their continuation with the subject, again echoing the relational theme in that chemistry classes were not only enjoyable but were more enjoyable than other subjects (e.g., "chemistry was one of my favourite classes"). As the majority of young people reported positive experiences of chemistry A level, this may provide an important foundation for realizing and supporting choices at degree level. Yet, on their own, these positive experiences do not seem to differentiate between those who do or do not continue, except in a small number of cases.

We probed the data further to try to unpick to what extent positive or negative experiences of chemistry A level related to the content and curriculum or the teaching. The five chemistry degree students in the qualitative sample gave the most detailed and extensive explanations of what they particularly liked about chemistry A level. For instance, Hailey, Mienie and Demi identified the real-life applications of chemistry as driving their interest in the subject ("I just feel like the applications to real life is the main thing that interests me," Demi; "I like applying it to like life … I've enjoyed chemistry and Biology more this year cos it's quite applied to real life, you can understand how it's being used", Hailey). Demi also liked particularly liked experimental work ("I like doing the practicals") and the maths content, which she both enjoyed and felt good at. For Davina and Poppy, it was the "problem-solving aspect" of chemistry that they found most interesting and engaging A level. As Poppy explained:

> "I like the problem solving aspect of it and how it applies to everything and it can explain like things that might seem strange at first… like each step is simple, but it comes together to solve something which is complicated. I quite like that" (Poppy, age 18).

Davina and Poppy also both articulated that they liked chemistry because they saw it as a "connecting" and "a nice in the middle" subject (Davina). As Poppy explained:

> "They call it the central Science. So it links to all of them, so that's why I chose it yeah […] Like if you were doing, if someone was doing like a physics research project they need chemists. If someone's doing biology they need a chemist… but if you're doing chemistry you don't necessarily need the other two."

However, these views were not restricted or unique to chemistry degree students and a number of those who chose otherwise also describing liking particular aspects of A level chemistry, such as experiments and problem solving.

Looking at the data pertaining to students' views of their A level chemistry teachers, we again found a generally positive picture. On the survey, only 0.9% of non-chemistry degree students (and none of the qualitative sample) reported that they had not applied for a chemistry degree due to negative experiences of chemistry A level teachers or teaching. Among chemistry degree students, we did not record any survey responses identifying chemistry teachers as being the reason they applied for the degree, although as discussed further below in the section on encouragement, within the qualitative sample we noted that a couple of students identified an influential role played by a particularly supportive teacher.

Hence, irrespective of whether they pursued a chemistry degree, or not, all of the young people in the qualitative sample reported that they had experienced good quality A level chemistry teaching and felt that their chemistry teachers had been supportive and enthusiastic about the subject, making it interesting and engaging to learn. An interplay between supportive, passionate chemistry teachers and engaging content was captured in Davina's reflections at age 18, "the teachers I had in like … particularly like in first year of A Levels were like quite like inspiring I guess." Indeed, both Davina and Poppy's particular interest in chemistry emerged during A level and, as Davina explained, grew once she started to encounter more "interesting" (and intriguing) content during A level thanks to her engaging teachers:

> "But I feel like chemistry, I kind of didn't really 'get it' when I was younger […] It just didn't really like intrigue me. But I feel like … because now … because of the teachers I've had … and I think also because A Level does go into a lot more depth, I think I've actually managed to … kind of almost like see what's interesting about chemistry if that makes sense'" (Davina, age 18).

Students who did not continue with chemistry at degree level also agreed that they had had good chemistry teachers at A level (e.g., "I think good teaching, that definitely made me like [chemistry], because I think it's like any subject isn't it, if you have a good teacher you're more likely to invest in it," Rebecca, age 18; "I'd say the most useful are the teachers themselves actually," Tom4, age 21). In contrast to the widespread experiences of A level chemistry teaching, among both chemistry degree students and those who chose otherwise, we found a number of examples in which young people, but particularly those from working-class backgrounds, had experienced poor quality, variable or disrupted chemistry teaching in younger years. For instance, at age 12, Demi complained about her "terrible" science teachers "who just give out generic worksheets and who don't check your work or help or tell how to improve." Demi's earlier chemistry aspirations disappeared during this time (age 12–16) and only reappeared when she began chemistry A level. We extrapolate that good quality teaching at A level may be a prerequisite for making the subject as a viable choice, but—given that such a high proportion of young people in our sample reported it—is not sufficient in its own right to result in a chemistry degree trajectory. We also suggest that experiences of poor-quality chemistry teaching in earlier years create considerable risks and impediments to young people's chemistry trajectories, and that the ongoing viability of a chemistry trajectory may depend on them having substantial other supporting factors (for instance, in Demi's case, a supportive family who specifically encouraged science) that can help sustain these trajectories against considerable odds.

4.3 | Key factors (iii): Identity: Feeling "not clever enough" or "good at chemistry"

On the survey, around a fifth (21%) of students who did not continue onto a chemistry degree and 8/13 of the students in the qualitative sample who chose otherwise said that a reason they had not continued with chemistry was because it is a "hard," "difficult" subject and they did not feel "clever enough" to continue with it further. Students who identified as women were almost 10 times more likely than men (and considerably more than those who identified as non-binary or did not state a gender identity) to cite these reasons. Typical responses included "I found it too difficult"/"way too difficult" and "too hard" with many explaining that this led them to feel like they "struggled" and were "not good" at chemistry. For example:

> "It was very difficult and I struggled a lot at A level" (White woman, IMD5).

> "A level chemistry was far, far too difficult and it ruined my interest in the subject" (White man, IMD2).

This personalization of the "problem" within the self and the impact of this on young people's chemistry identity was poignantly summed up by the following students:

> "Didn't feel I was clever enough" (White woman, IMD5).

> "[The] challenge of the subject was too much mentally to cope" (ethnic identity not given, man, IMD3).

Participants also drew on their relational experiences of chemistry, as compared to other subjects, highlighting how they experienced chemistry A level as being "harder" and "more difficult" than other sciences, which mediated their interest and motivation to continue with the subject further:

"I found it more difficult and thus less interesting than other sciences" (White woman, IMD4).

"Chemistry was more difficult" (South Asian woman, IMD3).

In comparison, 20% of the chemistry degree students in the survey and all five of the qualitative chemistry degree students said that a reason they had taken the subject further was because they felt that they see themselves and are recognized by other as being "good at chemistry." These responses were generally more gender balanced, albeit with men appearing to be slightly more likely than women to express feelings of competence in the subject. For example:

"I was good at it" (White man, IMD4).

"I enjoy it and am good at it" (Asian woman, IMD3).

"I really enjoy it and understand it" (White woman, IMD3).

Echoing the theme of relationality, discussed above, we interpreted the data as suggesting that for a number of the choosing otherwise students in the qualitative sample, it was not just that they found chemistry A level to be "hard" but also found it "harder" than their other subjects, requiring them to put in a disproportionate level of work and effort to do well. As Josh put it, chemistry was "the one [A level subject] I had to work hardest for." Both Bob and Rebecca also described how they had "struggled" with the subject and as Neb explained, chemistry is "probably my worst of those subjects… Like I would need to put a lot more effort into Chemistry to get a higher grade … than Maths and Physics." Tom4 also explained that he did "poorly" in his mock chemistry exam which led to him not continuing past AS level with the subject. However, when we mapped on students' achieved grades in chemistry A level, there was no clear relationship between those who said they found the subject hard and had to work harder in it (and/or were "struggling") compared with those who did not, suggesting that perhaps how students felt about and related to level and workload was perhaps more important for their choices than their actual attainment in the subject.

As has been noted in several reports and analyses, part of the reason for the perceived difficulty may relate to what students termed the "jump" between GCSE and A level and the practice of grade severity in A level chemistry and Physics (e.g., Ofqual., 2018), a point that was raised by students on the survey and in the qualitative sample, as exemplified by Colin:

"I think if you look at sort of data of like exam boards as well, you find that the amount of marks you need to get for an A* in Biology is less than what you need in chemistry or physics" (Colin).

Josh, Rebecca, Colin, and Neb also all raised the issue of finding the "jump" or "gap" between GCSE and A level chemistry problematic. As Rebecca recounted:

"Yeah, oh [it is a] massive [jump] … but nothing can prepare you for that. It's massive … like you literally feel like it's impossible… I really struggled at the beginning, because I thought 'oh gosh am I ever going to make it?' But you do … but it was hard definitely."

In comparison, these students felt "better" at other subjects. We interpret these students' experiences of chemistry A level being "hard" and a "jump" from GCSE as lending additional impetus to their decisions to pursue alternative routes. This possibility is further reinforced by the fact that Neb and Rebecca had previously named chemistry as one of their favorite subjects in year 6–9 (age 10–14), as had Colin, Kaka, and Tom4 in year 11 (age 15–16). A particularly clear example of how these issues played out can be found in the case of Samantha, one of the *would have been* students. At age 17–18, Samantha named chemistry as the "most interesting" of her A level classes and her "favorite" subject:

> "I just thought it was such an interesting subject. So interest is definitely the thing that prompted the switch to chemistry [...] I love doing experiments definitely ... I don't know why, but I just find it ... almost really satisfying doing all of the equations and ... because I guess you'd look at the detail of reactions and then you get to see how they're applied in industry ... which I found quite interesting."

However, at the same time, Samantha also felt that "hard" nature of chemistry A level pulled against this interest, which she felt was a key factor putting both herself and others off pursuing the subject further, a point with which her mother, Claire, also concurred:

> "Chemistry at A Level is kind of notoriously one of the hardest A Levels you can take. And I think for me especially like I had to work a lot harder at chemistry than I had to work at any of my other A Levels [...] Yeah I can't imagine ever wanting to do a chemistry degree after taking chemistry A Level" (Samantha).

> "Chemistry she's struggling, um, so now about two months ago we got a chemistry tutor. ... Biology is fine and I don't know why she's struggling with chemistry ... I don't think she anticipated how much more a step up A levels are" (Claire).

Compared with chemistry, Samantha felt that she had "never found biology difficult," despite it being "a heavy subject in terms of content" and felt that English was the subject "that I tend to do the least work for and still get an OK grade, whereas chemistry's quite difficult so you have to really work hard with it." Although in the end Samantha attained highly across all her subjects, we suggest that her case exemplified how issues of identity and recognition are not only important in relation to chemistry, for shaping the likelihood of a chemistry trajectory, but are also important relationally, in terms of how these perceptions fit with identity and recognition in other subjects.

In comparison, the five chemistry degree students in the qualitative sample felt that although chemistry A level had been "hard," they also felt that they were "good at chemistry." As Demi put it, while the subject was "hard" and demanded a lot of work, it did not "stress" her, which she attributed to being "naturally good at it," adding "it's easier and you tend to enjoy it more" (Demi, age 18). As we did not find any notable attainment differences between the young people who either did or did not continue on to chemistry degrees, we interpret the role of identity (seeing oneself as being good at chemistry and being recognized by others as such) may be more pivotal than attainment alone, while recognizing that a certain level of attainment is required to make a chemistry degree a realistic possibility in the first place.

4.4 | Key factors (iv): Views of chemistry jobs

This factor was found in both the qualitative and quantitative data, albeit to a relatively small extent. On the survey, 12% of students who did not pursue a chemistry degree and one of the thirteen students in the qualitative sample who chose otherwise cited negative views of the chemistry job market as influencing their decision to pursue alternative routes to chemistry after A level. Some young people, but notably young women, suggested that they did not know what jobs a chemistry degree might lead to, for instance:

> "Didn't know where it may lead" (White woman, IMD4).

> "I wasn't sure what I could do within chemistry after A level" (White woman, IMD1).

A number of students felt that other STEM fields offered better or more attractive job prospects than chemistry, for example:

> "Engineering seemed like it had better job prospects" (mixed ethnicity man, IMD5).

> "I could've easily chosen to pursue chemistry. I loved it at A level, however physics seemed more broad and applicable to more jobs (something that hasn't proven to be true after graduating)" (White man, IMD5).

> "There was more jobs and money in computer science" (White woman, IMD3).

A few young people also suggested that they did not perceive chemistry jobs to be attractive:

> "I found it interesting at A level and I like learning about chemical processes but I wasn't interested in any careers in the chemical field" (South Asian man, IMD2).

> "I just didn't see a job that I wanted to do from just chemistry at uni" (White woman, IMD5).

These themes were echoed among the interview sample, as Brittney confided that she did not know what careers chemistry might lead to, beyond becoming a high street chemist and Samantha and Joanne (both *would have been* students) explicitly stated that they felt chemistry degrees offer narrower career options than biological degrees.

In comparison, survey data showed that 10% of chemistry degree students and all five of the chemistry degree students in the qualitative sample felt that chemistry offered good job opportunities and was a transferable, flexible degree qualification. For instance, as one chemistry degree student explained, she felt that a chemistry degree offered a "wide variety of choice" of jobs and "left options open" (white woman, IMD1). The five chemistry degree students in the interview sample similarly identified a broad range of potential future career options. As Hailey explained:

> "The more I thought about it, the more I realised I didn't know what career I wanted, that I knew I liked Biology and chemistry, so I thought I'd just go for a course where … do that for three years, but then you can still like do anything you want afterwards" (age 17).

Poppy also recounted how she had been persuaded to consider chemistry as a degree route once she started looking into what employment options it might offer, discovering that these were "not as narrow as it sounds." Her comment hinted that she may have previously considered chemistry degrees as highly specialized, rather than broadly transferable but had changed her view after exploring the courses more. In this respect, we suggest that students' views of the transferability and employment prospects offered by chemistry degrees may be a "straw" that contributes to some students' decisions to apply for a chemistry degree, or not, but is not a main decision factor on its own for the majority of young people.

4.5 | Additional factors (i): Associations of chemistry with masculinity

This factor was only found in the qualitative student and parent data and was only mentioned tangentially in one of the non-chemistry degree survey responses. Specifically, three of the seven young women who chose otherwise indicated that their decision not to pursue chemistry had been partially influenced by their sense of the dominant culture of chemistry being aligned with masculinity, which sat at odds with their own femininity. For instance, Joanne's mother, Judy, worried that their experience at a university public chemistry lecture had had a potentially subtle, demotivating effect on Joanne's chemistry route ("We went to this chemistry lecture and you could see even though like it was … there was hardly any women. […] So, no, we could see like there was only one woman in the class"). Both Samantha and her mother Claire explained how associations of chemistry with masculinity played a part in pushing Samantha's trajectory away from the subject. Although they recognized the relative gender balance in the proportions of men and women taking undergraduate chemistry ("chemistry's kind of 50:50," Samantha), they felt chemistry was grounded in mathematics which in turn was associated with masculinity ("I always feel like boys are much more mathematical in their thinking, and I guess physics and chemistry to an extent is much more a logic[al] subject… I think there's definitely a difference in how boys and girls learn chemistry"). Moreover, Samantha's mother was keen for her daughter to have a career that supports part-time working, in order to combine work with motherhood, noting sadly "But you can't do part-time chemistry." As these associations were not found among all the young women who chose otherwise, we interpret this factor as being more akin to a "straw" (one of the various factors that accumulate over time to influence a trajectory—that is, a reason that, in addition and accumulation with other factors, helps to tip the balance of a young woman's trajectory away from chemistry, rather than significantly altering the course of trajectory per se).

The five young women who continued onto chemistry degrees did not say that they were attracted to associations of chemistry with masculinity but we did note various instances over time in which they constructed and negotiated a form of "not girly" femininity that could align with a perceived dominant masculine culture of the physical sciences. For instance, at age 10, Demi explained how she stood out from many of her female peers in both her love of science and being "not girly" ("I'm different. I'm not girly. I don't like pink... I don't like wearing like all them things ... Cos they're like all wearing that girly stuff... and I don't really"). This theme continued through her interviews at secondary school, where Demi reflected that most of the girls she knows do not like science because "they just like ... all like girly stuff, like singing and hairdressers. There's some girls in our class who are really bright, but they aren't interested in like the practical subjects." As discussed elsewhere in relation to young women and physics (e.g., Archer et al., 2017; Francis et al., 2017), young women's identification with the physical sciences is made possible through their negotiations of femininity, in which "girly" femininity is understood as antithetical to being recognized as a "serious" or authentic physics or chemistry student. For instance, Mienie talked enthusiastically in her teenage interviews about how she felt that the "geeky" image of science aligned with her own sense of identity and femininity, describing herself as "the geeky kids." We thus interpreted the negotiation of femininity and chemistry a potential prerequisite for possibilizing young women's chemistry degree trajectories.

4.6 | Additional factors (ii): Specific encouragement and support from a key adult

This reason was predominantly only found in the interview data (and less than 0.9% of students who did not pursue chemistry degrees) and was noted among most of those who did not continue with chemistry and all of the chemistry degree students. Among those who chose otherwise, one survey respondent referred to being dissuaded from considering a chemistry degree ("I initially applied for chemistry but a chemistry teacher suggested that I would not enjoy it," white man, IMD3) and among the interview sample we noted the potential impact of an absence of specific support (as exemplified by Brittney) and how specific support for another area played a part in the decisions of several students who chose otherwise. For instance, Brittney (who we categorized as a *should have been* chemistry degree student) described limited family support to pursue a chemistry degree trajectory from both her family and her sixth form teachers (as discussed in greater detail in the following section). In comparison, 12/13 of the students who chose otherwise reported significant family capital and support for another STEM area. For instance, Samantha and Joanne (the *would have been* students) described significant family science capital in relation to the field of medicine, which we interpreted as one of the factors that helped tip their choices away from chemistry and toward medical science. For instance, Samantha had been strongly encouraged toward medicine by her grandmother, who has been a doctor and provided Samantha with regular encouragement, resources, and support to pursue a medical trajectory:

> "She started kind of sending me BMJs [British Medical Journal] ... So we've talked about it quite a lot, and I think she ... I mean I think she's always been keen for me to do Medicine. So I think she was quite happy when I said that I was thinking about it again."

Both young women also described influential biology teachers who had provided support and encouragement at key points that had helped steer Joanne and Samantha's trajectories away from chemistry. Indeed, at various points across her interviews, it seemed that Joanne might pursue a chemistry trajectory, for instance, at age 17–18, her father, Matthew, felt that "she's probably drifting a bit back to more toward chemistry at the moment"—a point with which Joanne's mother, Judy agreed. Around this time, Joanne reported losing motivation in biology, finding the A level curriculum "a bit kind of dull, learning definitions and stuff." However, one of her biology teachers played a pivotal role in reengaging her with the subject, as Joanne conveyed at the time and reiterated in later interviews, referring to the importance of encouragement she received "especially [from] my famous biology teacher." Samantha also reported being similarly influenced by one of her biology teachers, who told her that studying biology at degree level would be far more interesting than at A level—helping to mitigate Samantha's waning interest at the time. In this respect, we suggest that influential subject teachers can be "deal makers/breakers" within young people's trajectories who can play a powerful role in helping to cement trajectories in a particular direction and mitigate the potentially negative effects of some (less engaging) curricula.

While only 1% of survey respondents identified specific support (in these cases, young women who identified "parents" and/or "family") as a key reason why they pursued a chemistry degree, all five of the chemistry degree students reported having received a significant encouragement, support, and/or inspiration from a key adult to study chemistry at university, including from both family members and teachers. For instance, Hailey described her parents as being the "biggest influence" on her biochemistry trajectory, as both parents had studied the subject to postgraduate level and Samantha's mother had taken a chemistry degree. While neither Demi nor Mienie's families had specific chemistry capital, they both strongly and actively encouraged and supported their daughters to pursue chemistry. In addition, all five young women reported specific support from a chemistry A level teacher at a key moment that helped support their chemistry trajectory. For instance, Davina, Poppy, and Demi all described supportive and inspiring chemistry teachers who went, in Davina's words, "beyond the curriculum." With the exception of Brittney, all the A level chemistry students in the sample (irrespective of whether they chose chemistry, or not) reported strong family support for them to continue with science at degree level and generally supportive teachers. However, we interpret the qualitative data as suggesting that it is where this encouragement and capital is particularly strong in relation to a specific disciplinary field that it seems to help tip the balance of young people's trajectories accordingly.

4.7 | Additional factors (iii): Views of university

Whereas the majority of young people in both the survey and qualitative samples had progressed to university and, among the interviewees, had indicated strong parental support for them to pursue a degree, we noted that on the survey a very small percentage (1%) of A level chemistry students, but particularly those from low-income families, indicated that they had not pursued a chemistry degree because they did not want to go to university due to the costs (e.g., "didn't want to attend university due to loans/fees, etc." Asian woman, IMD1; "expensive," Asian woman, IMD2). We also noted that this issue was significant in the case of Brittney, the "should have been" student within the qualitative sample.

Brittney, a white, working-class young woman from the South Coast of England, had loved chemistry and aspired to do "something to do with chemistry" since we first met her at age 10 ("because that's my favourite part of science"). Brittney successfully gained A levels in chemistry, maths, and history. Her mother, Carolyn, a single parent had left school at age 16 was concerned about Brittney accruing debt by going to university and did not want her daughter to study a subject with unclear job outcomes. Brittney's college tutor also advised her not to apply to university yet ("just leave it for a bit and then come back to it when you're ready"), as that was what the tutor had done herself. After her exams, Brittney took up full time employment in the supermarket where she had been working since age 16 and, as she explained at age 21, "I've been there ever since," gaining promotion to team manager. Reflecting on her daughter's trajectory and the alternative routes that could have been taken, Carolyn said: "Brittney had a real focus with chemistry, I think it was her own aspiration inside, she really enjoyed it." She felt that Brittney could have successfully gained a chemistry degree but recognized that her daughter had taken a different path due in large part to the family's financial situation, which had rendered a degree route too risky and unfeasible ("unfortunately because of the situation I was in I couldn't do that, where I was left on my own with them when they were 10"). While it is hard to extrapolate or generalize from a single example, we suggest that Brittney's case hints at how a family perception of HE as possible, desirable and affordable may be an important perquisite for making a chemistry degree a viable choice, particularly in low-income families with no prior experience of HE. While just a single example, we suggest that Brittney's case highlights the additional challenges faced by some working-class students, for whom the prospect of a degree in general, but specifically a degree in an area, like chemistry, that is unknown within their family and is perceived as a potentially risky route, is far from the *fait accompli* decision that seemed to characterize the middle-class students in our sample for whom the prospect of doing a degree was "always known" (Reay et al., 2005).

4.8 | Additional factors (iv): Work experience and outreach

There were very few survey responses (1%) that raised the issue of chemistry-related work experiences or outreach playing a factor in students' decisions to not/ pursue chemistry, and where these did appear it was as reasons for *not* choosing chemistry (e.g., "I almost did. I then realised I wouldn't enjoy working in a lab after having work experience in one," white woman, IMD3). In the qualitative data, there was some evidence that Joanne's work experience in a chemistry-related professional society had put her off chemistry because Joanne found the "office work" involved to be boring and unconnected to lab-based chemistry. As her parents explained, "she doesn't want to be in an office" (Judy) and "a week was a long time for her in the office" (Matthew). In contrast, Joanne had loved the biological work experience that she later undertook at a university lab. Indeed, 4/13 of the students who chose otherwise also reported being influenced away from chemistry by engaging work experience in other, non-chemistry areas (such as Samantha, whose work experience at a residential dementia hospice had been highly engaging and had influenced her undecided trajectory, especially when one of the doctors "kind of talked me into medicine again"). However, the picture was slightly further complicated by the case of Poppy, who, while studying for her A levels, reported a negative work experience with a chemical manufacturing company (doing "*spectroscopy and a bit of lab work*"). However, this did not ultimately deter her from doing a chemistry degree ("I didn't really enjoy working there … it seemed they did like the same thing for six months and the same thing again for six months …they just do it again and again and again. And I was like 'no'," Poppy, age 18).

In contrast, three of the five chemistry degree students (Davina, Hailey, and Demi) reported that their interest in pursuing a chemistry degree had been reinforced and boosted by positive experiences of engaging chemistry outreach and work experience activities. For instance, they had all enjoyed talks delivered by chemistry university departments and Hailey had found her gap year work experience placement, as a university lab technician, to be interesting and valuable. Demi also recounted how useful and engaging she had found a work shadowing placement that she had done with a chemistry researcher who worked for a commercial science company.

The majority of respondents, however, reported neither positive nor negative chemistry-related work experiences and/or outreach—rather there seemed to be a general absence of such experiences. We interpret these findings as suggesting that engaging chemistry-related work experience seemed to help reinforce and support some young people's chemistry trajectories and that negative experiences seemed to play a part in dissuading a number more. However, overall, chemistry-related work experience was not widespread and hence did not constitute a key reason shaping non/choices of chemistry.

5 | DISCUSSION: REASONS FOR NOT/CHOOSING CHEMISTRY

This article seeks to add to the existing modest, evidence base and understanding about what shapes young people's chemistry degree choices. Whereas previous studies have relied predominantly on retrospective analyses of surveys or small-scale qualitative interviews conducted with current chemistry students or professionals, in this study we sought to make an empirical contribution and add new insights by investigating the views and experiences of young people in England who took A level chemistry at age 18 and then either did, or did not, pursue a chemistry degree. To do this, we conducted a comparative analysis of open-ended survey data from 506 young people and longitudinal interviews conducted with students from age 10 to 21. Our analysis identified four key and four additional reasons, of varying strength and prevalence, that contributed to shaping suitably qualified young people's trajectories either toward or away from a chemistry degree.

In this final section, we now discuss these findings and develop our argument and conceptual contribution, in which we suggest that (chemistry) degree choices might be usefully understood as relational practices that are formed through intersections of habitus, capital, and field, within and through relations of power. We augment previous research that has tended to focus on chemistry choices in isolation (e.g., just focusing on young people's views and experiences of chemistry and at a single time point) and suggest that a relational view of subject choice offers some new insights to the field for how to support increased and widened participation in chemistry. We conclude by outlining some potential implications for policy and practice based on these analyses and interpretations.

5.1 | Contribution 1: A relational conceptualization of degree subject choice

Our qualitative and quantitative findings strongly pointed to chemistry degree subject choice being a relational process. That is, students' degree choices were not solely influenced or determined by factors to do with a young person's relationship to and experience of chemistry (such as their chemistry self-efficacy, as per Avargil et al., 2020; DeBoer, 1987; Shwatrz et al., 2021) but were also strongly shaped and mediated by their relation to other subjects and options (including how "good" they felt they were at other subjects). Our emphasis on relationality also resonates with the findings of Dagogo et al. (2019) who highlighted how chemistry was a second choice for a number of the students in their sample. That is, choosing a chemistry degree is not always determined solely by factors to do with the subject. Our longitudinal qualitative data suggested that not/choosing a chemistry degree was an iterative process that developed and changed over time through relational negotiations, as illustrated by students changing aspirations at different ages and time points. Hence, not/choosing chemistry does not constitute a single moment of calculated or individual cognitive decision-making nor is it attributable to a single factor, experience, or "trait." Rather, young people's trajectories toward or away from chemistry were influenced as much by the availability and comparative accessibility/desirability of *other* options and experiences as they were to do with reasons intrinsic to chemistry. Hence, the reason that many chemistry A level students in our samples did not pursue chemistry trajectories was not because they felt there was anything "wrong" with the subject—indeed, many found chemistry A level interesting and engaging and reported relatively positive experiences at A level. Instead, these young people had greater support for and/or found another option to be *more* interesting, engaging, viable, "easier" or with better job prospects. We thus propose that while, as per Shwartz et al.'s (2021) retrospective study, young people may attribute "pivotal moments" in their chemistry trajectories to particular points in time (such as during high school), our longitudinal data suggest that trajectories either toward or away from degree level chemistry appeared to be more subtle, nuanced and negotiated when narrated over time through repeat interviews as compared with Shwartz et al.'s findings gained from a single retrospective reflection. In this respect, we suggest that chemistry choices might more usefully described as "crystallizing" over time through an interplay of relational factors.

From a Bourdieusian perspective, we suggest that young people's engagement with the field of chemistry education is always in relation, tension and competition with other fields (both disciplinary fields and wider fields). Hence, in line with previous studies that focus on science in general (e.g., Claussen & Osborne, 2012), our findings suggest that chemistry subject and degree choices can similarly be understood as relational practices that involve navigations and negotiations of habitus and capital across multiple spaces. However, whereas previous work has focused on the role of science-related habitus and capital in making possible science trajectories, our current analyses suggest that choosing (or not choosing) chemistry cannot be understood without also recognizing its relationship with other competing alternatives (and the specific habitus and capital associated with these options) which form a more complex landscape of conditions within which these subjects are lived and experienced. So, to return to our opening vignette—if, as researchers, we only focus on Preeti's experiences and chemistry-related habitus and capital (which generate a positive disposition toward the subject, which remains her long-standing "favorite subject" and give her resources that are congruent and well-aligned with the field of chemistry and chemistry education—she attains well, feels good at chemistry, reports receiving supportive good quality chemistry teaching and has relevant forms of chemistry-related capital), we fail to understand why she did not pursue a chemistry degree. We only start to see a fuller picture when we approach Preeti's case using a relational lens, that considers her views, experiences and connection to chemistry *in relation* to other options, which then reveals how her positive experiences, dispositions, and capital relating to chemistry are replicated—and in some cases exceeded—in other areas, notably through her deeper personal connection with medicine.

5.2 | Contribution 2: A Bourdieusian interpretation of students' reasons for not/choosing chemistry degrees

A Bourdieusian lens is particularly helpful for understanding the relational factors that shape students' reasons for not/choosing chemistry degrees because, at its heart, Bourdieu's theory is highly relational. That is, habitus and capital do not exist or hold value in isolation—their function and value is determined by the field and hence can change between different fields (Bourdieu, 1990). Moreover, fields are not isolated or insulated from one another but can overlap and sit in tension with one another (ibid.). Fields are thus relational and constituted by power relations, hence we understand the fields of school and university chemistry as spaces of forces that students must navigate and which in turn exert forces on students' choices (see also Archer et al., 2020 in relation to physics). As we now discuss, using a Bourdieusian lens has helped us to make sense of why the reasons that we identified from the qualitative and quantitative data seemed to be influential in shaping young people's trajectories.

For ease, we organize our discussion of the reasons why young people found chemistry more or less appealing than other options (and vice versa) under two headings, considering first the four reasons that more closely pertained to the relationship between habitus and field, followed by the four that we felt more closely related to capital and field, although of course recognizing that all three remain interrelated.

5.2.1 | Habitus and disciplinary fields

Bourdieu's theory proposes that the habitus guides what is experienced as being normal, possible and/or desirable and includes a person's sense of self that is shaped by one's experiences within a given field. Hence, we understand students' subject and degree choices as being influenced by the extent of "fit" between habitus and the field in question, that is, the extent to which chemistry (or another subject) is felt to be "for people like me," thus replicating and extending previous work that has applied Bourdieusian concepts to understanding science aspirations (e.g., Archer et al., 2015) to consider subject-specific context of chemistry. Four of the reasons identified by our study fitted under this heading: A level experiences, feeling not/clever enough; personal connection and associations of chemistry with masculinity.

In terms of students' experiences of A level chemistry, overall our data suggested that students reported reasonably positive experiences. Unsurprisingly, survey data showed that the percentage of students who did not take a chemistry degree who reported negative experiences of A level chemistry was higher (12%) than among those who did pursue the subject at degree level (7%); however, the relatively modest size of these figures did not appear to offer an explanation for why the majority of students had not continued with the subject at degree level.

We interpret the data relating to "not/feeling clever enough," personal connection with a subject and associations of chemistry with masculinity, as all exemplifying how either a feeling of fit or disconnect between the habitus and disciplinary field in question influenced degree choices either toward or away from chemistry. Hence, where a young person felt "not clever enough" to continue with chemistry we interpret this as the habitus experiencing a disconnect with the (perceived) demands of the field, generating a predisposition to choose otherwise. Our data suggested that about one fifth of survey students and the majority of those in the qualitative sample gave “not feeling clever enough” at the chemistry as a main reason for not continuing with the subject further—replicating findings by Bennett and Hogarth (2009) which showed that perception of physics as being difficult and “hard” put students off continuing with the subject, particularly when they felt they could attain a higher grade in another subject. Yet our analyses also indicated that these perceptions did not map straightforwardly on to actual attainment—that is, we did not find any notable attainment differences between those who did or did not feel “clever enough” at the subject. Whereas previous studies have interpreted students' perceptions of being “good at” (or feeling “not clever enough”) to pursue chemistry in terms of individualized notions of self-efficacy (e.g., Avargil et al., 2020; DeBoer, 1987; Shwartz et al., 2021), we put forward here a more sociological interpretation that calls attention to the role played by identity/habitus, social structures, and chemistry practices in shaping students' feelings of competence and confidence in a subject—suggesting that such feelings are not only generated by a students' experience of the subject in question, but will be also relationally informed by their experiences of other subjects. Moreover, we draw on research that points to the powerful mediating role of identity on student choices and trajectories (e.g., Nasir & Hand, 2008) and in particular work that shows how dominant notions of “cleverness” are gendered, racialized and classed in ways that make it harder for nondominant communities to feel (and be recognized as being) “clever,” irrespective of actual attainment (e.g., see Archer, 2008, Archer & Francis, 2007).

We also hypothesize that the potential for a young person to feel connected with and “good at” a subject may also be mediated by the practice of grade severity in A level chemistry (Coe et al., 2008). This is not only because the practice of grade severity may depress a students' attainment in chemistry compared with other subjects in which grade severity is not practiced (i.e., potentially mediating student self-efficacy in chemistry compared with other subjects) but also because the symbolic attribution of “difficulty” that becomes attached to subjects that practice grade severity—and the resultant intensified requirement for chemistry students to negotiate performing and being recognized as “clever”—will differentially impact students by social location (e.g., by gender, race/ethnicity, and social class).

Bourdieu's work underlines how notions of “cleverness” and intelligence are not individual properties but are socially structured and re/produced as part of the social reproduction on injustices. Hence, the likelihood of a young person being able to recognize themselves and be recognized by others as “clever” will be structured by relations of social class, gender, and ethnicity, such that it is easier for more privileged students to be recognized as “clever” and harder for others, even when they attain highly (see also Archer & Francis, 2007).

Within the qualitative data, we noted how the dynamic between habitus and field shaped students' choices in terms of the extent to which they developed a personal connection with a subject area. Where a young person developed a close, meaningful personal connection with a subject, particularly through a direct personal experience (e.g., family health), this seemed to have had a profound impact on their degree trajectory, either toward or away from chemistry, such as was seen in the cases of Samantha, Joanne, and Preeti who all pursued medical-related degrees. Using our Bourdieusian lens, we suggest that experiencing a personal connection with a subject is particularly influential because such connections constitute important aspects of the habitus, shaping the extent to which a particular subject or area feels “right” and “for me.” We understand such connections as produced through a dialectic between the field (subject/aspiration) in question and the habitus, in which the field is felt to support a valued expression of the habitus. This point also resonates with Savickas' (2005) narrative approach to student career choices, in which he proposes that people make choices through the construction and negotiation of narratives based on personal meaning, which are highly influenced in turn by social values and relations (see also Del Corso & Rehfuss, 2011).

Similarly, we interpreted the theme raised by some of the young women, regarding the perceived association of chemistry with masculinity, as speaking again to the relationship (fit vs. disconnect) between habitus and field. While in England, participation in undergraduate chemistry is relatively gender balanced, in line with Steegh et al. (2021) and Cousins (2007), our data similarly suggest that some young women experienced chemistry as a gendered field and this disconnect played a part in them moving away from chemistry.

Finally, we reflect that in our data, habitus appeared to be more adaptive and responsive to the conditions of the field than perhaps is given credit in Bourdieu's writings. Thus, while Bourdieu argued that "the anticipations of the habitus, practical hypotheses based on past experience, give disproportionate weight to early experiences" (Bourdieu, 1990, p. 54), we found that alongside the influence of early experiences, current experiences and conditions also proved important influences on the young people's trajectories. We suggest that this observation may contribute to the ongoing development and deployment of Bourdieusian theory within science education.

5.2.2 | Capital and disciplinary fields

A Bourdieusian lens proposes that the extent to which a young person's social, cultural and economic capital is recognized and legitimated (or not) within a given field will impact the extent to which they are able to generate value and "get on" within that field. Hence, young people who do not have access to the forms of capital that are valued and can support progression within a particular field will be disadvantaged compared with those who do (see also Cooper & Berry, 2020). For instance, where students seemed to possess particular forms of cultural capital relating to the potential value and transferability of a chemistry degree in the job market, this appeared to support their progression to a chemistry degree. Likewise, where young people benefitted from specific forms of social and cultural capital in the form of motivation and support to continue with chemistry from significant adults (e.g., teachers, family members), this appeared to act in a number of cases as significant influences on young people's degree trajectories (e.g., tipping both Samantha and Joanne's trajectories toward more biological fields and helping to mitigate some of the impact of a less engaging curriculum on their choices). We interpret our data as reinforcing the importance of such support for students' chemistry aspirations, as noted by Mujtaba et al. (2018) in relation to younger children, although we also note that this factor occupied a lesser relative importance among our older sample.

As exemplified by Brittney's case study, for a smaller number of students, but particularly those from low-income families, the potential for undertaking a chemistry degree (or indeed any HE course) may be mediated by economic capital and exacerbated by the absence of specific forms of chemistry-related cultural and social capital. In such cases, even a long-standing love of chemistry is unlikely to be sufficient to realize a chemistry degree trajectory. In the wider sociological and HE literature, the financial cost of HE participation in England—and specifically the requirement to incur substantial student loan debt in order to pay for tuition and living costs—has been identified as a factor that disproportionately impacts working-class students, making HE feel like a risky and sometimes "impossible" choice (e.g., Callender & Mason, 2017).

However, this point has received less attention within the science participation literature. As Bourdieu writes, the habitus "tends to exclude all the 'extravagances' ('not for the likes of us'), that is, all the behaviours that would be negatively sanctioned because they are incompatible with the objective conditions" (Bourdieu, 1990, p. 56). In Brittney's case, her family's experience of financial hardship and a working-class habitus that included no family experience of HE had numerous influences on her trajectory—including having to give up a range of after-school clubs during secondary school, needing to work in part-time employment through her A levels and finding unthinkable the prospective student loan debt that HE participation requires. As we have discussed previously in relation to minority ethnic students, choosing is a socially located and socially loaded practice, such that the choice of "safe routes" is particularly crucial for those young people who are located at the intersection of inequalities (Archer & Francis, 2007).

We interpret work experience and outreach as forms of embodied social and cultural capital, access to which is differentially mediated by students' social positioning. Our findings indicated that engaging and accessible work experience opportunities were not widespread (either generally or specifically in relation to chemistry), but where students reported quality experiences, these tended to help support students' trajectories toward the subject area in question. It is difficult to guess what difference, if any, the provision of more and/or higher quality chemistry-related experiences might have made to the young people's trajectories. However, we suggest that their absence could be interpreted as a lost opportunity to have potentially added another "straw" to lend support toward a chemistry trajectory, as engaging chemistry work experience might also be understood as both a form of embodied cultural capital and as an experience that can help to cement the relationship between habitus and the disciplinary field in question. In all these respects, the accounts of the young people seemed to indicate that, as a field, they experienced chemistry as less "active" and successful in the game of marginal gains, compared with other subjects. Our analysis of the "could have been" and "should have been" students also hints that, as a field, chemistry outreach, enrichment, and work experiences may be somewhat patchy and uneven (strong in places, weaker in others), often failing to reach students from working-class communities.

Finally, we interpreted the absence of capital within a specific field as contributing to closing down a particular trajectory, due to the mismatch between a young person's resources and the field in question. For instance, we can understand the small number of students like Mienie (and the students in Dagogo et al.'s (2019) study), who ended up pursued a "second choice" degree trajectory as making strategic negotiations based on the conditions of the field. While there were relatively few students in this situation in our study, a UCAS (2021) report suggests that in the United Kingdom currently "One in five students couldn't study a degree subject that interested them because they didn't have the right subjects to progress. This is most apparent for some degree courses, such as medicine and dentistry, maths, economics, or languages." Our findings thus add to previous work, such as Cooper and Berry's finding from the Australian context that differential access to capital can support or restrict senior secondary participation in chemistry across social class and ethnicity. Our paper also extends understanding about the importance of building capital by considering ways forward as lying in changing the field (as determining the relations of production and valorization of capital).

6 | LIMITATIONS

We acknowledge that our study has a number of limitations, including that it pertains only to the English context and hence is not generalizable across other national and international settings. Our samples are also small and relatively unrepresentative, particularly in terms of the overrepresentation of young women chemistry degree students in our qualitative sample and survey sample, given that 100% of chemistry degree students in our qualitative sample and 59% of chemistry degree students in our survey sample identified as female, compared with national figures that indicate that around 45% of chemistry degree enrolments in the United Kingdom identify as female. Hence, while our findings offer perhaps useful depth on young women's experiences and reasons for not/choosing chemistry, we recognize that our data are more limited for understanding young men's choices.

7 | CONCLUSIONS AND IMPLICATIONS

In sum, we suggest that Bourdieu's work helps to explain the complex production and operation of the interplay of relational factors that "pull" student toward and "push" them away from chemistry degrees, resulting in patterns of participation that are shaped by differential distributions and configurations of habitus, capital, and field. We suggest that students' subject choices can be usefully conceptualized as practices that produce particular trajectories that are subject to competing social forces that impact on the direction and nature of their outcomes. In this way, rather than treating degree choices as simple "decisions" or cognitive phenomena, we propose that not/choosing a chemistry degree can be conceptualized using the metaphor of an ongoing "tug-of-war," in which multiple factors, forces, and experiences (produced through interactions of habitus, capital, and field) play out within complex fields of forces, competing in constant tension and negotiation, simultaneously exerting pushes and pulls either toward or away from chemistry and/or other options. Sometimes these experiences and factors combine to produce decisive moments, *deal breakers*, *that* exert sudden, significant influence on a young person's trajectory toward or away from chemistry (e.g.). In other instances, different experiences and interactions of habitus and capital can accumulate over time like the proverbial *straws* on a camel's back, to tip the balance of a young person's trajectory in a particular direction at a given moment. However, chemistry trajectories were not simply the product of additive push and pull factors, in the sense that the greatest number of influences will determine a trajectory (although this can certainly help). Rather, factors operated in combination, such that whereas a single factor or experience on its own might not exert a causal influence on a young person's trajectory, in combination and over time, the sum accumulation of differentially weighted influences could be highly impactful. But how might these insights be of practical use to chemistry education policy and practice?

We suggest that our arguments regarding the relationality of (chemistry) degree subject choice raise conceptual and methodological implications for educational policy and research, namely that our research calls for shifts in how subject choices are understood and approached. For instance, we suggest those concerned with researching subject choices might adopt more relational methodologies and those designing interventions to support increased and widened participation in particular areas might usefully consider how student choices are shaped by practices and experiences both within and beyond the area in question.

The second implication of our work for chemistry education policy and practice is that while to a reasonable extent, students seem to be reporting relatively positive views of A level chemistry as supporting interest and knowledge in the subject, there may be useful scope for extending this further through teaching and learning approaches and experiences that support student habitus and capital. Bearing in mind Bourdieu's somewhat inaccessible terminology, we use the framing here of "teaching for identity" and "building capital." In terms of the former (teaching for identity/ habitus), based on our findings, we suggest that practices could include (i) changing practices that lead students to feeling "not clever enough," (ii) using pedagogical approaches that support learners to find and experience a personal connection with chemistry, and (iii) challenging gendered practices and cultures within the subject.

In terms of (i), we suggest that consideration could be given to students' reports of the perceived "jump" from GCSE to A level. While our data are far from conclusive, we suggest that there may be value in further considering and exploring the observation made by a couple of students in the qualitative sample, who attributed the "jump" to the practice of grade severity in A level chemistry. Moreover, we suggest that there could be value in further exploring any potential link between the practice of grade severity and the likelihood of students reporting feeling "not clever enough" in a subject (i.e., the role of grade severity in mediating student subject identity and self-efficacy). While Ofqual, the national examination regulatory body, has recognized the existence of grade severity but declined to implement changes (e.g., Black et al., 2018; Ofqual., 2018), wider calls have been made for Ofqual to address grade severity (e.g., Tracy, 2016). We extrapolate that the continued practice of A level grade severity might be seen from a policy perspective as somewhat self-defeating, in that may be reducing participation in chemistry at degree level. Indeed, we find it difficult to see what useful function the practice serves, beyond reinforcing the elitist status of the subject. As Bourdieu reminds us, elite disciplinary cultures, such as chemistry, are "prolonged, strengthened and confirmed by social treatments that tend to transform instituted difference into natural distinction, produces quite real effects, durably inscribed in the body and in belief" (Bourdieu, 1990, p. 58). That is, how a student's habitus and sense of themselves as being a "chemistry person," or not, will be structured by their experiences of the field of chemistry education, which results in "durable dispositions to recognize and comply with the demands immanent in the field." (Bourdieu, 1990, p. 58). Hence, we suggest that the task of increasing and widening participation in chemistry may require changing the field and specifically the cultural norms and practices of chemistry education (in schools, HE, and informal settings), rather than simply seeking to persuade and change the aspirations of individual students to take the subject.

With regard to (ii), supporting students to find meaningful connections with chemistry, educators (in both formal and informal educational contexts) might usefully draw on wider existing resources that work with any curriculum and that support teachers to foster connections and build students' science-related capital through everyday teaching can be found in approaches such as the Bourdieusian inspired Science Capital Teaching Approach (e.g., Godec et al., 2017; Nag Chowdhuri et al., 2021). Changing and disrupting associations of chemistry with masculinity (iii) is a concern that is already recognized and shared by organizations such as the Royal Society of Chemistry, and we agreed with the recommendations of the Royal Society of Chemistry (2018) report that recognizes that change needs to be made to the culture of professional chemistry (e.g., to better enable the combination of career and caring responsibilities).

In terms of building capital, in line with our findings, we identify a further three areas for consideration: (iv) how to provide more young people with specific support and encouragement to continue with chemistry from a key adult, (v) how to provide more young people with high quality chemistry work experience and outreach offers and (vi) supporting more equitable access to HE for those from working-class and low-income communities. To provide more personalized support for young people, we suggest that professional societies or bodies with an interest in chemistry might consider providing additional guidance to chemistry teachers to enable them to both understand the consequential nature of providing this form of personalized form of encouragement and support to young people. While it is not appropriate to generalize from our relatively small sample, we would suggest that our data indicate that there may be scope to both increase and diversify provision and access to high quality chemistry-related work experiences, but that these might be usefully particularly targeted at underrepresented communities. Finally, while the financial costs of HE in England are out with the scope of chemistry education policy and practice, we echo ongoing calls on national government to understand and engage with ongoing classed inequalities in access to HE, noting that this may be particularly acute in relation to elite subjects, such as chemistry—and that, as exemplified by Brittney, this issue is not solely due to lower attainment or lack of interest. Chemistry organizations and funders may also consider the opportunity to provide additional support to students from underrepresented communities with the offer of fully funded bursaries. Such approaches would support the "chemistry pipeline" while also ensuring that a chemistry degree might be rendered a thinkable option for students such as Brittney.

To conclude, we extrapolate from our analyses that there is no single reason for declining chemistry degree enrolments, but that the situation appears to arise from a combination of factors, including comparatively: less widespread support for young people's chemistry self-efficacy, identity and recognition (compared with identity and recognition in other subjects); fewer opportunities for students to develop meaningful personal connections with chemistry, especially compared with areas like biology and medicine; less widespread significant support from chemistry teachers to pursue the subject at degree level; fewer (and unevenly spread) chemistry work experience opportunities, with some patchiness and variability in existing provision. We also note that some young women are put off by popular associations of chemistry with masculinity at degree level and in the future workplace and that on the whole, chemistry routes may be seen as less broad/transferable compared to biology-related and medical routes. As a result, the existence of other options that feel "easier," resonate personally with young people and benefit from greater support and capital from family/significant others mean that while many A level students find chemistry interesting, many choose not to pursue it further at degree level.

In sum, we suggest that subject choice needs to be understood as a comparative, relational process, which is not just shaped by views and experiences of chemistry but by young people's wider experiences of other subjects/aspirations and their relative push/pull factors. Ways forward lie in trying to support and change a range of cultural and systemic practices within chemistry education, rather than trying to increase interest in chemistry and change the aspirations and views of individual students per se.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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