STUDENT PERSPECTIVES ON CHEMICAL CAREERS: A COMPARATIVE STUDY OF PREPARATION, PERCEIVED CHALLENGES, AND ETHNIC DIFFERENCES

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Abstract

This qualitative study explores how final-year chemistry students at Durham University perceive career opportunities and preparation in the chemical sciences, with a focus on comparing the experiences of minority ethnic and White students. Through semi-structured interviews, the research investigates students' aspirations, perceived skill needs, and anticipated challenges in transitioning from university to industry. All participants highlighted the importance of hands-on practical skills, communication, and adaptability developed through university studies, but noted a significant gap between academic training and industry demands. Real-world experiences such as internships were seen as crucial for career development, yet access to these opportunities was perceived as limited. Support systems, including career services and mentoring, were valued by all students. Distinct challenges emerged by ethnic background: minority ethnic students reported additional barriers such as a lack of visible role models and difficulties integrating into the scientific community, while White students more frequently cited age discrimination and competitive job markets. The findings highlight the need for more inclusive environments, expanded access to industry placements, and tailored career guidance to support all students' successful transition into the chemical workforce. These insights inform recommendations for universities and employers seeking to promote equity and resilience in chemistry career preparation.

Keywords: *students' perceptions, higher education, chemical sciences, career aspirations, skills development, representation and inclusion, career guidance and support, transition to employment*

1. INTRODUCTION

The chemical sciences sector offers a wide range of career opportunities for graduates, with strong demand for chemistry skills in industries such as pharmaceuticals, manufacturing, and materials science. National data show that approximately 35% of UK chemistry graduates enter directly into science-based occupations, and a further 29% pursue technical roles in manufacturing and related sectors [1,2]. However, the pathways students take into the chemical industry, and the factors that influence their interest in these careers, are not uniform across all groups.

Recent reports highlight disparities in the progression of students from different ethnic backgrounds within chemistry. While White students remain the majority in undergraduate cohorts, students from minority ethnic backgrounds, including Asian, Black, and mixed or other groups, are increasingly present at the undergraduate level but remain underrepresented at higher academic and industry positions [3–5]. For example, Black students make up over 5% of undergraduate chemistry students but represent only 1.5% of those progressing to PhD level, and are almost entirely absent from professorial and senior industry roles [3,4]. Qualitative research and sector reports point to a range of barriers for minority ethnic students, such as a lack of visible role models, limited access to mentoring and networks, and a culture that can feel exclusive or unwelcoming [3,6–8].

These disparities raise important questions about what drives students' interest in entering the chemical industry and whether the factors that support or hinder this interest differ between White students and those from minority ethnic backgrounds. Previous studies have identified limited careers guidance, underrepresentation in leadership roles, and the impact of cultural expectations as significant barriers to progression for minority ethnic students [3,5–8]. In contrast, White students are more likely to see themselves represented in senior roles within academia and industry, which may contribute to a stronger sense of belonging and confidence in pursuing these careers [3,7]. However, they may experience different challenges, such as increased competition for limited high-status roles, unclear progression pathways, or a perceived pressure to meet high expectations, particularly in competitive STEM (Science, Technology, Engineering, and Mathematics) sectors [9,10].

To address these issues, this study adopts a qualitative, interview-based approach with final-year chemistry students at Durham University. By capturing and comparing the experiences, motivations, and perceived barriers of both White and minority ethnic students, this research seeks to contribute to a more nuanced understanding of the factors that shape career aspirations in the chemical sciences.

Specifically, this study seeks to answer the following research questions:

1. How do final-year Durham chemistry students perceive career opportunities in the chemical sciences?
2. What key skills do final-year chemistry students believe are crucial for industry, and how do university studies support their development?
3. What is the impact of support systems and real-world experiences on students' chemical industry career aspirations and readiness?
4. What challenges do final-year chemistry students anticipate when entering the chemical industry?
5. How do career perceptions, anticipated challenges, and experiences with support and opportunities differ between minority ethnic and White chemistry students?

By addressing these questions, the study aims to inform more effective and equitable strategies for supporting all students as they consider and pursue careers in the chemical industry.

Note on Terminology and Capitalisation

In this paper, we capitalise "White" when referring to students' racial or ethnic identity. This decision follows recent guidance from academic, journalistic, and advocacy organisations, which recommend capitalising all racial and ethnic group names (e.g., Black, White, Asian, Indigenous) to recognise them as constructed identities with social and historical significance [11–17]. We acknowledge ongoing debate on this issue; some style guides continue to use lowercase "white" [18]. Our choice aims to ensure consistency and to avoid implying that whiteness is a neutral or default category.

2. METHODOLOGY

2.1. Programme Structure

At Durham University's Chemistry Department, undergraduate students can pursue either a three-year Bachelor of Science (BSc) or a four-year Master of Chemistry (MChem) degree. Both programs share a common core curriculum in the first two years, providing foundational knowledge in organic, inorganic, and physical chemistry. This structure allows students the flexibility to transfer between the BSc and MChem courses until the end of the second year.

In the third year, BSc students complete their degree with modules such as Core Chemistry 3, a dissertation, and integrated practical chemistry courses. MChem students continue into a fourth year, engaging in advanced research projects and specialized modules that prepare them for professional careers in chemistry or further academic study.

MChem students also have the option to spend their final year in industry or abroad. The year in industry pathway allows students to gain hands-on experience working in a professional research or industrial setting, enhancing their practical skills and employability. The study abroad option provides the opportunity to conduct research at a partner university outside the UK, offering international exposure and experience in different academic and cultural environments.

2.2. Data Collection – Interviews

This study received ethical approval from the Chemistry Department Ethics Committee at Durham University (CHEM-2024-0798-793). All final-year students in both the BSc and MChem chemistry programmes were invited to take part. An email invitation was sent to everyone who was eligible, and seven students responded. Four of these students were from the MChem programme and three were from the BSc programme. Among those who took part, four students identified as being from Black, Asian, or other minority ethnic backgrounds (hereafter referred to as "minority ethnic backgrounds" for brevity), and three identified as White. The overall chemistry student population at Durham is predominantly White, with more than 80% of students identifying as White and less than 20% as being from minority ethnic backgrounds.

Of the four participants from minority ethnic backgrounds, one was studying for an MChem and completing their research project at Durham, while the other three were BSc students. All of the White students were on the MChem programme and were following a year in industry pathway.

All participants were invited to take part in semi-structured interviews aimed at understanding their post-graduation plans and the career support received during their degree. Four open-ended questions, developed specifically for this study, guided the conversations and allowed students to share their experiences and perspectives in their own words. Semi-structured interviews were chosen because they combine the flexibility of open ended exploration, which is important for sensitive topics like identity and inclusion, with enough structure to ensure comparability across participants and maintain focus on the research questions [19]. This approach enables the collection of rich, detailed accounts while still allowing for meaningful thematic comparison between groups. With participants' consent, all interviews were audio recorded and transcribed verbatim to ensure accuracy and transparency in data analysis, and to uphold ethical standards for qualitative research

Students were asked about their career goals, including whether they were considering working in the chemical industry. They were encouraged to talk about which areas of the industry appealed to them, the skills and qualifications they considered important, and how their degree had helped them build those skills.

The discussions also explored how students had prepared, or intended to prepare, for careers in the industry. This included participation in internships or industry-related projects and reflections on how those experiences had influenced their goals. Students described any challenges they had encountered or expected to face, as well as their views on diversity and inclusion within the sector. In addition, they were asked about their involvement in support systems such as mentoring or networking opportunities.

Towards the end of each interview, students were invited to share examples of times when they felt supported, as well as moments when they faced obstacles in pursuing their career aspirations. They were also encouraged to reflect on any alternative career paths they had considered. A full list of the interview questions used in this study is provided in the appendix.

To ensure accessibility and convenience, interviews were conducted online via Microsoft Teams at times that suited each participant. A flexible time frame was offered to allow students to speak comfortably and without pressure.

2.3. Data Analysis

The interview responses were analysed thematically to identify common themes and recurring patterns in students' perspectives on career support and post-graduation pathways. A qualitative, inductive approach was used, with themes emerging from the data rather than being predetermined [20]. This method allowed for an in-depth understanding of students' experiences, highlighting key areas of concern, support, and potential improvements in career guidance.

3. RESULTS

Interviews with final-year chemistry students at Durham University revealed a range of experiences and perspectives that shape how they think about careers in the chemical sciences. Students described the skills they consider essential, the impact of their university studies, and the support and challenges they encountered as they prepared for life after graduation. To capture both common ground and differences, the results are organised by student background: first highlighting the views of students from minority ethnic backgrounds, followed by those of White students. This approach allows for a clearer comparison between groups and helps identify both shared and unique challenges, as well as implications for education and policy.

3.1. Experiences of Chemistry Students from Minority Ethnic Backgrounds

This section explores the career perspectives and preparation of four chemistry students from minority ethnic backgrounds, drawing on their reflections about skills, experiences, and support during their degree. These students highlighted a range of technical and personal qualities they believed were essential for entering the chemical industry, as well as challenges they anticipated in doing so. Their accounts also emphasised the value of real-world experience, the role of university learning, and the importance of inclusive environments.

3.1.1. Perceived Crucial Skills for the Chemical Industry

Students identified several skills they believe are essential for success in the chemical industry. Hands-on and practical skills, particularly in laboratory settings, were frequently highlighted as paramount. Fluency with analysing data generated by analytical instruments, such as HPLC and NMR, was specifically mentioned as important practical expertise.

Beyond practical lab work, students noted other vital technical and personal attributes. Adaptability was described as a main skill, allowing individuals to adjust to the broad and varied nature of the chemical industry. This included being able to work effectively in unpredictable environments and deal with situations when experiments do not proceed as planned. Strong data and communication skills were also deemed essential. Proficiency with computational tools like Python for efficient sorting of large data sets was cited as important. Students emphasised the importance of being able to clearly present their findings, both in writing and through presentations. They felt that sharing knowledge effectively with other scientists is a valuable skill. All students felt that having the confidence to speak up and present their work was a key skill for working in the industry.

Students also identified important personal qualities. Patience was considered crucial, understanding that failure is a given in chemical work and that tasks often require extended effort. Additionally, the ability to understand and explore different methodologies to approach a problem, rather than getting stuck on a single linear route, was valued. Independent learning was seen as necessary to bridge the gap between academic study and the demands of the working field. One student also mentioned that while a strong theoretical foundation might be important for specific goals like winning a Nobel Prize, industry often prioritises skills like optimising processes and reducing costs, relevant to tangible outcomes like developing electric vehicles.

3.1.2. Role of University Studies and Lab Work

University studies were perceived as playing a significant role in developing some of these essential skills, particularly through practical components. Students stated that their studies, especially lab work, enhanced their hands-on skills. The practical aspects of the degree and research projects in later years were credited with fostering skills like adaptability and the ability to handle unpredictable situations. Studies were also seen as preparing students to link chemistry concepts with the real world and build confidence in expressing themselves.

However, some limitations were also noted regarding the alignment between university labs and industry reality. One student felt that the lab experience provided, at least in their third year, was not fully representative of the real industry due to limited hours. Methodologies in university labs were often perceived as being “too prescribed”, limiting the opportunity to explore alternative approaches or troubleshoot independently when experiments failed. It was suggested that the course design could better prepare students by allowing more experimentation within the structured lab environment. While university taught the theoretical basis for things like making batteries, it did not necessarily cover industry-specific needs like optimising charging time or reducing cost.

3.1.3. Importance of Real-World Experience (Internships/Placements)

There was a strong consensus among students that real-world experience, such as internships and placements, is crucial for career development and success in the chemical industry. These experiences were seen as vital for allowing students to understand what working in the field is truly like. Students felt that experiencing something first-hand could "make or break" their interest in a particular career path. Internships were described as highly impactful in shaping career goals, helping students identify what they enjoy, what they can learn, and what they are good at. For instance, enjoying a self-directed research project solidified one student's desire for academia, while an internship reinforced another's goal aligned with reducing environmental impact.

Students also recognised the practical value of these experiences in the job market, noting that employers value internship experience and that it makes candidates stand out. Conversely, a lack of real-world exposure through placements was perceived as a significant challenge and a disadvantage when entering the industry.

3.1.4. Challenges Entering the Industry

Students anticipated several challenges when entering the chemical industry. These included a general lack of experience and the initial difficulty of not fully understanding what one is doing in a new role. Developing confidence and overcoming the expectation of being perfect immediately were also anticipated challenges. Working with different instruments compared to those used in university labs was specifically mentioned.

A significant challenge was perceived to be the need for independent learning to bridge the gap between theoretical university knowledge and the practical realities of the working field. University courses cannot cover everything needed in industry, and the working field can be very different. Job hunting was seen as requiring "comprehensive abilities" that go beyond just theoretical knowledge from the curriculum, necessitating an understanding of trending technologies outside of academic study.

Integrating within the scientific community was identified as a potential challenge, particularly for individuals from diverse backgrounds who may not see many people like themselves in the industry. Practical aspects like time management and the expectation to figure things out independently without the structured "safety net" of university labs were also anticipated difficulties. Navigating the job search itself presented challenges, such as a lack of clear awareness of available jobs or the full process for applying to opportunities like PhDs. Encountering difficulties finding opportunities or receiving no response from potential contacts was also mentioned. External factors, such as the perceived low value and salary for chemistry graduates in certain regions of the world compared to others, were significant challenges influencing career location decisions. Missing opportunities due to simple habits like not checking emails was also noted as a challenge.

3.1.5. Support Systems and Resources

Students reported utilising various support systems during their studies. They sought guidance from career services and dissertation or personal advisors. Discussions with advisors were seen as helpful in confirming career pathways, understanding options, and gaining insights into the application process. Support from family and friends also played a role in feeling encouraged and navigating decisions, such as the value of pursuing a PhD. Attending career fairs and workshops provided valuable exposure to different companies and potential career paths, helping students “fine-tune” their goals.

Suggestions for additional resources and initiatives included implementing more explicit information about available jobs in the chemical industry and what they involve. Students wanted more industry talks from a broader range of companies. Initiatives to bridge the gap between universities and industry through greater outreach from companies were suggested. More career fairs and conferences, ideally spaced out to avoid overwhelming students, were also recommended. Integrating short industry experiences, such as a one-month placement or a tour, into the curriculum was proposed to give students a taste of the industry and enhance their CVs. University assistance in finding placement opportunities, including summer internships, was also suggested.

3.1.6. Diversity and Inclusion Perceptions

Regarding diversity and inclusion, students offered varied perceptions based on their experiences. Within the university setting, some observed diversity, noting the presence of female demonstrators in labs and teachers from different backgrounds. However, a lower proportion of female lecturers was also noted. Students felt that it is still rare to see people from diverse backgrounds (including race and sexuality) in more senior or visible positions within the industry.

One student noted that while barriers might not be explicitly in place, the historical shaping of the industry and courses leads to a lack of wide diversity representation, which can make individuals from diverse backgrounds “feel on the outskirts”. This individual felt that integrating within the scientific community could be a challenge due to this lack of representation. Although many people are open to the idea of diversity, students felt that the chemical industry doesn't fully reflect the wider population. One student observed that there are fewer minority ethnic students in chemistry compared to other subjects. They also highlighted that inclusion is important for effective communication, particularly for minority groups and in international settings. Diversity was viewed as an area needing significant improvement to make the field more open to different people and ways of thinking.

3.1.7. Career Goal Formation and Shaping

Career goals among students were shaped by a combination of intrinsic interests and practical experiences. Interest areas included material science, pharmaceuticals, and new energy/carbon reduction. Goals were also influenced by perceived skill sets. One student, for example, decided to move away from chemistry partly due to a perceived lack of sufficient practical lab experience. Enjoyment of specific experiences, such as a research project or an internship, significantly impacted career trajectory, either solidifying an interest in academia or reinforcing a passion for a specific industry sector like reducing environmental impact through new energy.

Real-world exposure through internships, placements, and research projects was considered highly influential in confirming or redirecting career paths. Exposure to different career options through career fairs and talks also played a role, revealing unexpected possibilities and building confidence in the employability of chemistry graduates. Seeking advice from support systems like advisors helped students confirm their chosen pathways. External factors such as job market conditions, perceived value of the degree, and potential salary in different geographic locations also significantly influenced students' career plans.

3.1.8. Defining Success in the Chemical Industry

Students offered different perspectives on what constitutes success in the chemical industry. One perspective related success to achieving prestigious recognition, such as a Nobel Prize, which was seen as requiring a strong theoretical foundation. Another perspective defined success more pragmatically as making a significant income, which was linked to developing innovative, beneficial, and profitable products like electric vehicles. This latter view highlighted the need for skills beyond theoretical knowledge, such as optimisation and cost reduction. More broadly, success implied having the confidence and ability to navigate the industry's challenges, effectively applying knowledge, and potentially contributing to trending and impactful areas like new energy.

3.2 Experiences and Perspectives of Chemistry Students Who Identified as White

This section summarises the main themes from interviews with three chemistry students who identified as White. Their accounts highlight a range of career plans, the skills they found most valuable, and the challenges they faced or anticipated as they prepared for work in the chemical industry. As with the previous group, these students discussed the importance of practical experience, support systems, and the transition from university to industry, while also raising specific concerns about workplace culture, diversity, and industry expectations.

3.2.1. Career Plans and Exploration

The students described a variety of future plans. One was considering a PhD or a career in environmental chemistry, depending on their experience during a master's project and available opportunities. Another was drawn to teaching and was actively applying for teacher training, with academia, especially teaching, seen as an attractive path. This student had considered the chemical industry but was hesitant due to ethical concerns, expressing more interest in sectors like environmental science and sustainability, and less in areas such as pharmaceuticals or petrochemicals. The third student planned to travel and then move into accounting, but remained open to working for a chemical company in a non-research role, possibly in manufacturing or a specialist area. Notably, their year in industry placement confirmed that they did not want to pursue a career as a chemist, reinforcing earlier doubts about the field. Across the interviews, students agreed that internships and placements played a significant role in shaping their career goals, helping them clarify what they enjoyed and what they did not.

3.2.2. Skills for Success in the Chemical Industry

All three students highlighted the importance of problem-solving, communication, and laboratory skills, which they felt were primarily developed during lab sessions at university. They also mentioned that the demanding workload of their studies improved their time management and ability to prioritise tasks. Critical analysis and the confidence to question established ideas were seen as valuable, as was the ability to think across disciplines and bring creativity into scientific work. One student emphasised the need to work independently and be self-directed, a skill they developed during their placement. The ability to switch between different perspectives, such as lab work and regulatory requirements, and to reach out to others for help was also seen as important.

3.2.3. Preparation Strategies for the Chemical Industry

Students suggested several ways to prepare for a career in the chemical industry. They saw internships and work experience as essential, though they acknowledged that these opportunities can be competitive. Talking to supervisors and advisors, especially those with relevant experience, was recommended for guidance and networking. Gaining work experience in different fields was also seen as helpful, as it teaches adaptability and exposes students to different ways of working. Attending talks by industry professionals, even when not specifically about careers, was useful for learning about possible job paths. On the practical side, students stressed the importance of quickly learning safety procedures and keeping detailed records of lab and manufacturing work, since these are crucial in industry. They also felt that university exercises, like identifying and ranking hazardous materials based on safety phrases, were good preparation for similar tasks they might face in the workplace.

3.2.4. Challenges in Entering the Chemical Industry

The students anticipated and described several challenges. Adapting to new equipment and the constantly changing nature of scientific theory were mentioned, with communication and confidence seen as important for overcoming confusion in the lab. Age discrimination was identified as a potential issue, with younger, less experienced individuals sometimes not taken as seriously. One student suggested that younger people could counter this by leveraging their technological skills. Finding relevant, funded research projects and dealing with the competitiveness of positions were also seen as hurdles. For one student, the biggest adjustment was transitioning to a professional workplace, rather than the chemical industry itself. They noted that industry labs differed significantly from university labs, especially in terms of safety and equipment, and that the hiring process in industry can be slow and discouraging. The field of patent law was described as particularly selective, often favouring candidates from certain universities or those with PhDs. One student also found industry lab work to be isolating and less intellectually challenging than university chemistry, and preferred roles with quicker goal turnover.

3.2.5. Diversity and Inclusion Perspectives

Diversity and inclusion were viewed as vital topics influencing how chemistry is taught and received. A lack of visible role models was seen as potentially demotivating. Awareness of historical and ongoing imperialism in research, such as the use of resources from native cultures or building facilities on native lands, was emphasised as crucial for avoiding negative associations with chemistry. One student felt that university curricula contribute to an inherent bias by predominantly featuring Western, male figures, inadvertently reinforcing beliefs about who holds positions of power. Individuals entering the industry were seen as having a responsibility to create more opportunities and platforms for minority groups. Observation from a placement experience indicated that while diversity might be increasing at entry levels, leadership roles were often predominantly held by white men, highlighting the importance of diversity across all organisational levels.

3.2.6. Support Systems and Resources

Students described a range of support systems they had used or would have liked to use. One student benefited from a widening participation scheme, which improved their employability skills and confidence. Meetings with supervisors were helpful for discussing career goals and finding resources. Another student, while aware of mentorship and networking groups, did not participate due to time constraints, but suggested that advisors could do more to help students explore career paths and discuss ethical concerns. Involvement in university committees and outreach activities was seen as valuable for developing transferable skills. Support from managers during industry placements was also appreciated. Students suggested increasing volunteering opportunities and organising "inside days" where students can observe team dynamics and the scale of operations in industry settings. They also proposed bringing more real-world industrial processes into lab work, such as scaling up procedures and using green chemistry principles, to make learning more practical and meaningful.

3.2.7. Comparisons Between University and Industry Environments

All three students noted significant differences between university studies and industry work. University lab sessions were highlighted as crucial for skill development. Industry labs were described as markedly different from university labs, especially regarding the scale of safety protocols and the type of equipment used. The need for meticulous record-keeping in industry was also emphasised. One student felt that the chemical content in industry was less challenging than at university and found that observing processes in the lab aided understanding. The transition between first and second year at university was described as a major difficulty due to a large increase in content complexity, impacting confidence. It was also noted that university curricula might heavily emphasise traditional lab work and research, whereas many industry roles are more technical, computer-based, or administrative, and these are not always prominently advertised by professors. University exercises on safety and hazard identification were seen as good preparation for similar industry tasks.

4. DISCUSSION

Reflecting on the experiences of both groups of students reveals shared challenges and strategies for entering the chemical industry, as well as distinct perspectives shaped by their different backgrounds. These insights provide a nuanced understanding of the factors that shape career aspirations in the chemical sciences, building upon previous studies that have identified barriers to progression for minority ethnic students and different challenges faced by White students [3,6,21,22]. The diverse post-graduation plans explored by students, including interest in various industry sectors, academia, teaching, and even non-chemistry roles, directly relate to the wide range of career opportunities available to chemistry graduates and highlight that the pathways students take are not uniform across all groups [6,23]. This diversity of plans and motivations directly addresses the first research question, showing that students' aspirations are influenced by personal interests, skill sets, practical experiences, and external factors such as job market conditions and degree value.

Turning to the second research question, students in both groups recognised the value of practical and transferable skills for success in the chemical industry, but their emphasis varied: minority ethnic students tended to highlight technical expertise and confidence in applying these skills to industry outcomes, while White students more often stressed problem-solving and independent thinking. This pattern closely reflects previous research and sector reports, which have shown that employers in the chemical sciences increasingly value both technical and transferable skills, but that students' perceptions of which skills are most critical may differ according to their background and experiences [9,24–34].

Addressing the third research question, students across backgrounds described the value of support systems and real-world experience in shaping their career aspirations and readiness for employment. Internships and placements were widely regarded as vital for career development, yet access to these opportunities was often seen as limited. Students valued guidance from career services, advisors, family, and friends, and suggested improvements such as more explicit job information and integrated short industry experiences [6,35–40]. These findings underscore the importance of practical experience and robust support networks in preparing students for the transition from university to industry.

For the fourth research question, students anticipated a range of challenges, including limited experience, confidence gaps, and the need for independent learning to bridge the gap between university and industry. Minority ethnic students described additional barriers, such as a lack of role models and difficulties integrating into professional communities, while White students mentioned age discrimination and issues with competitive recruitment. These findings are consistent with previous research and sector reports, which highlight that both minority ethnic and White students face barriers as they transition to the workforce, but the nature of these barriers can differ [3–5,7]. The greater participation of White students in the MChem year in industry pathway compared to minority ethnic students may also reflect differences in access to extended industry experience.

The fifth research question is addressed through the comparison of group-specific experiences. While students across backgrounds shared many aspirations and challenges, their perspectives were shaped by both individual and structural factors, including access to opportunities, support systems, and experiences of inclusion and identity within the field. Discussions with both groups also touched upon diversity, inclusion, and the transition from university to industry, reflecting wider themes in the literature on representation, privilege, and the influence of identity on STEM aspirations and career trajectories [3,5–7,41].

These findings highlight that students' career interests and choices are shaped not only by their skills and opportunities, but also by their experiences of inclusion, support, and identity within the chemical sciences. Building on these overarching themes, the following sections explore in greater detail the key aspects of career preparation, beginning with the crucial skills students perceive as essential for success in the chemical industry.

4.1. Perceived Crucial Skills

Students from both minority ethnic backgrounds and white backgrounds consistently identified hands-on, practical skills, particularly those gained in laboratory settings, as essential for success in the chemical industry [6,42]. This perception strongly reflects current employer expectations, where technical proficiency and real-world laboratory experience are frequently emphasised as core competencies [28,43,44]. In addition to technical skills, communication abilities were highlighted as crucial by both groups. This reflects the increasing demand within the sector for chemists who can articulate complex data clearly, collaborate across disciplinary boundaries, and contribute effectively to team-based projects [31,35,45].

The emphasis on particular skills differed between groups in this study. Minority ethnic students placed notable importance on adaptability, describing it as essential for navigating the rapidly evolving and technologically dynamic environment of the chemical industry, a view that aligns with literature highlighting adaptability as a key attribute in STEM careers [35,36,46]. These students also stressed the need for competence in data analysis tools such as high-performance liquid chromatography (HPLC), nuclear magnetic resonance (NMR), and programming languages like Python, reflecting the growing expectation for proficiency in these areas within both academic and industrial laboratories [32–34]. Confidence in presenting findings and speaking up in group settings was viewed as essential, particularly for professional development and increased visibility. For students from underrepresented backgrounds, these communicative competencies were seen as instrumental in overcoming participation barriers and fostering a sense of belonging, which is consistent with previous findings on the importance of communication skills for minority groups in STEM [7,41,47]. Patience and a willingness to experiment with different methodologies when addressing complex problems were also highlighted, aligning with the iterative and solution-driven nature of research and development in industry settings [36,48,49].

White students, while also valuing technical and communicative competencies, placed greater emphasis on attributes such as problem-solving, time management, critical thinking, creativity, and the ability to work independently. They also emphasised the importance of being able to shift between different perspectives and approaches. These qualities reflect a broader understanding of graduate employability, which integrates both domain-specific and transferable skills, such as teamwork, self-management, and analytical reasoning, as foundational for career readiness [9,50,51].

An additional distinction emerged in how minority ethnic students connected their skillsets to pragmatic industry outcomes. These students emphasised improving efficiency and reducing operational costs, reflecting a results-oriented mindset focused on delivering tangible value to future employers [36,39,52]. This practical orientation suggests that their approach to career preparation is not only skill-driven but also strategically aligned with measurable industry objectives.

These findings indicate that students are not only aware of the competencies required by the chemical industry but are also actively attempting to develop them. Both groups demonstrated an understanding that career success demands a blend of technical expertise, transferable skills, and a practical, outcome-driven mindset. The differing emphases between groups further suggest that while all students seek to enhance their employability, the strategies and skillsets they prioritise may reflect distinct personal experiences, perceived challenges, and professional aspirations.

4.2. Role of University Studies and Lab Work

Both minority ethnic and white students agreed that university studies, particularly laboratory work, played a significant role in developing essential hands-on skills relevant to the chemical industry [6,28,30,53]. Practical components of university courses and research projects were frequently credited with fostering adaptability, time management, and the ability to navigate unpredictable situations, skills that are highly transferable to industrial environments [50,54–56].

Despite this, students from both groups identified a persistent gap between academic laboratory experiences and the realities of industrial practice. University lab work was often described as "too prescribed," restricting opportunities for independent exploration and limiting students' exposure to authentic problem-solving scenarios. Participants noted that academic experiments frequently lacked focus on process optimisation, cost efficiency, and other priorities integral to commercial operations [31,33,34,57].

This perceived disconnect is echoed in the wider literature, which highlights that while academic laboratories tend to emphasise foundational knowledge and controlled experimentation, industry environments prioritise efficiency, safety, and practical application within a commercial context [33,34,58]. White students, in particular, commented on the marked differences between academic and industrial labs, citing stricter safety protocols, different types of equipment, and a broader scope of roles in industry, including technical, digital, and administrative positions, that may not be adequately represented in the curriculum.

Minority ethnic students especially noted the limited opportunities in university settings for independent troubleshooting and dealing with real-world challenges such as optimising chemical processes for cost and performance. This concern aligns with research showing that work placements and internships offer crucial experiential learning, bridging the divide between academic preparation and industry expectations [9,25,27,36,59].

The observation that university lab work often feels overly structured and lacks emphasis on optimisation or cost reduction suggests a potential misalignment between academic training and the skillsets required in industry [34,60,61]. While foundational skills are effectively developed, the 'recipe-like' nature of academic practicals may not adequately prepare students for the self-directed problem-solving, efficiency-driven thinking, and operational awareness that are vital in commercial chemical settings [53,60,62,63]. As a result, students may graduate with strong technical knowledge but a limited understanding of the economic and pragmatic drivers that shape real-world industrial practice [31,45]. This highlights the need to reconsider the balance between conceptual instruction and industry-oriented application in chemistry curricula, particularly in preparing students for employment in diverse roles within the sector [32,35,61].

4.3. Broader Context

The challenges and perspectives shared by students at Durham University reflect wider national and international trends within chemistry education and employment. Across the UK and beyond, research consistently underscores the critical importance of gaining practical experience, whether through internships, industrial placements, or applied university projects, for acquiring the skills sought by employers in the chemical sciences [25,27,55]. While communication, adaptability, and problem-solving are widely recognised as essential attributes, there remains an enduring concern around the misalignment between academic training and the dynamic requirements of industry [33,50,64].

Support structures such as university careers services, academic mentors, and peer support networks have been identified as key mechanisms helping students navigate complex career decisions and overcome obstacles, particularly among minority ethnic students who may lack access to informal networks or tailored guidance [24,7,47]. The growing emphasis on diversity and inclusion across the STEM landscape reflects a broader institutional and cultural shift toward more equitable and supportive educational environments. Representation, visibility of role models, and targeted support are increasingly recognised as essential factors influencing students' sense of belonging and long-term career trajectories [5,65].

Student accounts further highlight a perceived readiness gap, rooted in several interconnected challenges encountered when transitioning from university to industry. These include limited real-world exposure, difficulties bridging theoretical learning with practical application, intense competition for jobs, and the need to adapt quickly to unfamiliar workplace environments. Students reported finding it difficult to work independently and troubleshoot problems without the scaffolding typical of academic settings, challenges which they expect to intensify upon entering the less structured and fast-paced industrial context [9,26,66].

For minority ethnic students, these challenges are compounded by concerns about integrating into professional scientific communities where they see few individuals who share their background or lived experience. Anticipated barriers included limited representation, cultural or linguistic differences, and a perception of exclusion from informal professional networks. These concerns mirror broader findings on exclusive workplace cultures in STEM and emphasise that effective career preparation needs to address not only skill development but also social and cultural integration [5,7,34,49].

White students in the sample also raised structural concerns, such as age-related bias and frustrations with prolonged recruitment processes, suggesting that issues of access and equity extend beyond ethnic diversity and affect a wider cross-section of students [9,10,55]. These shared and group-specific challenges collectively underscore the importance of comprehensive and inclusive career preparation strategies. Addressing these perceived barriers requires more than generic skills training. Students need tailored guidance, access to authentic industry experiences, and honest engagement with the realities of the job market.

Students' reflections also demonstrate a strong desire for more visible diversity within the industry, especially at senior levels. A notable concern among minority ethnic students was feeling "on the outskirts," an expression that captures the sense of marginalisation they experience due to underrepresentation and a lack of role models [5,7,22,41,49]. Such experiences highlight that insufficient diversity is not merely symbolic, it can have concrete effects on students' motivations, confidence, and sense of belonging [35,36,38,67].

These perceptions affirm that diversity and inclusion efforts in the chemical industry are not only about fairness, they are central to effective student career preparation. When students do not see themselves reflected in potential roles or pathways, it can inhibit their engagement and limit their aspirations. Therefore, ensuring that all students, regardless of background, can envision a future for themselves within the sector is essential to developing a more inclusive and resilient scientific workforce.

4.4. Limitations and Recommendations

While this study provides valuable qualitative insights into the career perceptions and experiences of final-year Chemistry students at Durham University, several limitations must be acknowledged. The most significant limitation is the small sample size of seven final-year students. Although small samples are typical in qualitative research, allowing for in-depth exploration of individual perspectives and the identification of recurring themes, such findings are illustrative rather than generalisable to all Chemistry students at Durham or elsewhere [55,68,69].

The sample was diverse in terms of academic pathways (BSc and MChem degrees), industry exposure (research at Durham versus a year in industry), and demographic backgrounds (including both minority ethnic and White students). This diversity provided rich, detailed data and highlighted a range of individual experiences [6,70–72]. However, it also means that the results reflect specific personal accounts rather than a uniform group perspective, and may not capture the full spectrum of experiences present in the wider student population [69,70].

Given these limitations, future research could aim to include a larger and more representative group of participants. Expanding the sample size and incorporating students from other universities would help to verify the trends and themes identified in this study and allow for a more robust assessment of how prevalent certain perceptions, challenges, and needs are across the broader Chemistry student population [69,73]. Employing quantitative or mixed-methods approaches could also provide complementary insights and strengthen the evidence base for recommendations. Further research could additionally explore institutional differences in student experiences and support structures, as these may significantly shape career preparation and outcomes [6,69].

5. CONCLUSIONS

This qualitative study offers a nuanced understanding of how final-year chemistry students at Durham University perceive and prepare for careers in the chemical sciences, with a particular focus on the experiences of students from minority ethnic backgrounds compared to their White peers. Students across both groups described a diverse array of career interests, ranging from traditional roles in industry and academia to teaching and non-chemistry sectors. Despite this diversity, many students expressed uncertainty about their future paths and felt underprepared for the realities of industry work. Their aspirations were shaped by personal interests, practical experiences, and external factors such as job market conditions and perceived degree value [3,6].

A central theme was the importance of developing both technical and transferable skills, especially hands-on laboratory experience, communication, adaptability, and problem-solving. University studies, particularly laboratory work and research projects, were credited with fostering these competencies and building professional identity. However, students noted a persistent gap between academic training and industrial practice, observing that university labs are often overly structured and do not fully prepare them for independent problem-solving or industry priorities like process optimisation and cost efficiency [42,53,59].

Real-world experiences, such as internships and placements, were regarded as essential for clarifying career interests and strengthening employability, yet opportunities for such experiences were perceived as limited and highly competitive. Support systems, including career services, academic advisers, family, and peer networks, were valued for helping students navigate career decisions and overcome obstacles. Notably, minority ethnic students reported additional barriers, such as a lack of visible role models, feelings of isolation, and challenges related to language or cultural adjustment, which contributed to a sense of being “on the outskirts” of the scientific community [3,4]. White students more often cited situational barriers, such as age discrimination and the competitiveness of job applications.

These findings highlight that effective career preparation in chemistry requires not only technical and transferable skills but also robust support networks, inclusive environments, and authentic industry experience. Addressing barriers to representation, expanding access to placements, and strengthening career guidance are essential for supporting all students as they transition into the chemical workforce. While the small sample size limits generalisability, the study provides valuable qualitative insights and a foundation for further research into equitable and effective support strategies for chemistry students.

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APPENDIX

The questions used in interview with students are provided below.

1. What are your post-graduation plans?
2. Are you interested in pursuing a career in the chemical industry?

    a. Which sector of the chemical industry interests you the most (e.g., pharmaceuticals, petrochemicals, energy, environmental science)?
    b. What skills and qualifications do you think are crucial for success in the chemical industry? How have your studies enhanced these skills?
    c. How can you prepare for a career in the chemical industry (e.g., internships, industry-related projects)? How have these experiences shaped your career goals?
    d. What challenges would you anticipate as a student entering the chemical industry, and how do you plan to overcome them?
    e. How do you perceive diversity and inclusion in the chemical industry?
    f. Have you participated in support systems such as mentorship programs, networking opportunities, or professional development workshops? If so, how have they influenced your career development?
    g. What additional resources or initiatives do you believe universities and industry partners should implement to support students aspiring to work in the chemical industry?
    h. Have you explored other career paths (e.g., academia, research)?

3. Can you share an experience where you have felt supported in pursuing your career aspirations?
4. Can you share an experience where you have encountered challenges in pursuing your career aspirations?