

Introducing Graduate Employability Skills to Year 1 Chemistry Students: Reflecting Upon Impact

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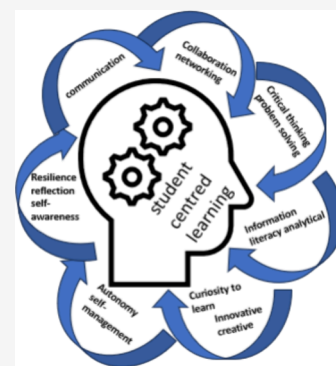
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ABSTRACT: Employability skills training is an important aspect of undergraduate chemistry degrees to ensure good graduate outcomes for students. In response to changes in the employability skills literature and to maintain good graduate outcomes, we redeveloped our Year 1 curriculum to include a dedicated graduate employability skills training (GEST) set of activities. They were designed and created to invoke transformative approaches to learning, peer group working and self-reflection on developing graduate attributes and employability skills. Our assessment of the effectiveness of the GEST focused on year 1 students' perceptions of engagement and relevance of the bespoke training compared to the rest of their curriculum in developing the target skills. In general, it was shown that the dedicated GEST was well received for students self-identifying as a woman (including transgender woman), mature students, students from a low socioeconomic background, and students without a graduate parent or guardian; in all cases students recognized opportunities for a range of skills development. This contrasted with student cohorts who self-identified as a man (including transgender man), students with reasonable or significant work experience and students with a graduate parent or guardian who perceived no-little skills development as a result of engagement with GEST compared to the rest of the curriculum. Recommendations include better communication to articulate skill development opportunities in dedicated employability focused activities and across theory and practical modules in the curriculum, and to perhaps create dedicated employability activities for students who have less employability experiences, less science capital, or those who come from a low socioeconomic background.

KEYWORDS: *Chemistry Education Research, Graduate employability skills, Self-Instruction, Student Centered Learning*



INTRODUCTION

Graduate attribute and employability skills training is no longer seen as an “add-on” to a discipline-based curriculum; it is a required component of undergraduate degrees in the UK, see for example guidance from QAA,^{1,2} Advanced HE³ and Skills Development Scotland.⁴ Skills development is also an accreditation requirement of chemistry degree programmes, as highlighted in the Royal Society of Chemistry’s accreditation of degree booklet.⁵ Development of non-discipline-based graduate attributes and skills are essential to provide a pipeline of excellence, and leading providers who can respond to regional, national, and global workplace priorities.^{6–8} High quality learning and training opportunities need to be relevant, enabling, and flexible to reflect the needs of future employers by providing innovative, creative, and independent employees. Arguably, the development of graduate attributes and employability skills aligns strongly with education for sustainable development (ESD), a transformative educational approach which seeks to empower learners with the knowledge, skills and competencies required to address complex real-world challenges.⁹ Graduates are required to develop multiple personal, higher level cognitive and professional, non-discipline based, learning skills that can be used to address complex problems or foster innovation. Undergraduate students must

therefore be given opportunities to extend their development beyond subject/discipline knowledge and incorporate training in competencies such as collaboration,¹⁰ critical thinking,¹¹ problem-solving,¹² self-awareness¹³ and emotional intelligence.¹⁴

Raising student awareness of the necessity of graduate attributes can be challenging, hindered by the use of outdated terms such as “transferable” or “soft skills”. These terms don’t adequately describe or explain key professional or personal attributes, or higher-level cognitive skills, sought by potential employers (often referred to as “industry-ready graduates”). Graduate employability as a skills-led “tick box exercise”¹⁵ has been previously critiqued for the absence of a reflective employability narrative.¹⁶ This challenges educators, as learners need to view the development of graduate attributes as mandatory training that leads to fulfilling graduate, industrial, or research-driven, career pathways.¹⁶ Learners

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should be guided to see the impact of developing attributes on their own professional and personal development, how these attributes relate to benchmark statements by professional bodies and, most crucially, that they are required by potential employers. There needs to be a move away from the idea that ticking the skills agenda in areas of teamwork, communication, problem solving, and numeracy will automatically lead to successful employment. Rather the focus needs to be on development of attributes that lead to interconnected learner experiences in research inquiry, learning literacy, self-reflection, ethics, and social understanding that creates resilient graduates who demonstrate entrepreneurship and enterprise in creative thought processes.¹⁶

Development of desired graduate attributes and employability skills has been a focus in the Higher Education Institution (HEI) sector for decades, typically with two main strategies for implementation: embedding employability strategies across the curriculum,^{3,17} or discrete “badged” employability activities.¹⁸ Students often do not recognize how they are advancing work-related credentials as they journey through their discipline-based programmes, focusing more on examination attainment rather than their personal or professional development.^{19,20} Research has shown that the development of such skills is a key requirement to successfully transition from university to employment,²¹ as reflected in the UK’s Quality Assurance Agency for Higher Education (QAA) subject benchmark statement for chemistry.² The definition of skills and their alignment with potential employability prospects differs within the literature,^{22,23} but typically includes personal and professional skills development including communication, teamwork, interpersonal, problem solving, critical thinking, self-management skills. Demonstration of personal skills such as motivation, positive attribute and emotional intelligence are also key to a holistic approach to increase an undergraduate student’s employability opportunities.^{24–26} Skills often cited in an academic context align with Wagner’s²⁷ description of the “seven survival skills” of active citizens; 1. critical thinking and problem solving, 2. collaboration, 3. agility and adaptability, 4. initiative and entrepreneurialism, 5. communication, 6. accessing and analyzing information, and 7. curiosity and imagination. Research has also shown a delineation of skills into categories such as basic professional skills, higher order thinking skills and personal qualities. This form of categorization maps broadly to the understanding, skills, efficacy beliefs and metacognition (USEM) account of employability.²⁸ Arguably USEM itself was built on a career planning model,²⁹ which sought to develop decision learning, opportunity awareness, transition learning and self-awareness (DOTS). Recently there has been a move away from the USEM and DOTS models, articulating to students the value of experience, degree subject knowledge, generic skills, and emotional intelligence.³⁰ A QAA report on graduate skills¹ aligned with readiness for employment, lists 12 key skills which, based on reviews of the literature,^{31,32} synthesis of work from national enhancement themes,³³ and research on student and employer views on the skills gap,³⁴ are relevant today, see Table 1.

Science capital, and its potential influence on a student’s interest and engagement with the development of employability skills should also be considered. Science capital can be thought of as the interpretation of social and cultural concepts that influence a student’s academic performance and how this may lead to higher levels of engagement, achievement, and

Table 1. Summary of Required Graduate Skills¹

Type of Skill	Abbreviation ^a
Basic Professional Skills	
Communication	Com
Collaboration	Coll
Interpersonal/networking	IP/Net
Higher Level Cognitive Skills	
Critical Thinking	CT
Problem Solving	PS
Information Literacy/Analytical	IL/A
Curiosity to Learn	CtL
Innovative/Creative	I/C
Personal Skills	
Autonomy	Aut
Self-Management	SM
Resilience	R
Reflection/self-awareness	R/SA

^aAbbreviations of each skill set has been defined in this research and will be used in subsequent tables.

aspirations (attainment) in young learners.^{35,36} Further, a parent or guardian who works in a science-related job can also positively influence science aspirations and participation.³⁵ Science identity formation motivates young learners to engage positively with science³⁷ and it was noted that differing levels of parental involvement with boys and girls may result in a gender gap in science engagement³⁸ and that girls are likely to face greater challenges to science achievements than boys.³⁹ In a focused study on graduate employability in East Anglia, interconnected graduate identities were shown to include values, intellect, social engagement, and performance; interestingly graduate identity was subject to interpretation depending on the employer, sector, and size of the organization.⁴⁰

■ THE LEARNING ENVIRONMENT

In the Department of Pure and Applied Chemistry, at the University of Strathclyde, the importance of employability skills has long been recognized.^{18,20} There are opportunities to develop employability skills in all parts of a degree, including within practical and theoretical modules, and skills development has always been supplemented with bespoke employability training. In preparation for the academic year 2020–21, we sought to update this bespoke training to align with current best practice and replace some of the traditional peer interaction lost to the ongoing COVID-19 pandemic. Consequently, all incoming first year students experienced a new Graduate Employability and Skills Training (GEST) set of activities that ran throughout the full academic year, guided by a combination of independent learning, peer-working opportunities, and academic staff support. Activities were designed to develop the student graduate skills and competencies listed in Table 1.

The GEST was formally associated with a mandatory laboratory module, and it was necessary to pass the GEST to gain academic credits for the laboratory module, although GEST assignments themselves did not carry a mark. Engagement was a mandatory requirement to pass the GEST, so it was monitored by the student’s personal development adviser (PDA). In our department, students have the same PDA for their entire degree, and have reflective development meetings with them, so this role already supported employability and graduate attribute development.

Table 2. A Summary of the GEST: Semester 1 Assignments and Related Tasks

Assignment Topic	Brief Description of Assignment	Submission Type	Expected Skill Development
Assignment 1: weeks 0–1	Introduction to GEST peer group. Introducing effective learning strategies.	Powerpoint presentation (5 slides max). Reflections on key learning strategies (200–300 words).	Com, Coll, IP/Net, R/SA, CtL, I/C
Assignment 2: weeks 2–5	Understanding good academic practice and how to avoid academic dishonesty.	Reflect upon academic integrity and ways to ensure good practice—provide verbal feedback (approximately 5 min) to PDA.	Coll, CT, PS, R/SA
Assignment 3: weeks 6–8	Scientific writing and how to reference scientific work.	Review of literature (200–300 words). Powerpoint presentation (5 slides max).	Com, Coll, CT, IL/A, I/C
Assignment 4: weeks 9–10	Reflect upon the three activities undertaken so far.	Complete the skills and competency table in the training handbook (1–2 h)	R/SA

Table 3. A Summary of the GEST: Semester 2 Assignments and Related Tasks

Assignment Topic	Brief Description of Assignment	Submission Type	Expected Skill Development
Assignment 5: weeks 0–2	Reflecting on work, and other relevant, experience.	Re-evaluate the skills and competency table by adding relevant work-related skills (1–2 h).	IL/A, Com, IP/Net, Aut, SM, R/SA, PS
Assignment 6: weeks 3–5	Chemistry Careers: Diversity in Graduation Pathways. Reflecting on your career trajectory.	Create a mini job profile for a chemistry specific job (1–2 h). Create a mini job profile for a nonchemistry graduate job (1–2 h).	IL/A, CT, I/C
Assignment 7: weeks 6–8	Understanding professional registers and continuing professional development—reflecting on professional practice.	Start to complete the Registered Scientist (RSci) competency framework (2–5 h).	IL/A, CtL, R, R/SA, Com, Coll, CT
Assignment 8: weeks 9–10	Create a C.V. that incorporates the skills and competencies identified throughout the year 1 GEST.	Create a 2 page C.V. for a chemistry-related position (2–5 h)	I/C, Com, Coll, IL/A, R/SA

Within the rest of the year 1 curriculum, in addition to the practical module, students undertook 40 credits of chemistry theory, 20 credits of mathematics, a 20-credit science module in biology or physics and 20 credits of electives (chosen from modules across the University). It is notable that during the academic year 2020–21 students worked remotely in completing the GEST and across all theory-based modules. Students were only on campus for the delivery of practical laboratory training.

THE GEST ACTIVITIES

The GEST was designed as a series of activities to develop the graduate skills identified in the QAA “Focus On: Graduate Skills 2019” report,¹ appropriate to our UK HEI context. The GEST was introduced to the students by the Year Head who supplied the students with activity guidance material in the form of an employability handbook. Guidance was also provided to PDAs, including a staff version of the handbook which detailed activities, deadlines, and guidance on what to expect from submissions. Students and staff were introduced to a list of employability skills (Table S1) that should be developed during year 1 of their studies. Students were informed that participation in the GEST was mandatory and were sent targeted reminders of any missed activities or submissions and given the opportunity to complete missed assignments. The written and communication components were not marked, however (with guidance) PDAs provided formative feedback to students during dedicated meetings. To receive a pass for this part of the module students were required to complete at least 80% of the activities. At the start of academic year 2020–21, 116 students embarked on the GEST activities and all students passed this part of the module.

At the start of each semester, students were introduced to the employability handbook which presented a series of assignments, tasks and expected outcomes (see Tables 2 and 3). Students worked independently, or in groups of 3 or 4, reporting periodically to their PDA for general guidance and feedback. After tasks were completed, students received

formative feedback from their peers and/or PDA. The activities were designed to develop and/or enhance a range of employability skills and competencies which could be mapped onto specific tasks.

RESEARCH AIMS

Research suggests that undergraduate students do not identify with, or value the development of nondiscipline related skills.²³ In our chemistry programmes students recognize development of key skills through their engagement with the bespoke GEST, however, they are also expected to identify other opportunities for development in the rest of their discipline-based curriculum. As noted previously, students often struggle to recognize improvements in their own skills, both in bespoke employability work and across the rest of the program. It is within this context that we sought to evaluate the effectiveness of GEST activities for skills development compared with opportunities across the rest of the curriculum.

Obtaining objective measures of improvements in employability skills would require longitudinal studies of considerable duration to observe graduate outcomes. Consequently, the focus of this research was to evaluate students’ perceptions of their own employability skills development after completing their first year of study. It was of particular interest to compare the students’ perceptions of skills development in GEST versus the rest of their curriculum (termed REST).

These research interests allowed us to define the following research questions:

RQ 1A: To what extent did students engage with their studies when working almost entirely remotely during academic year 2020–21 in GEST vs REST?

RQ 1B: Did the peer group setup in GEST give students increased opportunities to connect while working remotely, compared to working independently through the rest of their curriculum?

RQ 2: Which employability skills did students identify with in year 1 of their studies? Of particular interest was

Table 4. Summary of Demographic Data Collected from 44 Participants of the Employability Survey

Student Groupings	Total (N)	Gender ^a	Low Socioeconomic Background	Mature Student
Students with no-little work experience—Group A	14	8 (W) 6 (M)	2 (W)	1 (W)
Students with a reasonable level of work experience—Group B	6	2 (W) 4 (M)	1 (M)	1 (W) 1 (M)
Students with high or significant work experience—Group C	24	20 (W) 4 (M)	3 (W)	3 (W) 1 (M)
Students with a graduate parent or guardian	26	14 (W) 12 (M)	2 (W) 1 (M)	2 (W) 2 (M)
Students a parent or guardian who did not attend university	18	16 (W) 2 (M)	3 (W)	3 (W)

^aWoman or transgender woman coded as W, man or transgender man coded as M.

an evaluation of any notable differences between the students' perception of skill development in basic professional skills, higher level cognitive skills or personal skills in GEST vs REST.

RESEARCH METHODOLOGY

Immediately after students completed their first year, they were invited to complete a survey to reflect upon their perceived impact of GEST and REST on their skills development (see Tables S1 and S2). Further details of GEST activities in semesters 1 and 2 are listed in Tables S3 and S4. The survey was a mix of Likert-scale and free-text questions (see Table S2 for questions) and was developed from a combination of previously cited literature and consideration of our research questions. Survey participants were provided with a privacy information statement and were required to give voluntary informed consent to begin the survey. No incentives were offered, and invitations were sent by a student intern to minimize any coercive power dynamics. Ethical approval was granted by the departmental ethics committee prior to release of the survey. Responses were allocated a unique code and anonymized at the point of data collection.

The employability survey was completed by 44 students (approximately 38% of the year 1 student cohort). Subgroups were created for participants based on gender, those who self-identified as a mature student,⁹ coming from a low socioeconomic background,⁶ or having a level of previous work experience. Groups were also created depending on whether the student had a parent or guardian who had previously graduated from university (Table 4). To evaluate responses, subgroups were assessed to provide median values, with responses over 3 taken as a positive response and an indication of a perceived skill development. To compare subgroups, median values were compared using the Mann–Whitney U test ($\alpha = 0.05$).

EDP led the thematic analysis^{41–43} on free text data, and themes and subthemes were interpreted independently by EDP FS and LGvM during and after identification as a form of verification. Themes attempted to answer the question 'What feeling, or response does this answer lead to?', by examination of expressions and keywords given in the free text. Themes were identified by the following observational techniques looking for repetitions, metaphors and analogies, similarities and differences, and linguistic connectors.

RESULTS AND DISCUSSION

Part A: General Interpretation of Employability Survey Responses, Including an Evaluation of Student Engagement and Community-Building Opportunities

Before assessing the development of individual skills, responses were compared for different groups to compare engagement with GEST versus the REST of the year 1 curriculum. The

mean and median responses are given in Table 5, with the *p*-value for the Mann–Whitney U-test ($\alpha = 0.05$). The

Table 5. Mean and Median Responses Used to Self-Assess Level of Engagement in GEST vs REST and Results of Significance Test (*p*-Value)

Student Cohort Group	Woman (<i>n</i> = 30)		Man (<i>n</i> = 14)		Mature Students (<i>n</i> = 9)	
	GEST	REST	GEST	REST	GEST	REST
Activity						
Mean	3.7	4.6	3.3	4.4	4.0	4.9
Median	4	5	3	4	4	5
<i>p</i> -Value	0.923		0.004		0.037	
Significant	No		Yes		Yes	

Student Cohort Group	Low socioeconomic background (<i>n</i> = 6)		Parent or guardian as a uni Graduate (<i>n</i> = 26)		No parent or guardian at university (<i>n</i> = 18)	
	GEST	REST	GEST	REST	GEST	REST
Activity						
Mean	4.3	5.0	3.5	4.5	3.7	4.6
Median	4.5	5	4	4.5	4	5
<i>p</i> -Value	0.174		0.0009		0.0135	
Significant	No		Yes		Yes	

Student Cohort Group	Work experience Group A (<i>n</i> = 14)		Work Experience Group B (<i>n</i> = 6)		Work Experience Group C (<i>n</i> = 24)	
	GEST	REST	GEST	REST	GEST	REST
Activity						
Mean	3.9	4.6	3.5	4.2	3.5	4.6
Median	4	5	3.5	4	4	5
<i>p</i> -Value	0.023		0.522		0.005	
Significant	Yes		No		Yes	

engagement of all student cohorts was shown to be positive, with all median (and mean) values for GEST and REST reported as >3.0 for every student cohort, with one exception: the median response for students who self-identified as a man was 3, indicating a neutral level of engagement with GEST.

Across the different subgroupings, in every case there was a higher level of engagement with the REST of the curriculum, which was not unexpected as the GEST activities only carried a nominal 5-credit weighting from the 120-credit year 1 curriculum. Using the Mann–Whitney U test ($\alpha = 0.05$) to compare responses given within each subgroup, levels of engagement with GEST versus REST were not found to be statistically significantly different for women, students from a low socioeconomic background, or those with a medium level of work experience. A significant difference was observed for men, mature students, and students with no-little or significant work experience, with these student cohorts reporting higher levels of engagement with REST.

Students were also asked to consider whether each GEST or REST provided opportunities to build support networks with peers. Students did not tend to agree that peer networking opportunities were provided, with most subgroups providing

Table 6. Median Values of Full Data Set in Response to Students' Perceived Development of Skills after Participation in GEST or in the REST of the Program

	Com	Coll	IP/Net	CT	PS	ILA	CtL	I/C	Aut	SM	Res	Ref/SA
GEST	3	3	3	3	3	3	3	3	4	4	3	3
REST	3	3	3	4	4	4	4	3	4	4	4	4

median values ≤ 3 , see Table S5. This was a surprising result since all assignments within GEST involved peer working.

Part B: Quantitative Evaluation of Likert Responses in Relation to the Development of Specific Skills in GEST vs REST

Students were asked rate their development of each of the 12 graduate skills (Tables S1 and S2) after participation in GEST and across the REST of the year 1 curriculum. The median values obtained for the full data set (Table 6) indicate that students identified autonomy and self-management skills in both GEST and REST, but additionally recognized critical thinking, problem solving, information literacy/analytical, curiosity to learn, resilience, reflection/self-awareness skills in the REST of their curriculum only. The full data set was then subgrouped into different student cohorts to determine any influence of background or experience on the collected data, with a visual representation of all responses given in Table S6.

Student Cohorts: Women/Men/Mature. Subgroups were created for students who self-identified as a woman, a man or a mature student. For the cohort of students identifying as a woman, there was an overall positive identification of skills development in year 1 (across GEST and REST for all 12 skills, Table S7). Women identified more strongly with the development of professional skills in the GEST, higher level cognitive skills in REST, with personal skills development opportunities being identified in both GEST and REST. Comparing median values for women between GEST and REST, differences were not statistically significant for professional skills, but they were statistically significant for higher level cognitive and most personal skills (Table S7) indicating a stronger sense of skills development across the REST of the curriculum for these skills. As shown visually in Table S6, students who identified as a man did not identify one positive skills development opportunity after engaging with GEST assignments, and only 5 skill development opportunities were identified across the rest of the curriculum. Comparing median values for men across all skills in GEST v's REST (Table S7), almost all median values were not found to be statistically significant, with one exception for problem solving which showed a higher positive association with REST. Mature students had an equally positive reflection of their skills development as women, with 11 of the 12 skills generating median response values greater than 3 in either GEST or REST (see visual representation in Table S6). Also, like the women subgroup, mature students associated skills development opportunities with the GEST assignments for professional and personal skills but mapped higher-level cognitive skills development opportunities only to REST. This subgroup also, similar to women, identified opportunities for higher level cognitive and personal skills development in REST however, differences between GEST and REST median values were not statistically significant for any skill (Table S7).

Student Cohorts: Socioeconomic/Graduate Parent or Guardian/No Graduate Parent or Guardian. Subgroups were created for students who self-identified as coming from a low socioeconomic background, and those with, or without, a

graduate parent or guardian. Students from a low socioeconomic background, saw high value in the GEST, identifying opportunities to develop across all three categories of skills, see visual representation in Table S6. Like other groups this student cohort identified with a higher number of development opportunities for higher level cognitive and personal skills with REST, with development of only one professional skill via REST. Interestingly, this one student cohort did not see development opportunities for collaborative or innovation/creative skills in either GEST or REST. Across GEST and REST these students saw opportunities to develop 10 out of the 12 skills listed with no significant difference between median scores given for skills development in GEST v's REST (Table S8). To assess the influence of science capital student responses were also sorted into subgroups of students who had a university graduate parent, guardian or carer, and those who did not. Looking at their perception of skills development, students with no graduate influence thought GEST provided opportunities to develop 7 of the 12 skills, mainly from the professional and personal skills categories, this was in stark contrast to students with a graduate influence who only thought self-management was developed during GEST (Table S6). Looking at the views of skills development in REST for students with or without a graduate influence, this time similar views were presented, with high level cognitive or personal skills being developed for both student cohorts. Comparison of median values from student cohorts with or without a graduate influence were often found to be statistically significant (Table S8) indicating a positive increase in skills development in REST compared with GEST.

Student Cohorts: Previous Level of Work Experience. Subgroups were also created to identify with a students' self-perceived level of previous employment experiences. Responses from students who identified as having no or little work experience were collated into Group A, students who reported as having some work experience, were Group B, and responses from students with significant or high levels of work experiments were collated into Group C. Looking at the responses for skills development through engagement with the GEST, a different pattern of responses emerged (Table S6). Students in Groups A, B or C reported development of 6, 1, or 3 skills, respectively in the GEST. It was of interest to note that the GEST responses for Groups A and C were similar, but quite different to the responses of Group B students. More specifically Group B students, those with some work experience, did not see any value in the GEST for skill development except for autonomy, and they thought the GEST had a negative impact on the development of most higher-level cognitive skills. A more positive set of responses was shown for these three student cohorts in REST with similar levels of appreciation of skills development in higher level cognitive and personal skills, however Group B only identified with the development of 4 skills compared to Groups A or C who reported development of 8 or 10 skills (Table S6). Indeed, Group B perceived there to be little-no skills development opportunities in year 1 of the chemistry program,

Table 7. Themes and Codes Identified from the Inductive Thematic Analysis of Free Text Response in Relation to the Students' Increased Appreciation of the Importance of Employability Skills after GEST

Themes	Codes	Representative Quotes
Reflective/Self-Awareness	• Skills acknowledgment	<i>The breakdown of skills that were needed (critical thinking, autonomy... etc.) was very handy as it showed us what employers were looking for (ESP16)</i>
	• Future Career Development/Enhancement	<i>The course also helped me to narrow down potential options for my future career, thus allowing me to develop and progress the skills I will have to possess in those particular job sectors (ESP26)</i>
	• CV Development	<i>I think if it hadn't made me think about employability, I would have found it difficult to perhaps build a CV in the future (ESP34)</i>
Engagement & Participation	• Online learning	<i>online zoom sessions [. . .] are more convenient than meetings in person (ESP1)</i>
	• Participation in learning	<i>It is useful in understanding and developing key skills for the future with peers (ESP8)</i>
	• Collaborative participation	<i>I enjoyed working with my group as it allowed me to interact with other people considering we've not had a lot of face-to-face interactions, it also helped when we had to go into laboratories with the same people. (ESP23)</i>
Self-Management	• Workload	<i>Did not really tell me anything new. Just increased workload when wanted to focus on the actual course (ESP20)</i>
		<i>Put this on the back-burner when there is a large workload... (ESP25)</i>

whether via GEST or REST. This may be due to the small sample size and nonrepresentative demographic. Comparison of median values for GEST v's REST were not statistically significant for most skills for students with no-little (Group A) or some (Group B) work experience, Table S9. However, the median values for Group C students had the most statistically significant differences between GEST and REST for median values across all student subgroups (followed closely by women), with all 9 cognitive and personal skills being higher in REST than GEST.

To assess the different GEST v's REST median responses for students with a significant-high level of work experience (Group C), responses were further subdivided to probe the influence of science capital on their evaluation of skills development. The median responses given in Table S10, indicate that students with no graduate parent or guardian, and a high level of previous work experience, identified development of 7 skills development opportunities in GEST. This contrasted with students with a high level of work experience and a graduate parent or guardian, who saw no skills development in GEST. Views on skills development in REST were more aligned with these two subgroups with a positive response indicating skills development opportunities for 9 or 10 skills for students with or without a graduate influence.

Part C: Results of Qualitative Data—Inductive Thematic Analysis

Three themes were identified from free-text comments (see Table 7). Themes, and the individual codes therein, were analyzed for subgroups of gender and work experience level (Tables S11 and S12)

Most comments (66 out of 90) belonged to the first main theme, relating to reflectiveness and self-awareness and with three codes (Table S12). 'Skills acknowledgment' refers to positive or negative students' perception of the GEST. 'Future Career Development/Enhancement' reported on the usefulness of GEST in making students think about their future career. 'CV Development' covered responses where the students recognized that GEST helped them (or not) write, rewrite, develop, or update their CV. Interestingly, there was an even distribution of responses regardless of prior work experience, with most comments acknowledging that the activities developed their skills, were relevant to their future careers, and enhanced opportunities for employment.

The theme 'Engagement & Participation' included three codes, although the overall number of comments received

was much lower; 22 in total. "Online learning" included all answers where students provided a positive or a negative feedback response to the experience of online learning. Students' answers reporting their engagement or evaluation of the courses were included in the code "Participation in Learning", whereas the positive or negative feedback on their experience working with their peers were reported under the code 'Collaborative Participation'.

The theme "Self-Management" included just one code, "Workload", and referred to just two responses concerning students' capability of managing the workload, as well as their evaluation of the work amount associated with GEST.

Comments were mainly positive with 76 out of 90 giving a positive evaluation across all 3 themes, compared to 14 negative evaluations. Under the theme of *Reflective/Self-Awareness*, evaluations were positive for Groups A and B with 25 or 7 positive evaluations: each group only contributing 1 negative evaluation each (online delivery for Group A and skills development for Group B). Out of the 32 comments provided by students with significant work experience (Group C), 4 were negative in relation to skills acknowledgment (2 comments), future career development (1 comment) and the online learning platform (1 comment). Students also presented positive and negative evaluations under the 'Engagement and Participation' and *Self-Management* themes; although overall the number of comments received were much lower than for the *Reflective/Self-Awareness* theme. For evaluations related to codes for participation and learning, 8 were positive and 4 were negative. A similar distribution was observed for the collaborative participation code with 7 positive and 3 negative evaluations. The authors acknowledge that one free-text question within the survey asked students to comment on their "increased appreciation of the importance of employability skills to your future employment as a consequence of participating in the year 1 GEST activities". The use of 'increased' within the question could potentially lead students to answer in a positive way about GEST, introducing bias. However, this wording was chosen in an effort to be transparent about the explicit and implicit communication that students received during the GEST program, which encouraged them to engage with the experience in order to gain a better understanding of the importance of employability skills. Moreover, as noted above, both positive and negative evaluations of the GEST were received in survey responses.

To summarize the thematic analysis, the amount of work experience did not appear to influence the students' perception

of the usefulness of the GEST, and the highest theme appearing in evaluations was that of *Reflective/Self-Awareness* with most responses mapping onto Skills Acknowledgment and Future Career Development/Enhancement codes, with 66 evaluations submitted of which 85% were positive.

CONCLUSIONS

In this study, we developed and evaluated graduate employability skills training (GEST) against the REST of the curriculum, to improve our first year chemistry undergraduate students' experiences and perceptions of these skills. Qualitative and quantitative evaluation of student survey responses provided the following general conclusions in relation to a student's perception of their skills development after engagement with the GEST, compared to the development of skills due to engagement of activities embedded across the REST of the year 1 curriculum.

In Research Question 1A, we set out to determine if students engaged with their studies while studying remotely, with particular interest in their perceptions of the GEST compared to REST. Self-reported engagement suggests that all student subgroups were able to engage positively with their studies to various extents, with slightly lower engagement reported by those who self-identified as a man. However, students, including all subgroups, reported better levels of engagement with the REST of the curriculum compared to the bespoke GEST set of activities. This is not unexpected given the much smaller credit weighting of GEST compared to the REST of the curriculum. It may also reflect students' preference for subject-specific content illustrating the need to communicate better about how GEST enhances employability skills.⁴⁴ The greater engagement of the students with REST vs GEST is also reinforced by the far fewer instances of comments in the thematic analysis aligned to the 'engagement and participation' theme, compared to "reflective/self-awareness". Indeed, the balance of more positively coded 'engagement and participation' theme statements is also aligned with the quantitative results.

Notably, students with no or limited work experience viewed the GEST program as containing more skills development opportunities, compared to those with moderate or higher levels of work experience. This may indicate that the GEST program is able to provide experiences for the no-limited work experience group that they are otherwise lacking in comparison to others. Moreover, the students with the highest level of previous work experience recognized significantly more skills development opportunities across the REST of year 1, and more when they did not have a university graduate as a parent/guardian. This aligns with observations of Bennett⁴⁵ noting that pre-entry work experience can lead to more confident self-perceptions of employability. Similarly, the highest scores for GEST are seen in the low socioeconomic background and mature student groups, perhaps suggesting that these groups are particularly benefiting from the GEST. Similarly, women and students with no-little work experience and no graduate parent or guardian, found high value in GEST for skills development. Skills development in REST was valued more highly by almost all student subgroups, the only exception being for mature students and those from a low socioeconomic background, who valued GEST and REST similarly.

In Research Question 1B, we asked if the emphasis of peer-engagement in GEST gave students increased opportunities to build support networks with peers while working remotely.

Previous work⁴⁶ suggests that it is crucial to develop social networking to support each other, particularly during the pandemic. Our results show that students did not perceive any peer networking opportunities in GEST or REST. The students were working almost entirely remotely due to COVID-19, so it is perhaps not a surprise to see they did not rate networking opportunities highly. However, it was disappointing to see that the group activities in GEST did not positively influence their rating of this question, even though the activities required multiple interactions with the same peer group. It may be that students desired, or needed, more networking opportunities than the GEST could provide. GEST may not have been sufficient to replace the peer networking opportunities of "normal" times, but students would likely have had fewer opportunities without it. Reasons for engagement and participation being a strong theme in the free text question together with collaborative participation is interesting and contrasts with quantitative peer-engagement findings. It may be that students reflected on their engagement with the exercises in the narrative but did not translate this activity to the term peer-engagement. That said, because of this research, future GEST will be transitioned back on campus rather than continuing as an online set of training activities.

In Research Question 2 we were interested in understanding to what extent year 1 students perceive employability skills development in GEST vs REST. Our results show that all student subgroups could positively identify skills development opportunities, either by participating in the bespoke GEST activities, or by engaging with activities embedded within the REST of the year 1 curriculum. However, there was significant variation across individual skills. These findings align with another study²³ where chemistry undergraduate students were able to recognize development of some key skills (e.g., teamwork, communication, thinking/problem solving, organization/time management) but not others (numeracy, independent learning, interpersonal, creativity/innovation and initiative). There may therefore be a requirement to develop methods to improve student's understanding of these skills in relation to their studies to allow them to articulate a better sense of personal and professional development to potential employers.

Subgroups that identified strong areas of skills development by participation in the GEST activities included women, mature students, students from a low socioeconomic background, and students with either no-little or significant work experience. Men did not identify any skills development anywhere in GEST, and student with some work experience only identified with the development of autonomy in GEST. This may be related to lower levels of engagement across the board, with both GEST and REST, compared to the woman and mature student cohorts (Table S5). This also aligns with the results of the qualitative analysis where overall, male participants mapped onto fewer themes and codes than for woman (Table S11).

Comparison of GEST and REST responses were not statistically significant for most subgroups, except for women and students with significant levels of work experience who perceive the REST of the degree to offer more opportunities for skills development than GEST. The similarity in subgroups can be attributed to demographic overlap; most students with high levels of work experience were women. For students with significant levels of work experience, it is reasonable to speculate that they perceived the REST of the degree more

useful in developing their skills as “generic” employability skills, otherwise developed through GEST, were already enhanced through employment. For most subgroups, as there was no statistically significant difference between GEST and REST, we conclude that both programmes are perceived to be similarly useful to developing students’ employability skills, but students consistently viewed skills development in REST higher than in GEST. Previous research indicates that the development of skills is most effective when it integrated into the curriculum.⁴⁷

We also observed that students with a graduate parent or guardian did not identify many skill development opportunities in the GEST activities but could see positive levels of skills development across the REST of the curriculum. This was not observed for students without a graduating parent or guardian, who perceived opportunities for skill development across both GEST and REST. It is possible that students with a graduate parent or guardian, and higher science capital, enter university with advanced employability skills due to an importance placed on these during upbringing. The advantages of not being the first in a family to enter higher education is well documented, and includes a greater appreciation of the wider academic environment, such as employability skills.⁴⁸

Overall, the research presented a potential benefit of a bespoke employability program, which may disproportionately benefit women students, mature students, those from a low socioeconomic background, or those less influenced by science capital. These results may also indicate that work experience is useful in helping students identify skills development opportunities across the curriculum.

■ LIMITATIONS

As with many chemistry education research studies, it is necessary to consider the generalizability of our findings. While the GEST could be used by others, it was specifically designed to articulate with the degree structure and content in the Department of Pure and Applied Chemistry at the University of Strathclyde and may therefore require modification to be appropriate. Indeed, since designing and analyzing the GEST’s effectiveness, as presented herein, the students are no longer working hybrid and are operating back on campus; working remotely may have influenced the findings on engagement and peer-networking.

Our findings are a direct result of the implementation of the GEST, and therefore may not be applicable to other contexts without a similar program. For example, to degrees where no dedicated employability skills modules are used, and instead these are embedded throughout a degree. Additionally, our findings are based on a relatively small number of students who participated in GEST, and completed the evaluation, and may therefore not be representative of a whole student cohort. For example, 55% of the target year group identified as a woman, but 68% of survey participants did. Subgroups had smaller numbers of responses and may not be representative of the full student cohort. That being said, the response rate was about 38%, which is a good participation rate for such studies.

Another consideration concerns our methodological approach, specifically using self-reported questionnaires that measure students’ perceptions rather than an objective measure. In particular, a student that has perceived an activity to have increased a particular employability skill has not necessarily had that employability skill improved.

Finally, as our findings include a demographic analysis, one must take care in generalizing to institutions that have a very

different demographic of students. We can have some confidence that findings are relevant to other Scottish HE institutions, and likely the wider UK, but beyond this may require further consideration of appropriateness.

■ IMPLICATIONS

There are several implications that are relevant for others who are considering developing employability skills within their curricula. Dedicated employability modules can be good and can complement the degree. Student perceptions may not be aligned with our own perceptions as module designers, and perhaps better communication is needed to convince some students of the usefulness of employability focused activities, in the cases where they fail to see their usefulness.

Unsurprisingly, we found that not all students perceive the usefulness of employability skills similarly, and that employability skills activities may be received differently by different groups of students. Students with advantageous backgrounds, such as having a high level of work experience, or a parent or guardian that is a university graduate, may not perceive employability skills activities as positively as others. Indeed, it may be valid to say that these groups of students benefit less from these activities if they already have well-developed employability skills when entering University. Therefore, educators who are designing employability skills activities may wish to focus on other, less advantaged, demographic groups and the disproportionate impact it may have.

■ ASSOCIATED CONTENT

SI Supporting Information

The Supporting Information is available at <https://pubs.acs.org/doi/10.1021/acs.jchemeduc.3c01287>.

Table S1: Ps developed through participation in GEST or REST, together with a short description of what the skill should allow the student to be able to do. Table S2: Lists the survey questions and gives a short description of each skill. Table S3: Provides further details of the GEST activities undertaken by students in semester 1. Table S4: Provides further details of the GEST activities undertaken by students in semester 2. Table S5: Presents the mean and median responses provided by students to self-assess their peer-support networks as a result of engagement in GEST vs REST. Table S6: Provides a pictorial representation of median responses for student cohort groups and their perception of skills development opportunities in GEST or REST. Table S7: Provides the median responses from students after they were subgrouped into those who identify as a woman, a man or a mature student. Student subgroups self-assessed their skills development after engagement with GEST and in the rest of their year 1 curriculum. Table S8: Provides the median responses from students identifying as coming from low-socio economic backgrounds, students with a graduate parent or guardian, and those whose parents or guardians are not graduates. Table S9: Presents the median responses from students after they were subgrouped into different levels of work experience, which they themselves self-assessed. Student subgroup A contained all responses from students who had no or little work experience. Student subgroup B identified as having some work experience and subgroup C assessed their prior work experience as significant or

high. Table S10: Presents data from students with a significant to high level of work experience after being further broken down into those students with a graduate parent or guardian or those without. Table S11: Summarizes the results of the thematic qualitative analysis and presents themes and codes for each participant based on their free text responses. Table S12: Looks at the distribution of themes and codes aligned with the students' self-assessed level of prior work experience (PDF, DOCX)

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Notes

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