IChemE

Major Hazards Committee

Assuring competence in process safety for chemical engineers

Final Report

September 2024: Version 2

ACKNOWLEDGMENTS

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GLOSSARY

AIChE – American Institute of Chemical Engineers

ACTS – Accredited Company Training Scheme

ALARP – As Low As Reasonably Practicable

CDOIF – Chemical and Downstream Oil Industry Forum

CIA – Chemical Industries Association

CIEHF – Chartered Institute of Ergonomics and Human Factors

EAF – Education Accreditation Forum

EdSIG – Education Special Interest Group

EPC – Error Producing Condition

FMEA – Failure Modes and Effects Analysis

HazOp – Hazard and Operability study

HCEUK – Heads of Chemical Engineering United Kingdom

HF – Human Factors

IAEA – International Atomic Energy Authority

ISC – IChemE Safety Centre

LPB – Loss Prevention Bulletin

MHC – Major Hazards Committee

NTS – Non Technical Skills

PDCA – Plan, Do, Check, Act

PEI – Professional Engineering Institution

PIF – Performance Influencing Factor

PFF – Professional Formation Forum

PPSE – Professional Process Safety Engineer

PS – Process Safety

PSEP – Process Safety and Environmental Protection

PSF – Process Safety Forum

PSMS – Process Safety Management System

PTW – Permit to Work

S&LP SIG – Safety and Loss Prevention Special Interest Group

SFAIRP – So Far As Is Reasonably Practicable

TSA – Tank Storage Association

1. EXECUTIVE SUMMARY

Major Hazards is a priority topic for IChemE and the Major Hazards Committee (MHC) is the volunteer body that leads major hazards activities within IChemE. The MHC was established in 2020 and brings together the various IChemE major hazards groups:

- S&LP SIG
- LPB
- PSEP
- Hazards
- ISC

The MHC's vision is that:

IChemE is a peer group leader for major hazards management, sharing our knowledge in this area and learning from others

https://www.icheme.org/sustainable-world/priority-topics/major-hazards-management/process-safety-statement/

After developing and agreeing a strategy and mapping the constituent group activities to this strategy, the MHC selected two projects as the initial focus:

- Process Safety Competence
- Lessons Learned

There are three parts to the MHC Process Safety (PS) Competence Project:

- Part 1 – Assuring Competence in Process Safety for Chemical Engineers
- Part 2 – Assuring Competence in Process Safety for Process Safety Professionals
- Part 3 – Organisational Process Safety Competence

This report and the work so far, has been focussed on Part 1 of the project:

- Assuring Competence in Process Safety for Chemical Engineers

Figure 1 provides an overall summary of the project aims /objectives, activities, findings and recommendations.

Aims /Objectives	Project Activities	Findings	Recommendations
Conduct a review of IChemE's activities in building competence in Process Safety (PS) though an individual's professional lifecycle	• Develop career phase journey maps • IChemE member survey • Hazards 22 discussion • IChemE data analysis • Review and comparison with other competence frameworks and approaches • Review of IChemE networks and member engagement	• Career phase journey map summarise pathways available to chemical engineers to develop and assure PS competence • Need to provide a competence framework for the whole career of a chemical engineer • Key role for IChemE via professional networks, member engagement and support	2.1 Develop and provide a competence framework for the whole career of a chemical engineer that incorporates PS competence standards 4.1 **Vocational:** Improve promotion of the Engineering Technician membership grade **Undergraduate** 5.1 Make FOPs training materials available 5.2 Embed the ISC recommended learning outcomes in PS education 5.3 Provide opportunities for practical, experiential learning (e.g. as a summer school) at a facility /facilities such as CATCH 5.4 Increase and improve IChemE member involvement in undergraduate PS teaching 6.1 **Fellow:** Review and revise Fellow competence standard to include defined competencies relevant to process safety including Non-Technical Skills (NTS). Require competence demonstration.
Determine ***'What Process Safety Competence looks like?'*** for Chemical Engineers, covering the subjects and level of competence required including: • Reviewing existing documentation including work by IChemE such as the IChemE Safety Centre (ISC) and others such as the Chemical Industries Association (CIA) • Reviewing what the accepted definition of competence is, including the focus on learning outcomes to be demonstrated	• Document review: • IChemE competence standards and guidance • ISC outputs • Background info and references • IChemE internal and external stakeholder engagement • IChemE member survey • IChemE data analysis • Review and comparison with other competence frameworks and approaches • Evaluation of contribution of Technical Skills and Knowledge and Non Technical Skills	• Process Safety is core to Chemical Engineering • Need to review, evaluate and understand the relationship of PS to and within Chemical Engineering • Table 6 summarises IChemE competence standards and guidance with respect to PS • Need to clarify the PS competence standard applicable for a particular individual at a particular career phase • Need to improve availability and flexibility of pathways to PS competence development and assurance for chemical engineers	1.1 Review, evaluate and understand relationship of PS to and within chemical engineering 1.2 Feed forward into Part 2 of the project: Assuring Competence in Process Safety for Process Safety Professionals, consideration of the different varieties of PS professional 2.2 IChemE's PS competence standards should include sufficient overlap between chemical engineering and PS competencies demonstrating understanding and application 2.3 Ensure that the developed competence framework provides adequate pathways to PS competence development and assurance for chemical engineers
Make recommendations on any changes needed to improve effectiveness	• Stakeholder engagement throughout to elicit improvement suggestions, test, develop and refine recommendations • Interim report recommendations shared and discussed with IChemE internal and external stakeholders	• Need to combine a whole career approach to chemical engineering PS competence, including specialisation, with a set of overarching PS competences • Five cross cutting themes identified and improvements for specific career phases	3.1 Review how IChemE facilitates professional networks for individual members and opportunities to increase the span and improve the quality of engagement 3.2 Review IChemE participation and leverage within wider networks 3.3 Review how resources provided by IChemE online could be consolidated and organised more by potential user group and service / resource offering

Figure 1 – Overall Summary of Project Aims and Objectives, Activities, Findings and Recommendations

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1.1 INTRODUCTION

Aims and objectives for Part 1 of the project are to develop a 'route map' for process safety competence over the full lifecycle of a chemical engineer:

- To conduct a review of IChemE's activities in building competence in Process Safety (PS) though an individual's professional lifecycle
- To determine ***'What Process Safety Competence looks like?'*** for Chemical Engineers, covering the subjects and level of competence required including:
    - Reviewing existing documentation including work by IChemE such as the IChemE Safety Centre (ISC) and others such as the Chemical Industries Association (CIA)
    - Reviewing what the accepted definition of competence is, including the focus on learning outcomes to be demonstrated
- The project should include, but not be restricted to training and assessment for: undergraduates, graduates /postgraduates and in house accredited schemes provided by IChemE and others
    - This focusses on the demonstration of competence, not just assessment of training
- To make recommendations on any changes needed to improve effectiveness

1.2 APPROACH

The project has been undertaken by a Working Group (WG) of volunteers in conjunction with a Peer Review Group of volunteers. The project has been led and co-ordinated by two Co-Chairs.

The definition of competence agreed and used for the project is the definition provided by the International Atomic Energy Authority (IAEA) in their 1996 publication[1], with emphasis added:

'The **ability** to put **skills** and **knowledge** into **practice** in order to perform a job in an **effective** and **efficient** manner to an **established standard.'**

The project has mapped user experience using the tool of journey maps and the free online software version of Miro.

A journey map is a visualisation of the process that a person goes through in order to accomplish a goal.

The overall goal for the 'user' (a chemical engineer) in Part 1 of the project was defined as:

A chemical engineer that develops and maintains their process competence to defined standards throughout their career.

The career of a chemical engineer was defined by the following phases:

- Undergraduate
- Postgraduate
- Early career professional
- Vocational (at or equivalent to Engineering Technician)
- Mid-career professional (at or equivalent to Chartered Engineer)
- Late career professional (at or equivalent to Fellow or a deep subject specialist)
- Partially /actively retired professional

A journey map has been developed for each phase covering the start, middle and end of that phase. The structure for each phase includes:

- Expectations and goals (what an individual wants to achieve)
- User mindsets, actions and emotions (by individual)
- Opportunities, insights, inputs, measurements /assessments (the offering from e.g. academic institution, professional institution, employer, volunteering)
- Process Safety competence standard
- Influencing factors

The journey map development has considered how the journey may differ for different users including:

- Geography
- Social /academic /professional background
- Entry point and accessibility
- Incomplete and broken up journeys
- Macro-economic, technological and societal change

The key parallel activity to journey map development has been stakeholder engagement internal and external to IChemE in various forms. This has been used to inform journey map development, identify, explore and develop ideas within the project and for recommendations as outputs.

Background information and relevant good practice references have been used to support journey map development.

Table 1 summarises the stakeholder engagement conducted during Part 1 of the project.

Table 1 – Summary of Stakeholder Engagement

IChemE	External to IChemE
Major Hazards Committee– Ongoing engagement	Other Engineering and Wider Professions (e.g. CIEHF) – Ongoing engagement
Safety and Loss Prevention Special Interest Group – Ongoing engagement	Regulatory Authorities – Ongoing engagement
Education Special Interest Group – Ongoing engagement. Potential future webinar?	Process Safety Forum to include Trade Associations such as CIA – Ongoing engagement
IChemE Safety Centre – Ongoing engagement via Trish Kerin	Accredited Universities – Ongoing engagement
Professional Formation Forum (includes ACTS) – Ongoing engagement	Hazards Forum to include other PEIs – Ongoing engagement
Education Accreditation Forum (includes curriculum content) – Ongoing engagement	Cogent Skills Process Safety Management Competence Programme Board – Ongoing engagement
Qualifications Committee – Ongoing engagement via Director of Qualifications	Energy Institute Process Safety Committee – Ongoing engagement

IChemE	External to IChemE
IChemE Training department – Ongoing engagement	

There have been multiple activities and sources of data and knowledge elicitation throughout Part 1 of the project including:

- IChemE Competence Standards
- ISC Outputs
- S&LP SIG University Process Safety Workshops
- Background information and references
- Career Phase Tables and Journey Maps
- Working Group members
- Peer Review Group members
- Previous IChemE activities
- IChemE stakeholder
- External to IChemE stakeholders
- S&LP SIG Newsletter
- Hazards 32 discussion session
- IChemE Membership data
- IChemE Member survey
- IChemE Process Safety Training Course data

1.3 FINDINGS

Table 6 in Section 4.1 summarises IChemE process safety competence standard requirements and guidance.

The career phase journey maps as at the end of September 2023 are included in Appendix C.

There has been significant effort to populate these maps by WG members who represent all career phases and multiple industry /academic sectors and geographic locations. Therefore, they are considered to be a valuable and informative snapshot of how IChemE members view the career journey of a chemical engineer and how process safety competence is developed, retained and assured.

Figure 2 shows an overall journey map for a chemical engineer which summarises the content of the individual career phase journey maps.

IChemE's Director of Qualifications shared several data sources with the project including 2022 membership data. Please see Section 4.4.1 for the following Figures.

Figure 6 shows 2022 IChemE membership data broken down by grade. It shows that Chartered Member (29.1%) is the largest membership grade category, followed closely by Associate Member (28.9%) then Affiliate Member (16.5%), Student Member (15.7%) and Fellow (8.9%) grades.

Figure 7 shows 2022 IChemE membership data broken down by country. It shows that the UK is by far the largest source of members and accounts for 64.5% of all IChemE members. The next largest source of members is Malaysia (8.1%), followed by Australia (7.5%) then Ireland (3.7%). All other countries contribute less than one thousand members each.

Figure 8 shows 2022 IChemE membership grades by age and illustrates that there is an overall journey, which transitions from Student Member to Associate Member to Chartered Member to Fellow as age increases.

For time taken from Graduation to Chartership, Table 7 in Section 4.4.2 indicates a typical elapsed time of between 5 and 8 years for the ‘Early Career Professional’ phase between graduation and chartership for all members.

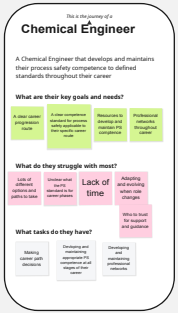
As an input to the Hazards 32 discussion session, a brief survey of IChemE member involvement in process safety education was conducted via HCEUK. 12 replies were received from the 31 Colleges and Universities.

The following thoughts arose from the above survey responses and were presented at Hazards 32:

- There is a clear appetite for member involvement in teaching Process Safety to undergraduates – about half of Departments use members currently.
- The S&LP SIG University Process Safety Workshop seems to be well regarded – but only available in London (as of 2022)
    - Possibility of further content review to provide an IChemE resource
    - Find members across the UK to deliver – Local Member groups?
    - Use it virtually, as well as in person?
- Use Imperial's self-assessment against the IChemE accreditation requirements to identify other areas where members could help? [This refers to a paper[3] by Chris Tighe from Imperial and the Supplementary Information in particular, which contains a gap analysis of the Imperial Safety and Loss Prevention Module against the IChemE accreditation requirements and the ISC recommended learning outcomes in process safety education.]

The discussion session had the following output:

- Very high level of interest in process safety competence for chemical engineering undergraduates
- High level of engagement during 45 mins long discussion
- Multiple volunteers for getting involved
- Students and recent graduates appeared to feel that they developed limited PS competence during their academic studies
    - Instead, the bulk was developed during placement /post-graduation work experience
- Students appeared to be unsure what the benefit of IChemE membership was
- Students and tutors present considered that more practical PS content earlier would be beneficial
- Barriers
    - Available time in undergraduate academic programme
    - Exam and results pressure on students and tutors
    - Reduced availability and take up of industrial placements
    - Academic tutor industry experience?
- Options
    - Summer placements
    - 'Summer school' opportunities
    - Increased IChemE visibility to encourage early engagement
    - Increased connections and interactions between members and chem eng departments
- Multiple additional volunteers for survey completion
- Request for personal mentoring



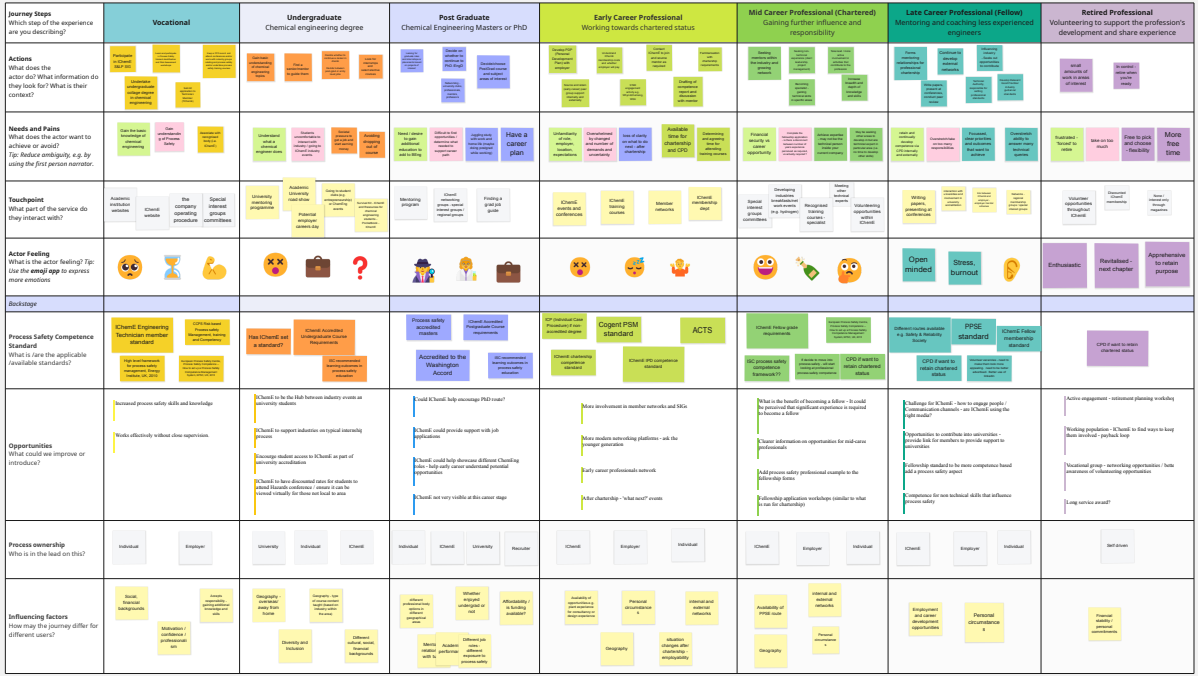


Figure 2 – Overall High Level Journey Map for a Chemical Engineer Developing and Maintaining Process Safety Competence

- Follow-up discussions with multiple placement students and graduates and mid and late career professionals

Therefore, the Hazards 32 discussion session provided valuable input to the project and enabled further exploration of the Undergraduate Career phase with a much wider audience.

IChemE stakeholders (staff and volunteers) approached by the project have been highly supportive and generous with their time, ideas and information. The emerging findings and outputs have been welcomed and often corroborate findings from other activities.

External stakeholders approached by the project have been very interested in hearing about the objectives and approach and are keen to receive updates on project recommendations and outputs.

Both the above experiences have reinforced the importance of stakeholder engagement throughout the project to maximise relevance and benefits from recommendations and outputs.

The process safety competence survey of the IChemE membership had 492 respondents. The majority (83.3%) classified their career phase as mid or late career. Comparison of the survey respondents characteristics and the 2022 full IChemE membership data demonstrates reasonable overall agreement in terms of the distributions of membership grade and geographical location.

Section 4.7 presents the member survey findings as charts, summarised responses and data analysis. The detailed survey responses are included in Appendix D.

Several survey question responses (4, 14, 15) indicated that there is a need to improve the perceived availability of PS competence standards for all career phases and this provides an opportunity for IChemE to better support members.

There were several hundred further comments provided at the end of the survey and some recurring themes are summarised below:

- There is an overlap and a difference between professional chemical engineers and process safety professionals, it would be beneficial to understand the relationship better.
- There is very wide variability in the mix of process safety competences required by different roles and sectors and therefore any competence standards need to be sufficiently flexible.
- It would be beneficial for IChemE to provide more support and guidance on alternative potential career pathways with process safety competencies and training suggestions indicated.
- Undergraduate chemical engineering courses could improve and strengthen process safety content, engage more industry professionals to provide practical content and go beyond HAZOP.
- Availability and dissemination of incident investigation reports, case studies and lessons learned.
- IChemE providing /signposting access to other PS resources such as AIChE and CCPS.
- Concerns about deterioration in PS competence of chemical engineers and process safety professionals.
- Making Professional Process Safety Engineer (PPSE) registration available again including to non-chemical engineers.

IChemE Training provided data for process safety training course attendance between 2019 and 2022. IChemE Training identified the courses they regard as process safety training. Five years data was requested, however IChemE Training did not have confidence in data held beyond the previous three years. Section 4.8 presents the IChemE process safety training data analysis in several charts. Please see Section 4.8 for the charts referenced below.

Figure 14 shows attendance by Membership grade (for IChemE member attendance) and illustrates that 55% of IChemE members attending IChemE PS training course are Associate Members (versus 28.9% of IChemE 2022 membership being Associate Members), which would be expected as they work towards chartership. Chartered members make up the next largest group at 32% (versus 29.1% of IChemE membership being Chartered Members). It should be noted that for 2019 to 2022, 48% attendees of IChemE PS training courses were IChemE members and 52% were non-members.

Figure 15 shows the split of member /non-member attendance by PS training course. The five most popular courses were:

1. LOPA
2. Fundamentals of Process Safety
3. HAZOP Leadership and Management
4. Human Factors in the Chemical and Process Industries
5. HAZOP Study for Team Leaders and Team Members.

The combined numbers for the two HAZOP training courses make it the most popular subject during 2019 to 2022. All other PS training courses had <100 attendees between 2019 and 2022.

Figure 16 shows the split between IChemE members and non members by IChemE PS training course compared with the overall split of 48% member and 52% non member. Figure 15 shows that there is a wide variation either side of the overall split of 48% /52% for different IChemE PS training courses. This may be an indication of which courses are considered core to chemical engineers and process safety professionals (high member attendance) versus courses not considered core to either group (high non member attendance).

The two PS training courses with highest relative member attendance were Inherent Safety in Design and Operation Development (attendance 94.1% members) and Quantified Risk Analysis (attendance 92.3% members).

The two PS training courses with highest relative non member attendance were Process Safety Leadership and Culture (attendance 77.1% non members) and Hazard Identification Techniques (attendance 70.7% non members).

Figure 17 shows IChemE PS training course member attendance by location during 2019 to 2022. 68% of members attending were UK based (versus 64.5% of IChemE 2022 membership being UK based), 13% Europe based (versus 6.6% of IChemE 2022 membership being Europe based (outside UK), 5% Australasia (versus 9.2% of IChemE 2022 membership being Australia /New Zealand based) and 5% Middle East (versus 2.1% of IChemE 2022 membership being Middle East based).

The project Interim Report was shared widely and discussed as far as practicable with IChemE and non IChemE stakeholders. Section 4.9 summarises the verbal and written feedback and comments provided. The overall feedback from all stakeholders was strongly supportive of the approach and emerging findings and recommendations with further suggestions and insights provided.

1.4 DISCUSSION

The member survey results combined with the wider findings from Part 1 of this project support the conclusion that:

Process Safety is core to Chemical Engineering.

Therefore, if the above conclusion is true then it is key for IChemE to provide leadership.

IChemE resource constraints are recognised by the project, therefore it is necessary to determine how to facilitate improvement by harnessing and organising all available resources, relationships and networks efficiently and effectively.

Five cross cutting themes which apply to all career phases and can assist IChemE in providing leadership are:

1. The need to review, evaluate and understand the relationship of PS to and within chemical engineering
2. Provision of a competence framework for the whole career of a chemical engineer
    a) Recognising that there are many pathways and the framework must be have adequate breadth and depth
    b) Facilitating and supporting the overlap /crossover and pathways between chemical engineering and process safety
    c) Recognising that PS is a very broad topic and can be studied in depth for life, in many different ways
    d) A framework that is capable of being applied to recognise depth and PS specialisation as well as broader contribution via being a chemical /process engineer or being a manager /director of process safety /HSSE /Operations /Engineering /Company /Regulator.
3. What is the PS competence standard applicable for a particular individual at a particular career phase?
    a) Where is it defined?
    b) How is it communicated?
    c) How does it evolve and adapt?
    d) Use whole career competence framework to address gaps and inconsistencies
4. Are the pathways to PS competence development and assurance for chemical engineers adequate?
    a) Balance of theoretical and practical (experiential and applied) learning and assessment
    b) Technical and Non Technical Skills
    c) How do pathways evolve and adapt?
    d) Use whole career competence framework to address gaps and inconsistencies
5. Professional networks and member engagement and support
    a) Role of IChemE
    b) Role of IChemE members
    c) Role of Universities
    d) Role of employers
    e) Role of Industry and Professional Forums
    f) How can IChemE improve effectiveness for all members?

Figure 3 provides a summary illustration of the various pathway options during a Chemical Engineer's career. It is recommended that a competence framework is developed that is sufficiently flexible to be applied throughout. Guidance and support should guide IChemE members to the appropriate career phase as AIChE and CIEHF competence frameworks do. Individuals may leave and return to chemical engineering throughout their career for professional or personal reasons. IChemE's competence framework should support individuals to refresh and re-establish their competence. Similarly, individuals who choose to specialise, start a business or change their employer /sector /role should be able to access guidance and support which enables them to develop /retain appropriate PS competence.

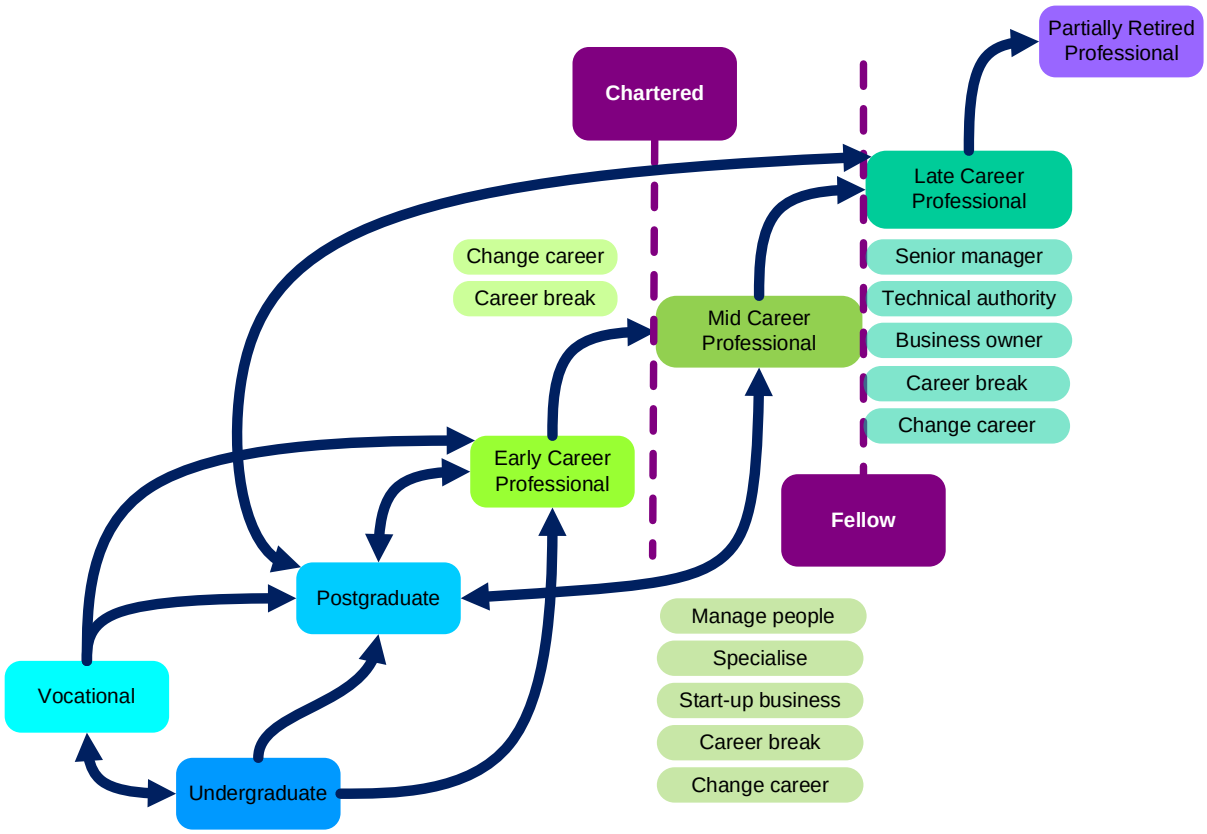


Figure 3 – Summary Illustration of the Various Pathway Options During a Chemical Engineer's Career

It is suggested that IChemE could learn from other professional institutions such as CIEHF to develop a whole career competence framework that can be applied to all membership grades and with reference to PS competence standards available inside IChemE and external to IChemE such as AIChE /CCPS.

Combining a whole career approach to chemical engineering process safety competence, including specialisation, with a suitable overarching set of PS competencies could greatly simplify, streamline and make more accessible the defined competence standard for each career phase and individual members. The development of such a career competence framework and incorporating content from existing IChemE and external competence standards would enable provision and application of clear competence standards for all career phases and career pathways.

The project so far has highlighted two career phases in particular that could benefit from further strengthening of arrangements for competence development and assurance:

- Undergraduate

- Late career professional

The vocational IChemE route currently has limited use, there were 38 Technician Members in 2022. This could be a growth area for IChemE and for developing and assuring process safety competence within industry via IChemE interactions and engagement.

The three career phases above are discussed within Section 5.4.

The career phase that appears to be the best defined, understood in terms of process safety competence standard and the means to achieve it; is the early career professional. The goal of chartership provides clear requirements and also guidance on how to achieve them.

1.5 RECOMMENDATIONS

Recommendations from Part 1 of the Project are summarised in Table 2 by Theme or Career Phase.

Following conclusion of Part 1, it is intended to agree the basis for Part 2 – Assuring Competence in Process Safety for Process Safety Professionals and for Part 3 (Organisational Process Safety Competence) to follow on from conclusion of Part 2.

Table 2 – Summary of Recommendations from Part 1 of the Process Safety Competence Project

Ref.	Theme /Career Phase	Recommendation
1.	**Relationship between chemical engineering and process safety**	
1.1		Review, evaluate and understand relationship of process safety to and within chemical engineering e.g. by mapping knowledge, skills and behaviours
1.2		Feed forward into Part 2 of the project: Assuring Competence in Process Safety for Process Safety Professionals, consideration of the different varieties (flavours) of process safety professional dependent on their background discipline and professional development pathway.
2.	**Chemical Engineer career competence framework and competence standards**	
2.1		Develop and provide a competence framework for the whole career of a chemical engineer that incorporates process safety competence standards: a) Utilising assessment of breadth and depth of competencies b) Facilitating and supporting the overlap /crossover and pathways between chemical engineering and process safety c) Recognising the breadth and depth available in process safety and chemical engineering d) Capable of being applied to recognise depth and process safety specialisation as well as broader contribution via being a chemical /process engineer or being a manager /director of process safety /HSSE /Operations /Engineering /Company /Regulator e) Utilise examples from other professional bodies such as CIEHF
2.2		Review the process safety content of chemical engineer career phase competence standards using existing IChemE competence standards and guidance and relevant competence standards external to IChemE

Ref.	Theme /Career Phase	Recommendation
		IChemE's process safety competence standard should include sufficient overlap between chemical engineering and process safety competencies demonstrating understanding and application in topics such as: a) Design Envelope (Basis of Design) b) Safe Operating Envelope (Basis of Safety) c) Inherent safety design principles d) Chemical, physical, toxicological properties and how they relate to process hazards e) Chemical reaction hazards f) Overpressure and underpressure hazards g) High and low temperature hazards h) Material and substance compatibility i) Hazards arising from particular unit operations, substances and process /plant equipment j) Benefits and limitations of alternative protective measures in terms of engineering attributes and considerations k) Engineering substantiation of processes, equipment and protective measures.
2.3		Ensure that the developed competence framework provides adequate pathways to process safety competence development and assurance for chemical engineers including: a) Balance of theoretical and practical (experiential and applied) learning and assessment b) Technical and Non Technical Skills c) The flexibility to allow pathways evolve and adapt
3	**Professional networks, Member engagement and support**	
3.1		Review how IChemE facilitates professional networks for individual members and opportunities to increase the span and improve the quality of engagement. This recommendation is expected to tie into ongoing work by IChemE on member engagement.
3.2		Review IChemE participation and leverage within wider networks such as the Hazards Forum, PSF and CDOIF and the extent and quality of links into the wider membership communities and membership.
3.3		Review how resources provided by IChemE online could be consolidated and organised more by potential user group and service /resource offering to aid navigation and increase access and application by the membership. Utilise examples and learning from other professional bodies e.g. AIChE
3.4		Contribute to Hazards Forum Group of Interest 2 (Engineering Systems Hazards) including an event on NTS in 2023 and on the new Building Safety Regulator in 2024. Note: this is progress as an outcome of this project.
4	**Vocational**	
4.1		Review priority and approach to IChemE support and promotion of the Engineering Technician membership grade within the vocational career

Ref.	Theme /Career Phase	Recommendation
		phase. In particular all Level 3 Science Manufacturing Technician UK Apprenticeships and Professional Qualifications.
5	**Undergraduate (and Postgraduate)**	
5.1		Make the training materials of the IChemE Training Course Fundamentals of Process Safety (FOPS) available to institutions offering IChemE accredited chemical engineering undergraduate and postgraduate courses
5.2		Embed the ISC recommended learning outcomes in process safety education (ISC, 2018) within IChemE accredited undergraduate and postgraduate courses. It is recommended that institutions undertake a gap analysis similar to Imperial's as the first step[3].
5.3		IChemE to work with internal and external stakeholders to: a) Identify available facilities and delivery methods b) Develop and c) Provide opportunities for practical, experiential learning (e.g. as a summer school) at a facility /facilities such as CATCH (expanding and scaling the initiative already introduced by Leeds University and similar to the civil engineering /built environment initiative at Constructionarium). This initiative has the potential to: • Improve IChemE engagement amongst the student population • Provide a wide range of opportunities for developing and improving practical chemical engineering and process safety knowledge and skills • Provide an opportunity for engaging with potential employers who may sponsor such an initiative • Provide an opportunity for interacting with other engineering disciplines
5.4		Increase and improve IChemE member involvement in undergraduate process safety teaching (e.g. via recommendation 5.3 and 5.5) and experience provision (e.g. year or summer placements). Volunteer recognition by IChemE is recommended to facilitate increased and wider member engagement. The recent (December 2023) IChemE Volunteer digital badge scheme was a good initial step.
5.5		Increase S&LP SIG University Process Safety Workshops in the UK and internationally. There were two additional institutions (to the three existing London institutions) in 2023: • UAE • Lancaster
6	**Fellow**	
6.1		Review and revise Fellow competence standard to include defined competencies relevant to process safety including Non-Technical Skills (NTS) e.g. process safety leadership, coaching and mentoring of undergraduates, early and mid-career professionals as well as technical process safety knowledge, understanding and skills. The Fellow

Ref.	Theme /Career Phase	Recommendation
		application process should require demonstration of meeting the required competence standard. a) It is recommended that it is a flexible competence framework, with respect to breadth and depth, that can be applied to the very wide range of roles that apply to become a Fellow of IChemE. b) Utilise examples and learning from other professional bodies e.g. CIEHF, AIChE

2. INTRODUCTION

2.1. BACKGROUND

Major Hazards is a priority topic for IChemE and the Major Hazards Committee (MHC) is the volunteer body that leads major hazards activities within IChemE. The MHC was established in 2020 and brings together the various IChemE major hazards groups:

- S&LP SIG
- LPB
- PSEP
- Hazards
- ISC

The MHC's vision is that:

IChemE is a peer group leader for major hazards management, sharing our knowledge in this area and learning from others

https://www.icheme.org/knowledge/priority-topics/major-hazards-management/

After developing and agreeing a strategy and mapping the constituent group activities to this strategy, the MHC selected two projects as the initial focus:

- Process Safety Competence
- Lessons Learned

There are three parts to the MHC Process Safety (PS) Competence Project:

- Part 1 – Assuring Competence in Process Safety for Chemical Engineers
- Part 2 – Assuring Competence in Process Safety for Process Safety Professionals
- Part 3 – Organisational Process Safety Competence

This report is the final report for Part 1 of the MHC PS Competence Project.

2.2. SCOPE

This report and the work so far, has been focussed on Part 1 of the project:

- Assuring Competence in Process Safety for Chemical Engineers.

2.3. AIMS AND OBJECTIVES

Aims and objectives for Part 1 of the project are to develop a 'route map' for process safety competence over the full lifecycle of a chemical engineer:

- To conduct a review of IChemE's activities in building competence in Process Safety (PS) though an individual's professional lifecycle
- To determine ***'What Process Safety Competence looks like?'*** for Chemical Engineers, covering the subjects and level of competence required including:
    - Reviewing existing documentation including work by IChemE such as the IChemE Safety Centre (ISC) and others such as the Chemical Industries Association (CIA)
    - Reviewing what the accepted definition of competence is, including the focus on learning outcomes to be demonstrated
- The project should include, but not be restricted to training and assessment for: undergraduates, graduates /postgraduates and in house accredited schemes provided by IChemE and others

    - This focusses on the demonstration of competence, not just assessment of training
- To make recommendations on any changes needed to improve effectiveness

3. APPROACH

The project has been undertaken by a Working Group (WG) of volunteers in conjunction with a Peer Review Group of volunteers. The project has been led and co-ordinated by two Co-Chairs.

The project ways of working were discussed and agreed in the WG kick off meeting of 26 November 2021:

- Collaboration by all and mutual support
- Listen to each other and develop shared understanding and perspectives
- Organic and fluid approach to progressing project activities in between and during meetings
- Group purpose is to question, challenge and explore – each other and the status quo
- Use of sub-groups for activities as required and agreed
- No agenda, no minutes, no action register – we will capture agreed actions within the meeting slides as they are raised and review at the end
- Use of MS Teams collaborative tools and for document holding and sharing

3.1 METHODOLOGY

3.1.1 Competence Definition

The definition of competence agreed and used for the project is the definition provided by the International Atomic Energy Authority (IAEA) in their 1996 publication[1], with emphasis added:

'The **ability** to put **skills** and **knowledge** into **practice** in order to perform a job in an **effective** and **efficient** manner to an **established standard.'**

The same IAEA publication defined competency as:

'A group of related knowledge, skills and attitudes needed to perform a particular job.'

The IAEA refined their definition of competence (competency) in their 2006 publication[2]:

'(1) The ability to put skills, knowledge and attitudes into practice in order to perform activities or a job in an effective and efficient manner within an occupation or job position to identified standards.

(2) A combination of knowledge, skills and attitudes in a particular field, which, when acquired, allows a person to perform a job or task to identified standards. Competence (competency) may be developed through a combination of education, experience and training.'

3.1.2 Mapping

The project has mapped user experience using the tool of journey maps and the free online software version of Miro.

A journey map is a visualisation of the process that a person goes through in order to accomplish a goal.

An example applied to 'Whynotchemeng?' is shown in Figure 4.

This is the journey of a

Whynotchemeng? student

School student considering chemical engineering as a career

What are their key goals and needs?

- A secure lifelong career
- A personally rewarding career
- A career that provides a good lifecycle

What do they struggle with most?

- So much choice of career
- So much choice of degree
- Finance

What tasks do they have?

- Choose school exam subjects
- Choose career
- Choose degree
- Choose academic institution

Journey Steps Which step of the experience are you describing?	**Discovery** Why do they even start the journey?	**Evaluation** Why chemical engineering?	**Choice** How will they know it is the right decision?	**Implementation** How to apply, succeed and start?
Actions What does the actor do? What information do they look for? What is their context?	Research course options Research degree options Talk to teachers Talk to friends and families Attend info events organised by school /college	Evaluate against experience of subjects studying now Evaluate what courses are available where Work out degree costs Evaluate potential career options after degree	Visit institutions Talk to current and past chem eng students Visit locations around the institution Talk to lecturers Talk to teachers Talk to friends and family	Apply for degree Receive degree offers Achieve entry requirements Start degree
Needs and Pains What does the actor want to achieve or avoid? *Tip: Reduce ambiguity, e.g. by using the first person narrator.*	Want to complete a degree Dead end job(s)	Varied and rewarding career options Interesting and challenging degree Good academic institution Too difficult degree High debt	Institution visits are fun and interesting Good quality course info Meet people that get on with Not knowing what the degree involves Poor facilities for degree, living or socialising	A choice of place offers 1st choice course and institution Achieve grades required Clearing Mismatch between expectations and reality
Touchpoint What part of the service do they interact with?	Syllabuses Academic institution websites Whynotchem eng? events	Whynotchem eng? events IChemE website Syllabuses Academic institution websites	Institution and study facilities Lecturers IChemE staff if present IChemE members if present	Entry requirements IChemE membership for Student membership IChemE website
Actor Feeling What is the actor feeling? *Tip: Use the **emoji app** to express more emotions*	🔍	🤔	😵	🤩 🍾
Backstage				
Opportunities What could we improve or introduce?	Increase/decrease a leading metric by improving ? or introducing Y.	Increase/decrease a leading metric by improving ? or introducing Y.	Increase/decrease a leading metric by improving X or introducing Y.	Increase/decrease a leading metric by improving X or introducing Y.
Process ownership Who is in the lead on this?	School /College	IChemE	Academic institution	Academic institution

What changes for them?

Outcome

Describe how the life and environment of the actor changes once they used the product or service.

What are they able to do now?

- Study chemical engineering
- Plan a career in chemical engineering
- Develop new knowledge and skills

What can they finally stop doing?

- Worrying about studying the wrong degree
- Evaluating more degree options
- Applying for degrees

What changed in my environment?

- Became a university student
- Moved away from home
- Started to become a chemical engineer

Figure 4 – Example Journey Map Applied to ‘Whynotchemeng?’

The overall goal for the ‘user’ (a chemical engineer) in Part 1 of the project was defined as:

A chemical engineer that develops and maintains their process competence to defined standards throughout their career.

The career of a chemical engineer was defined by the following phases:

- Undergraduate
- Postgraduate
- Early career professional
- Vocational (at or equivalent to Engineering Technician)
- Mid-career professional (at or equivalent to Chartered Engineer)
- Late career professional (at or equivalent to Fellow or a deep subject specialist)
- Partially /actively retired professional

A journey map has been developed for each phase covering the start, middle and end of that phase. The structure for each phase includes:

- Expectations and goals (what an individual wants to achieve)
- User mindsets, actions and emotions (by individual)
- Opportunities, insights, inputs, measurements /assessments (the offering from e.g. academic institution, professional institution, employer, volunteering)
- Process Safety competence standard
- Influencing factors

The journey map development has considered how the journey may differ for different users including:

- Geography
- Social /academic /professional background
- Entry point and accessibility
- Incomplete and broken up journeys
- Macro-economic, technological and societal change

The initial data and knowledge elicitation for each career phase was conducted using phase tables in Excel. The WG, Peer Review Group and their wider network contributed to their population. This initial step was used as journey maps were unfamiliar to all volunteers at project start and enabled information to be elicited in a format that could then be transferred to the journey maps. The phase table structure is shown in Table 3.

Table 3 – Phase Table Structure Used

Career Phase	Description			
Expectations and Goals (what want to achieve)	**Individual Mindsets, Actions and Emotions**	**Opportunities, insights, inputs, measurements assessments (The offering)**	**How differs for different users? (Need for more than one map)**	**Applicable /Available Process Safety Competence Standards**
Start				
Middle				
End				

The key parallel activity to journey map development has been stakeholder engagement internal and external to IChemE in various forms (see Section 3.5 for further information). This has been used to inform journey map development, identify, explore and develop ideas within the project and for recommendations as outputs.

Background information and relevant good practice references have been used to support journey map development (see Section 3.6 for further information).

3.2 PROGRAMME

The programme for Part 1 of the project is shown in Table 4.

Table 4 – Project Programme for Part 1

Ref.	Activity	Q2 2021	Q3 2021	Q4 2021	Q1 2022	Q2 2022	Q3 2022	Q4 2022	Q1 2023	Q2 2023	Q3 2023	Q4 2023
1	Project start after MHC approval											
2	Recruit volunteers											
3	Establish WG and Peer Review Group											
4	Agree scope and draft timetable											
5	Establish shared online work area											
6	Identify and engage stakeholders											
7	Elicit data and knowledge											
8	Data analysis											
9	Populate phase tables											

Ref.	Activity	Q2 2021	Q3 2021	Q4 2021	Q1 2022	Q2 2022	Q3 2022	Q4 2022	Q1 2023	Q2 2023	Q3 2023	Q4 2023
10	Develop journey maps											
11	Interim report to MHC											
12	Develop conclusions and recommendations											
13	Final report to MHC											
	WG Meetings			X	X X	X X	X	X	X X	X		X
	Peer Review Group Meetings					X	X					

3.3 WORKING GROUP

As of the end of December 2022, seven two hour bi-monthly WG meetings have been held with contributions to working documents being made during and between meetings. There have been additional sub-group meetings held to progress the work as required.

This project's progress and success is due to the dedication and contribution by all active WG members.

3.4 PEER REVIEW GROUP

There have been two Peer Review Group meetings held so far with information provided via the shared work area for peer review and contribution.

3.5 STAKEHOLDER ENGAGEMENT

Table 5 summarises the stakeholder engagement conducted during Part 1 of the project. The engagement typically comprises a mixture of presenting project information, discussion of project progress and exploration of approach, findings and recommendations. The engagement is generally virtual via MS Teams meetings. The frequency and duration varies and is adapted to project and stakeholder requirements. For example, there have been approx. monthly meetings with IChemE's Director of Qualifications for over eighteen months and these have been highly beneficial to the project.

Table 5 – Summary of Stakeholder Engagement

IChemE	External to IChemE
Major Hazards Committee– Ongoing engagement	Other Engineering and Wider Professions (e.g. CIEHF) – Ongoing engagement
Safety and Loss Prevention Special Interest Group – Ongoing engagement	Regulatory Authorities – Ongoing engagement
Education Special Interest Group – Ongoing engagement. Potential future webinar?	Process Safety Forum to include Trade Associations such as CIA – Ongoing engagement
IChemE Safety Centre – Ongoing engagement via Trish Kerin	Accredited Universities – Ongoing engagement

IChemE	External to IChemE
Professional Formation Forum (includes ACTS) – Ongoing engagement	Hazards Forum to include other PEIs – Ongoing engagement
Education Accreditation Forum (includes curriculum content) – Ongoing engagement	Cogent Skills Process Safety Management Competence Programme Board – Ongoing engagement
Qualifications Committee – Ongoing engagement via Director of Qualifications	Energy Institute Process Safety Committee – Ongoing engagement
IChemE Training department – Ongoing engagement	

3.6 DATA AND KNOWLEDGE ELICITATION

There have been multiple activities and sources of data and knowledge elicitation throughout Part 1 of the project and these are summarised below.

3.6.1 IChemE Competence Standards

The following IChemE documents defining competence standards (often comprising submission and application guidance) have been inputs to Part 1 of the Project:

- Accreditation of Chemical Engineering Programmes, A guide for education providers and assessors
- Individual Case Procedure Guidance
- Initial Professional Development (IPD) submission guidance
- Technician Member Guidance for Applicants
- Chartered Chemical Engineer (Stage – Professional Review Guidance for Applicants)
- Fellow Application Guidance
- Professional Process Safety Engineer Guidance

3.6.2 ISC Outputs

The following ISC documents were used as inputs to Part 1 of the project:

- ISC, *Benchmarking Exercise: Improve Process Safety in Engineering – Undergraduate Education* (2018) [PowerPoint]
- ISC, *Benchmarking Exercise: Improve Process Safety in Engineering - Undergraduate Education* (2018) [Word]
- ISC, *Benchmarking Exercise: Improve Process Safety in Engineering - Undergraduate Education*, Data (2018) [Excel]
- ISC, *Learning Outcomes: Improve Process Safety Education in Undergraduate Engineering*, Edition 1 (2018)
- ISC, *Sample University Laboratory Process Safety Management System* (2019)
- ISC*, Process Safety Experiences During Industrial Placements for Undergraduate Engineering Students The diary scheme* (2021)
- ISC, *Process Safety Competency Guidance*, Edition 2 (2018)
- ISC, *Process Safety Competency Guidance: Supplementary guide – how to build and develop process safety competence* (2020)

3.6.3 S&LP SIG University Process Safety Workshops

The academic contacts from the 2022 S&LP SIG Process Safety Workshops were engaged with post workshop to discuss and explore the MHC PS Competence project and their perspectives on:

- Process safety requirements within IChemE accreditation requirements and how they can be met.
- The benefits of the S&LP SIG University Process Safety Workshop.
- The role and relationship between IChemE and academic institutions with respect to accreditation and process safety.

3.6.4 Background Information and References

A wide range of background information and references have been used throughout Part 1 of the project. This section summarises the sources identified at project start.

A further initial IChemE data source was:

- Professional Process Safety Engineer Research Data REDACTED [Excel]

Relevant Good Practice identified at the project start included the following references:

- Chartered Institute of Ergonomics and Human Factors, *Professional Competencies Checklist Guidance*
- HSE Research Report 086, *Competence Assessment for the Hazardous Industries* (2003)
- Institute of Engineering and Technology (IET), *Competence Criteria for Safety Related System Practitioners* (2007)
- HSE, *Managing Competence for Safety Related Systems* (2007)
- Office of Road and Rail, *Developing and maintaining staff competence* RSP1 (Nov 2016)
- Rail Safety & Standards Board (RSSB), *Good Practice Guide on Competence Development* – RS/100 (March 2013)
- Rail Safety & Standards Board (RSSB), *Good Practice Guide: Competence Retention* – T717
- ONR, *Training and Assuring Personnel Competence* (NS-TAST-GD-027 Revision 6) (July 2017)

Other relevant background material identified at project start included the following publications:

- Engineering Council, *UK Standard for Professional Engineering Competence and Commitment (UK-SPEC)*, Fourth Edition (August 2020)
- Engineering Council, *Guidance on Risk for the Engineering Profession* (March 2011)
- BSI Flex 8670: v3.0 2021-04 *Built Environment Core Competence for Building Safety in Competence Frameworks – Code of Practice*, Version 3 (April 2021)

3.6.5 Career Phase Tables and Journey Maps

The career phase tables and journey maps have been used to prompt data elicitation and to organise and provide a structure. The career phase tables and journey maps as at the end of September 2023 are provided in Appendices B and C, respectively.

3.6.6 Working Group Members

WG members have provided the bulk of the data and information gathered and have organised this using the phase tables and journey maps as well as prompting discrete discussion on particular topics such as the grade of Fellow.

3.6.7 Peer Review Group Members

Peer Review Group members have reviewed information and contributed at discrete stages of the project.

3.6.8 Previous IChemE Activities

Previous IChemE activities relating to PS competence for chemical engineers throughout the lifecycle including the work by the ISC and the S&LP SIG University Process Safety workshops were fed into the project as summarised above.

3.6.9 IChemE Stakeholders

IChemE stakeholders have provided significant data and information throughout the project via data, documents and discussion.

3.6.10 External to IChemE Stakeholders

External to IChemE stakeholders have provided input data and a wider context for the project and been provided with the opportunity to engage and shape as desired.

3.6.11 S&LP SIG Newsletter

Articles on the MHC PS Competence project were included in the February 2022, July 2022 and December 2022 S&LP SIG Newsletters. The articles prompted members to get in touch with input information for the project and to volunteer to participate in the project member survey planned for January 2023.

3.6.12 Hazards 32 Discussion Session

There was a discussion session run at Hazards 32 on Wednesday 19 October 2022 titled: 'IChemE's and Members' Role in Teaching Process Safety to Chemical Engineering Undergraduates'. An input to the discussion session was a brief survey of member involvement conducted via Heads of Chemical Engineering UK (HCEUK). 31 departments were contacted and three questions were asked:

1a) Apart from lectures /tutorials provided to Undergraduate Students by academic staff, what other learning methods are provided with regards to Process Safety?

1b) In particular, do Chemical Engineering Departments invite seasoned Process Safety Engineers /Managers to give special seminars to Undergraduate Students?

2a) If you do invite outside speakers, what particular aspects of Process Safety are covered in such special seminars?

2b) For example, do they include detailed analyses of past incidents /accidents, and lessons learned from past disasters in terms of Process Safety Management?

3) Would Chemical Engineering Departments be interested in asking IChemE to provide such seminars?

The Hazards 32 discussion presented the results of the survey and asked the audience the following questions:

- What is the process safety competence required for chemical engineering undergraduates?
    - What do employers want and /or expect?

- What are the benefits from IChemE and members' involvement in teaching process safety and providing experience (e.g. placements)?
- What are the barriers?
- What are the options, current and future?

As well as eliciting much useful information directly, the discussion session led to multiple volunteers for getting involved in the S&LP SIG University Process Safety Workshops and MHC PS Competence Project via the member survey and WG.

3.6.13 Member Survey

A member survey was undertaken during January /February 2023. The survey's objectives and purpose were:

1. To test the definitions and approach used within MHC PS Competence Project
    a) Identify and evaluate potential adjustments
2. To ask a wider IChemE member audience questions relevant to their individual career phase, experience and journey to help validate and expand the journey map work
3. To identify and evaluate trends and patterns from a wider audience
4. To identify areas that work well and areas for improvement
5. To engage the wider IChemE membership in the project

The member survey audience was an initial 10.5% of the membership (3,146), sent 11 January 2023, with the following member groups ring fenced:

- Technician members [38]
- All the Process Safety Associate [123], Member [67] and Fellow [1] IChemE members (i.e. PS only, non chemical engineers)
- PPSE held by IChemE Members [64] and Fellows [85] (i.e. chemical engineers and PS)
- All the Safety Register members [33]

The above totalled 411 (13.1% of 3,146) and left 2,735 (86.9%) available for the remainder of the cross section sample.

In addition, members who volunteered to participate via the S&LP SIG Newsletter and Hazards 32 were sent the survey question set.

The above recipient were sent a reminder e-mail w/c 23 January 2023.

Additionally, a link to the survey was provided in a Member News e-mail to the full membership in the first week of February 2023.

The survey was supported by IChemE Communications via Member News e-mails.

The survey question set is provided in Appendix A. The questions were developed and agreed by the WG and Peer Review Group and e had limited piloting to test usability and usefulness.

3.6.14 IChemE Data Analysis

Several data sets were provided by IChemE during the course of the project including:

- Membership data
    - By grade
    - By country
    - By age
    - PPSE and Safety Register membership data splits

    - Time taken from graduation to chartership
- IChemE Process Safety Training course data
    - IChemE versus non IChemE member attendees
    - By membership grade
    - By geographical region
    - By course
    - Pass rates for courses with assessment
    - Feedback data

4. FINDINGS

This section summarises the findings from Part 1 of the Project so far.

4.1 ICHEME PROCESS SAFETY COMPETENCE STANDARDS

Table 6 summarises IChemE process safety competence standard requirements and guidance.

4.2 CAREER PHASE TABLES AS AT END OF SEPTEMBER 2023

The Phase Tables as at the end of September 2023 are included in Appendix B.

4.3 CAREER PHASE JOURNEY MAPS AS AT END OF SEPTEMBER 2023

The career phase journey maps as at the end of September 2023 are included in Appendix C.

There has been significant effort to populate these maps by WG members who represent all career phases and multiple industry /academic sectors and geographic locations. Therefore, they are considered to be a valuable and informative snapshot of how IChemE members view the career journey of a chemical engineer and how process safety competence is developed and maintained.

Figure 5 shows an overall high level journey map for a chemical engineer developing and maintaining PS competence, which summarises the content of the individual career phase journey maps.

The key findings from the mapping exercises are:

- Availability and knowledge of competence standard for career phase
- Process safety competencies within each career phase competence standard
- Exposure to IChemE contact points and relationship with IChemE during career phases:
    - How is IChemE perceived by members?
    - Purpose of IChemE beyond path to chartered chemical engineer?
    - Ways IChemE could assist members during their career
    - CPD administered by IChemE
- Professional network availability throughout career

Table 6 – Summary of IChemE Competence Standard and Guidance Process Safety Content

Career Phase	Relevant IChemE Competence Standard /Guidance	Process Safety Content
Undergraduate	Accreditation of B-Standard and M-Standard Chemical Engineering programmes – A guide for education providers and assessors	Learning outcomes A2.6 'Process Safety' (B-Standard) Students graduating from an accredited programme will: • *Be able to identify the principal hazard sources in chemical and related processes (including biological hazards);* • *Understand the principles of safety and loss prevention, and their application to inherently safe design;* • *Understand the principles of risk assessment and of safety management, and be able to apply techniques for the assessment and abatement of process and product hazards;* • *Be able to apply systematic methods for identifying process hazards (e.g. HAZOP), and for assessing the range of consequences (e.g. impact on people, environmental reputation, financial, security);* • *Be aware of specialist aspects of safety and environmental issues, such as noise, hazardous area classification, relief and blowdown, fault tree analysis;* • *Have knowledge of the local legislative framework and how it is applied to the management of safety, health and environment in practice and in the workplace, from the perspectives of all involved, including operators, designers, contractors, researchers, visitors and the public*
		Learning outcomes A2.6 'Process Safety' (F-Standard) which in addition to the B-Standard comprises the M-Standard Build on the Level B learning outcomes: • *Be able to apply the same principles with systems thinking to more complex problems;* • *Have some understanding of the limits of available technology and of the potential of new and emerging technology.*
	ISC. Learning Outcomes. Improve Process Safety Education in Undergraduate Engineering.	This document sets out learning outcome expectations across four categories: • A. Process safety overview • B. Process safety in design

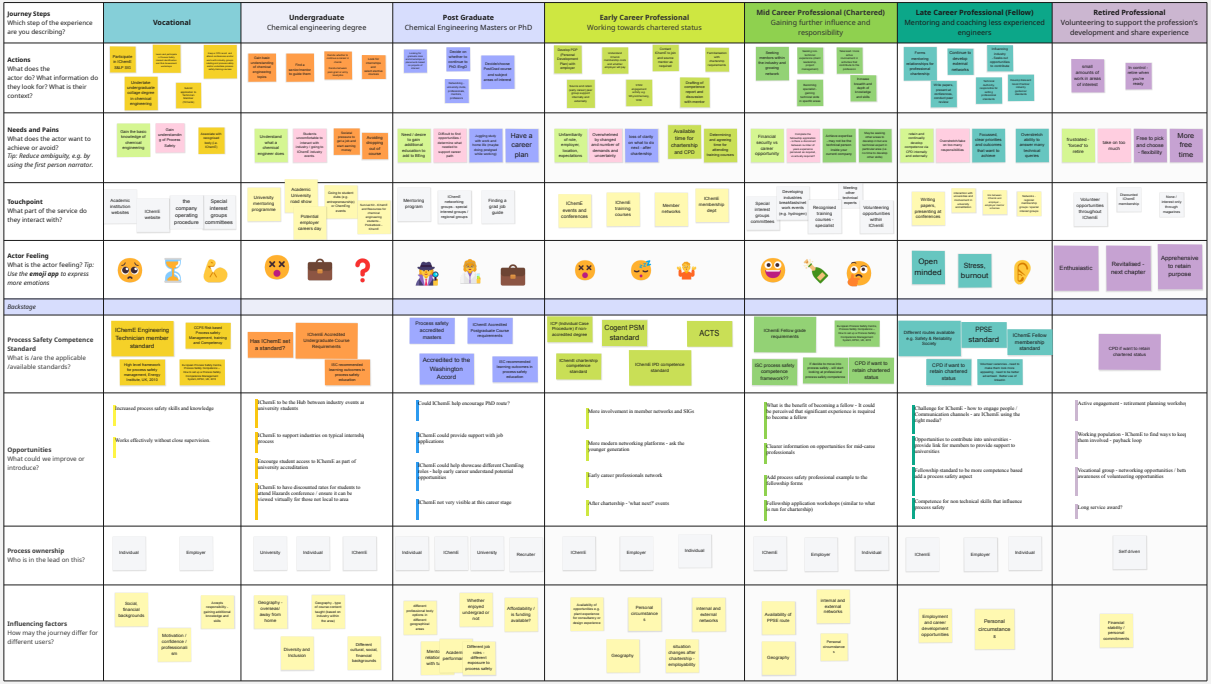
Career Phase	Relevant IChemE Competence Standard /Guidance	Process Safety Content
		• C. Guidelines for process safety risk assessment • D. Process safety in practice Sections A, B and C are intended to apply largely to classroom learning. Section D applies to practical application within the undergraduate course. This document also provides learning guides on how the practical application could be achieved.
	ISC Guidance. Process Safety Experiences During Industrial Placements for Undergraduate Engineering Students. The diary scheme.	This guidance document defines a framework for the interactions between students, employers and universities that occur during work placements. It aims to increase student's understanding of process safety in practice.
Postgraduate	Accreditation of F-Standard process safety programmes – A guide for education providers and assessors	Learning outcomes: • B2 Science and mathematics • B2.2 Tools to identify and assess process safety hazards • B2.3 Incident investigation • B3 Engineering Analysis • B3.2 Understanding and application of relevant regulations • B3.3 Process safety management (PSM) • B4 Design and Innovation • B4.2 Emergency planning • B5 The engineer and society • B5.2 Protection of society and the environment • B5.3 Human factors • B5.4 Safety culture • B5.5 Leadership • B6 Process Safety Engineering practice

Career Phase	Relevant IChemE Competence Standard /Guidance	Process Safety Content
		• B7 Embedded learning • B7.2 Problem solving, communication, working with others, leadership, IT, planning and time management, personal development, CPD
Vocational (EngTech)	Technician Member EngTech guidance for applicants	• Competency B2 'Ability to identify, organise and use resources effectively to complete tasks, with consideration for cost, quality, safety and environmental impact'. • Competency E2 'Ability to manage and apply safe systems of work'. • Competence E3 ' Ability to undertake technical and process engineering in a sustainable way an demonstrate awareness of sustainable development' Guidance suggests ' Provide an example of a methodical assessment of risk you've made on a specific project(s) and the actions taken to minimise risk to health, safety, society or the environment'.
Early Career Professional	Accredited Company Training Schemes (ACTS) – A comprehensive guide for the accreditation of in-company graduate training	• Competency B 'ability to handle the wider implications of your work as an engineer' • 'B1: Handling of health, hazard and safety aspects, apply appropriate principles, good practice, meet legislative requirements etc'
	Chartership Application Stage 1 - Individual Case Procedure – Technical Biography guidance	Part A. Fundamentals of chemical engineering. • *'You should demonstrate the knowledge and ability to handle broader implications of work as a chemical engineer. These include sustainability aspects, process safety, health, environmental and other professional issues including ethics, risk, commercial and economic considerations etc.'* • *'You should demonstrate high standards of appreciation and practice of Safety, Health and Environment (SH&E) in all aspects of your work'* • *'You should demonstrate understanding of the concept of 'fit for purpose', the importance of delivery, and the need to meet ethical and legal requirements to protect safety, health and the environment.'*
	Chartership Application Stage 1 - Individual Case Procedure – Technical report questionnaire example answers	1.5 Core Chemical Engineering – Process Safety Evidence of: • *Ability to identify the principal hazard sources in chemical and related processes (including biological hazards);*

Career Phase	Relevant IChemE Competence Standard /Guidance	Process Safety Content
		• *Knowledge of the principles of safety and loss prevention and their application for inherently safer design;* • *Knowledge of the principles of risk assessment and of safety management, and ability to apply techniques for the assessment of process and product hazards;* • *Ability to apply systematic methods for identifying process hazards (e.g. HAZOP) and for assessing the range of consequences (e.g. impact on people, environment, reputation, financial).*
	Chartership Application Stage 2 – Initial Professional Development (IPD) guidance for applicants	Section B 'Evidence that you are able to handle the wider implications of your work as an engineer' *'What the assessors look for:* • *This section is a critical requirement for successful application for Chartered Chemical Engineer status. Assessors look for knowledge and breadth of experience, where you identify, evaluate and address process safety issues in research, design or operation, contribute as a chemical engineer in structured process hazard evaluation, show a clear understanding of the legislative requirements and the wider impact safety related issues can have.'*
	Chartership Application Stage 2 – Initial Professional Development (IPD) – example submissions from applicants	• Example submission includes reference to management systems, HAZOPs, emergency preparedness, MOC, safety cases, bowtie analysis.
Early /Mid Career Professional	Chartership Application Stage 3 – Professional review – guidance for applicants	Competency B 'ability to handle the wider implications of your work as an engineer' • *B1: Handling of health, hazard and safety aspects, apply appropriate principles, good practice, meet legislative requirements etc* • *Competency B 'ability to handle the wider implications of your work as an engineer'* • *'Professional reviewers look for knowledge and breadth of experience, where you identify, evaluate and address process safety issues in research, design or operation, contribute as a chemical engineer in structured process hazard evaluation, show a clear understanding of the legislative requirements and the wider impact that safety related issues can have.'*

Career Phase	Relevant IChemE Competence Standard /Guidance	Process Safety Content
		Examples focus on HAZOP
	Professional Process Safety Engineer PPSE (Currently Unavailable)	**A Ably apply knowledge and understanding of technical process safety to practical engineering situations (in design and/or in operations) and ably apply appropriate theoretical and practical methods to the analysis and solution of process safety problems.** • A1 Hazard identification: Able to identify hazards using recognised hazard identification techniques. • A2 Assessment of consequences: Able to assess hazard consequences using recognised consequence modelling techniques. • A3 Control of hazards: Able to assess and implement safeguards appropriate for the hazard being considered in an operations or design environment. • A4 Risk assessment: Able to undertake risk assessment to determine whether safeguards are adequate to mitigate hazards. **B Ably handle the wider implications of work as a process safety practitioner** • B1 Understanding and application of relevant Regulations: Able to demonstrate effective understanding and application of regulations appropriate to the industry and geographical area(s) in which the engineer practises. • B2 Protection of the public: Able to demonstrate understanding and application of process safety principles in reducing public risk. • B3 Incident investigation: Able to demonstrate understanding and experience of incident investigation and implementation of lessons learned. • B4 Emergency planning: Able to demonstrate understanding and experience in defining emergency actions for hazards identified. **C Ably provide effective process safety leadership and communication** • C1 Process safety management: Able to demonstrate understanding and personal experience of process safety management. • C2 Influencing process safety culture: Able to demonstrate direct influence of process safety culture during professional practice.

Career Phase	Relevant IChemE Competence Standard /Guidance	Process Safety Content
	ISC Process Safety Competency Guidance & Supplementary guide	This guidance document provides an example of a process safety competency model. This guideline provides a list of generic organisational roles and provides a matrix which defines the required competencies for each of those organisational roles, grouped into 18 competency topics. Competency is defined across a four-tier scale. The Supplementary guide provides an example of the tasks and activities that could be undertaken to achieve the relevant level of competence in the range of competency topics covered in the main guidance document.
Mid /Late Career professional (chartered engineer)	Fellow application guidance	The word ‘safety’ appears only once as an example of important operational aspects.
Late Career professional (Fellow or subject specialist)	CPD only	
Partially /actively retired professional	CPD only	



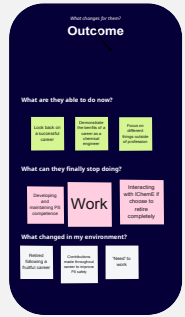


Figure 5 – Overall High Level Journey Map for a Chemical Engineer Developing and Maintaining Process Safety Competence

4.4 ICHEME DATA

4.4.1 2022 Membership Data by Grade, Country and Age

IChemE's Director of Qualifications shared several data sources with the project including 2022 membership data.

Figure 6 shows 2022 IChemE membership data broken down by grade. It shows that Chartered Member (29.1%) is the largest membership grade category, followed closely by Associate Member (28.9%) then Affiliate Member (16.5%), Student Member (15.7%) and Fellow (8.9%) grades.

Figure 7 shows 2022 IChemE membership data broken down by country. It shows that the UK is by far the largest source of members and accounts for 64.5% of all IChemE members. The next largest source of members is Malaysia (8.1%), followed by Australia (7.5%) then Ireland (3.7%). All other countries contribute less than one thousand members each.

Figure 8 shows 2022 IChemE membership grades by age and illustrates that there is an overall journey, which transitions from Student Member to Associate Member to Chartered Member to Fellow as age increases.

4.4.2 Time Taken from Graduation to Chartership

Table 7 shows summary data of time taken from graduation for those Chartered Members who hold an MEng qualification. IChemE have limited the analysis to this degree because there is no simple way of calculating the time for others who have /require more than one degree to meet the educational base requirements. There were 1,827 Chartered Members with an MEng in 2022 (19.7% of all Chartered Members), so the sample size is considered to be reasonably representative.

The data indicates a typical elapsed time of between 5 and 8 years for the 'Early Career Professional' phase between graduation and chartership for all members.

Table 7 – Summary Data of Time Taken for Graduation to Chartership (for Chartered Members with an MEng)

	All 2022 Chartered Members with an MEng	Female 2022 Chartered Members with an MEng
Mean /Years	7.8	7.8
Mode /Years	5.7	5.1
Median /Years	6.7	6.8
Total Number of Members	**1,827**	**711**

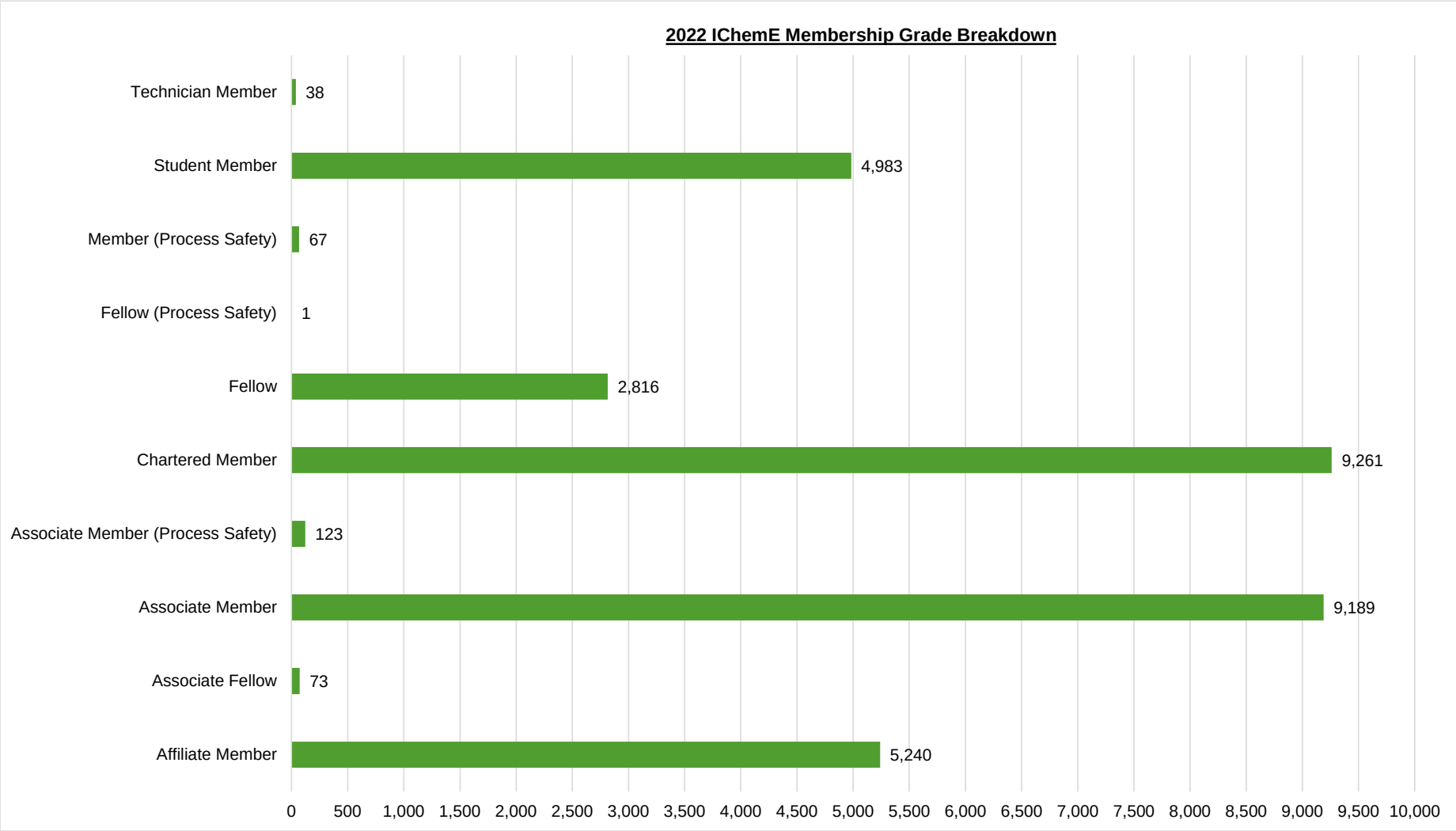


Figure 6 – 2022 IChemE Membership Grade Breakdown

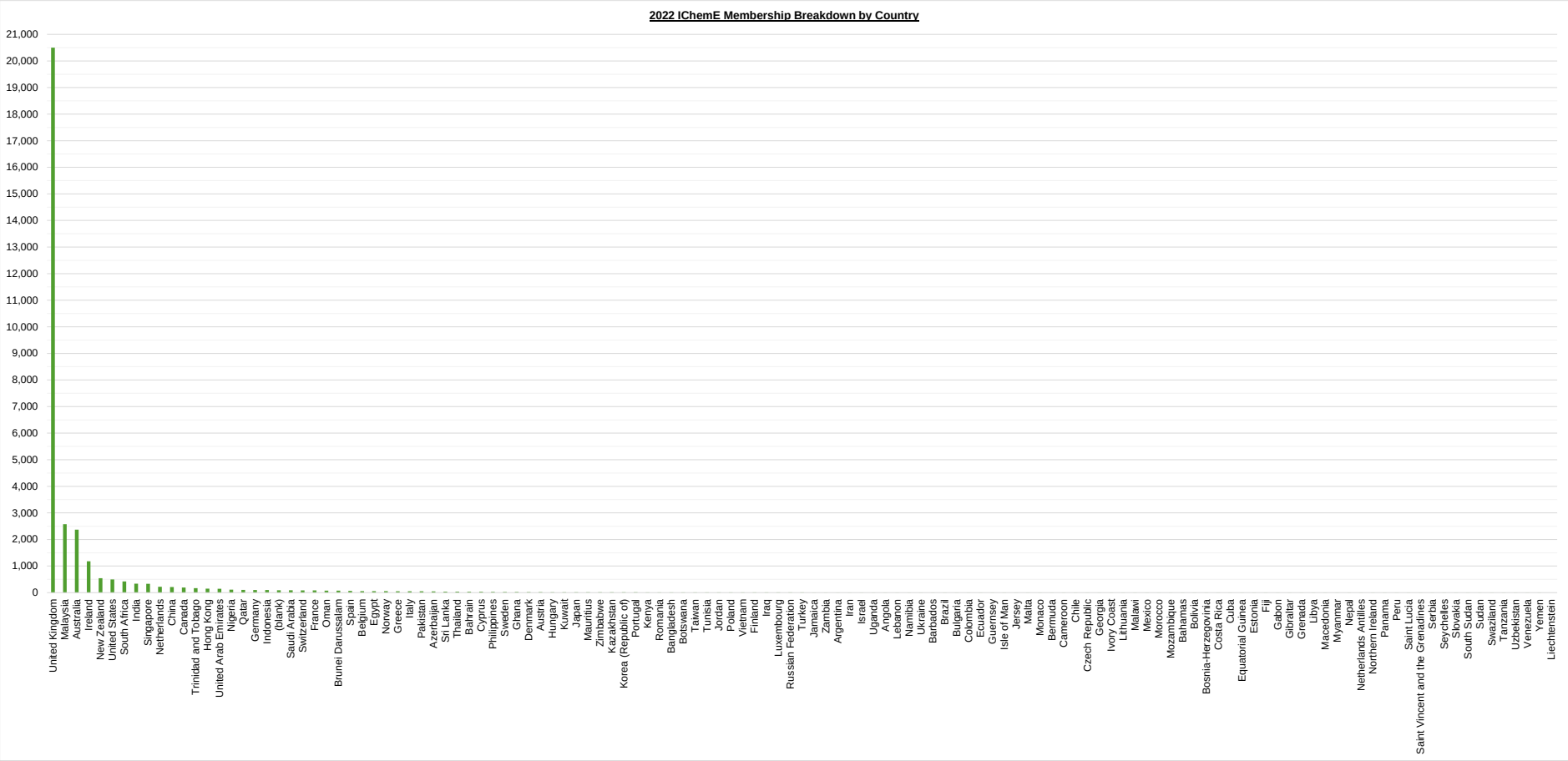


Figure 7 – 2022 IChemE Membership Breakdown by Country

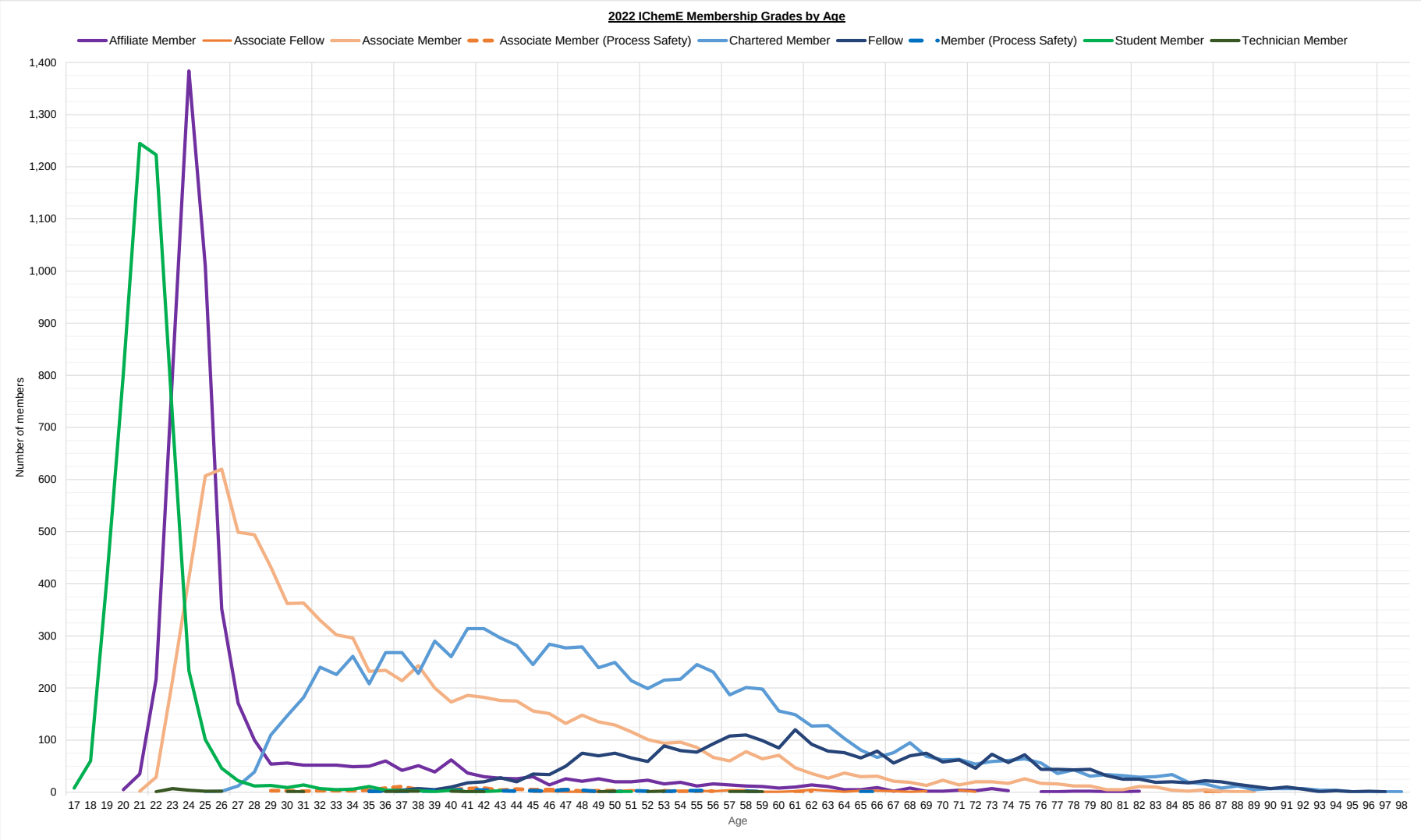


Figure 8 – IChemE Membership Grade by Age (2022)

September 2024: Version 2

4.5 HAZARDS 32 DISCUSSION SESSION

In response to the brief survey of IChemE member involvement in process safety education conducted via HCEUK, 12 replies were received from the 31 Colleges and Universities. Table 8 presents the summary of the responses received, which were presented as an input to the Hazards 32 discussion session.

It is appreciated that:

- The sample is self-selecting and therefore only very general conclusions are possible
- Data is UK only – it would be beneficial to expand to collect international data
- The survey was very brief – would additional questions be beneficial?

Table 8 – Summary of Responses Received from UK Chemical Engineering Departments

Ref.	Survey Question	Summary Overall Response
1a	Apart from lectures /tutorials provided to Undergraduate Students by academic staff, what other learning methods are provided with regards to Process Safety?	• Most commonly PS is incorporated into the design study but is clearly also introduced at other suitable points in UG courses • The most common PS element directly taught is HazOp • Three London institutions use the SLPG seminar
1b	In particular, do Chemical Engineering Departments invite seasoned Process Safety Engineers /Managers to give special seminars to Undergraduate Students?	• More than half (7 /12) do have outside involvement in teaching PS • Swansea have a well developed structure for using outside PS professionals to deliver teaching modules fitted to their particular expertise • Imperial have an impressive list of guest speakers • Other courses are more 'ad hoc' and /or rely on staff (who may have industrial experience) for most teaching
2a	If you do invite outside speakers, what particular aspects of Process Safety are covered in such special seminars?	• Most commonly mentioned were HazOp and case studies of accidents and incidents
2b	For example, do they include detailed analyses of past incidents /accidents, and lessons learned from past disasters in terms of Process Safety Management?	• 5 /12 said yes • 3 suggested staff experience used

Ref.	Survey Question	Summary Overall Response
3	Would Chemical Engineering Departments be interested in asking IChemE to provide such seminars?	• **12 /12 would welcome this** • 3 Universities offered to share resources. Possibility of using virtual resources?

Some thoughts arising from the above survey responses, which were presented at Hazards 32:

- There is a clear appetite for member involvement in teaching Process Safety to undergraduates – about half of Departments use members now
- The S&LP SIG University Process Safety Workshop seems to be well regarded – but only available in London (as of 2022)
    - Possibility of further content review to provide an IChemE resource
    - Find members across the UK to deliver – Local Member groups?
    - Use it virtually, as well as in person?
- Use Imperial's self-assessment against the IChemE accreditation requirements to identify other areas where members could help? [This refers to a paper[3] by Chris Tighe from Imperial and the Supplementary Information in particular, which contains a gap analysis of the Imperial Safety and Loss Prevention Module against the IChemE accreditation requirements and the ISC recommended learning outcomes in process safety education.]

The discussion session had the following output:

- Very high level of interest in process safety competence for chemical engineering undergraduates
- High level of engagement during 45 mins long discussion
- Multiple volunteers for getting involved
- Students and recent graduates appeared to feel that they developed limited PS competence during their academic studies
    - Instead, the bulk was developed during placement /post graduation work experience
- Students appeared to be unsure what the benefit of IChemE membership was
- Students and tutors present considered that more practical PS content earlier would be beneficial
- Barriers
    - Available time in undergraduate academic programme
    - Exam and results pressure on students and tutors
    - Reduced availability and take up of industrial placements
    - Academic tutor industry experience?
- Options
    - Summer placements
    - 'Summer school' opportunities
    - Increased IChemE visibility to encourage early engagement

- Increased connections and interactions between members and chem eng departments
- Multiple additional volunteers for survey completion
- Request for personal mentoring
- Follow-up discussions with multiple placement students and graduates and mid and late career professionals

Therefore, the Hazards 32 discussion session provided valuable input to the project and enabled further exploration of the Undergraduate Career phase with a much wider audience.

Many thanks to Chakib Kara-Zaitri of Bradford who tragically passed away during 2022, Ken Patterson of the WG and Nooryesha Choudhury of IChemE for organising the HCEUK survey and to Ken for his analysis and for securing the Hazards 32 discussion session slot.

4.6 STAKEHOLDER ENGAGEMENT

IChemE stakeholders (staff and volunteers) approached by the project have been highly supportive and generous with their time, ideas and information. The emerging findings and outputs have been welcomed and often corroborate findings from other activities.

External stakeholders approached by the project have been very interested in hearing about the objectives and approach and are keen to receive updates on project recommendations and outputs.

Both the above experiences have reinforced the importance of stakeholder engagement throughout the project to maximise relevance and benefits from recommendations and outputs.

4.7 MEMBER SURVEY RESULTS AND DATA ANALYSIS

The process safety competence survey of the IChemE membership had 492 respondents. The majority (83.3%) classified their career phase as mid or late career (see Figure 9).

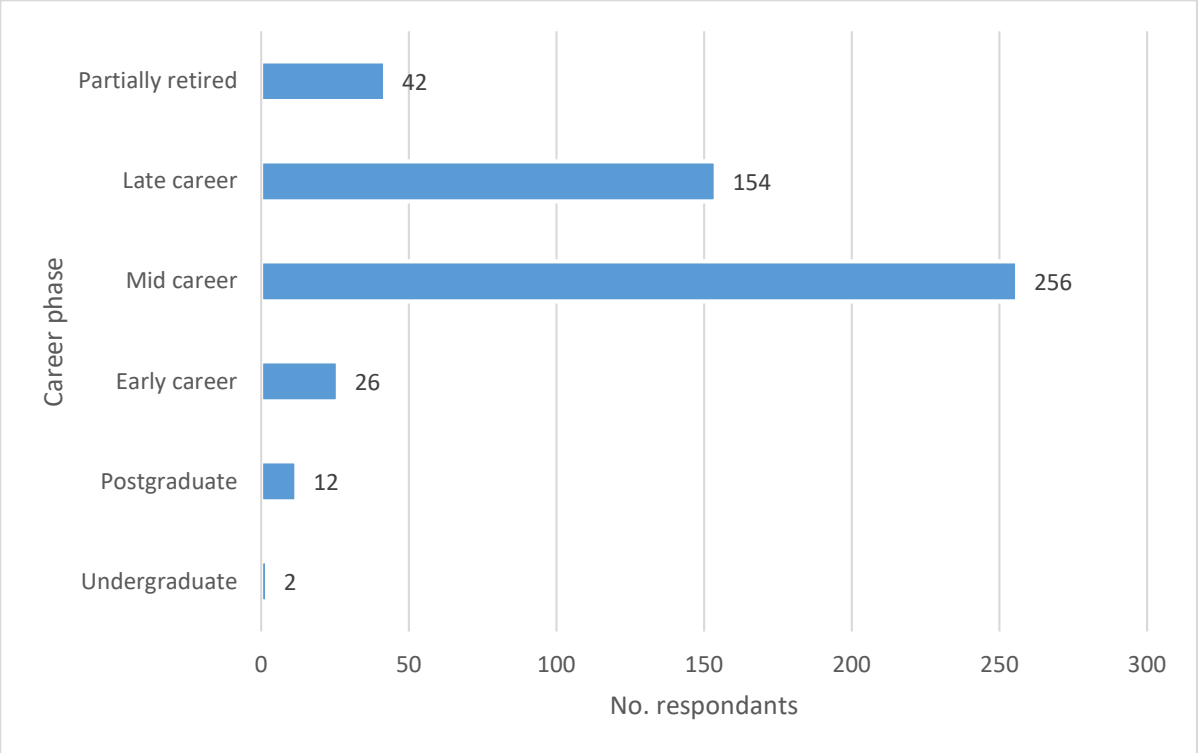


Figure 9 – Split of How Survey Respondents Identified Their Career Phase (n = 492)

Limited data was collected and available to support survey responses in terms of member characteristics captured during accessing the survey i.e. IChemE membership grade, country, sector. This data captured 295 clicks from the survey e-mail, it is unclear why there is such a large discrepancy between 492 and 295. However, IChemE are confident in the survey responses from the full 492 respondent data set. Figure 10 shows the membership grade breakdown from this data set. Table 9 compares the breakdown in Figure 6 to that of the 2022 IChemE membership data from section 4.3.1:

Table 9 – Comparison of Membership Breakdown from 2022 Membership Data with Survey Respondents

Grade	% of 2022 Full Membership	% of Respondents from E-mail Click
Student	15.7%	0% [Note there were 14 self-identified student responses within the 492 survey response dataset but none within the 295 dataset]
Associate Member	28.9%	28.5%
Affiliate Member	16.5	12
Technician Member	0.1%	0% [1 person]
Chartered Member	29.1%	34%
Fellow	8.9%	17%
Associate Member (Process Safety)	0.4%	3.7%
Member (Process Safety)	0.2%	2%
Non-member	N/A	3%

Table 9 shows reasonable overall agreement between the full 2022 membership data set and the survey respondent 295 data set in terms of membership grade breakdown. The differences within the 295 respondents compared to the full 2022 membership breakdown are:

- Lack of student representation;
- Much higher representation of Fellow grade;
- Much higher representation of the Associate Member and Member Process Safety grades;
- Non member representation.

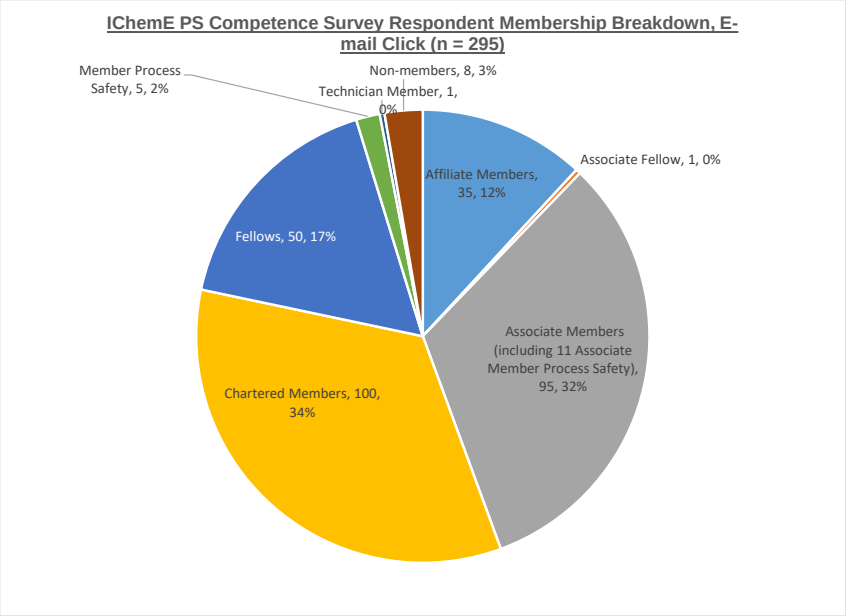


Figure 10 – Survey Respondent Membership Breakdown, E-mail Click (n = 295)

Figure 11 shows the country breakdown from the 295 respondent data set. Table 10 compares the breakdown in Figure 11 to that of the 2022 IChemE membership data from section 4.3.1 for the top eight contributing countries to the 2022 membership data:

Table 10 – Comparison of Membership Breakdown from 2022 Membership Data with Survey Respondents

Country	% of 2022 Full Membership	% of Respondents from E-mail Click
UK	64.5	44
Malaysia	8.1	5
Australia	7.5	9
Ireland	3.7	5
New Zealand	1.7	2
US	1.6	1
South Africa	1.3	2

Table 10 shows reasonable overall agreement reasonable overall agreement between the full 2022 membership data set and the survey respondent 295 data set in terms of country breakdown. The differences within the 295 respondents compared to the full 2022 membership breakdown are:

- Significantly lower UK contribution;
- Lower Malaysia contribution;
- Higher Australia contribution.

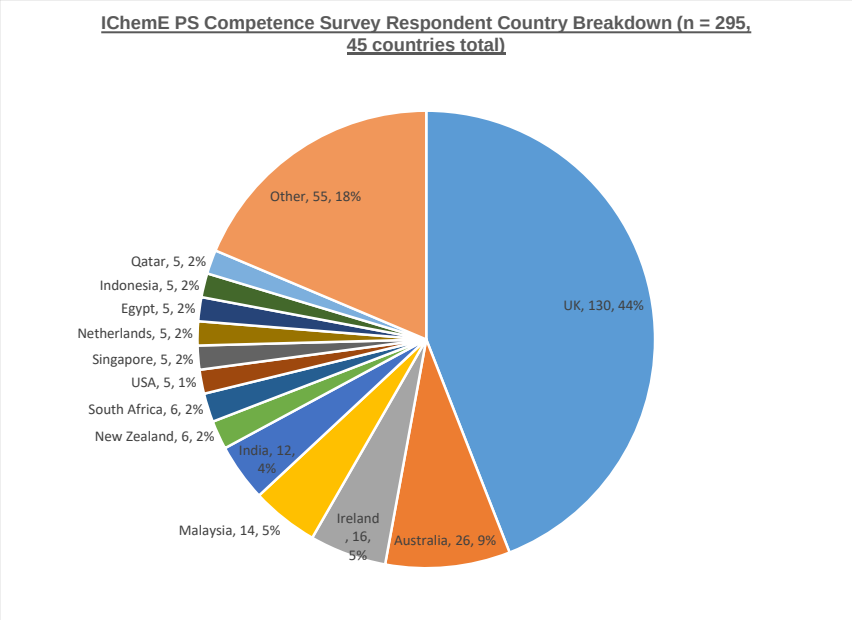


Figure 11 – Survey Respondent Country Breakdown, E-mail Click (n = 295)

Appendix D includes charts and word clouds covering all the survey questions. Key findings are summarised in Table 11 below.

Table 11 – Summary of Member Survey Responses

Ref.	Survey Question	Response Summary
2.	Do you agree with the IAEA definition of competence used by the project?	Vast majority (94%) agreed with the IAEA definition of competence used by the project
3.	How important do you think Process Safety Competence is to a Chemical Engineer?	There was strong agreement that process safety competence was essential and core throughout a chemical engineer's career.
4.	Do you agree that the process safety competence standard for your career phase is clearly defined?	Respondents were split as to whether the process safety competence standard for their career phase was clearly defined (45% agreed, 55% disagreed)
		Analysis of respondents by self identified career phase produced similar distribution to the full population across all phases, with the exception of Undergrad /Postgrad student phase (N.B. small sample size of 14 for combined student phases).
5.	Where is the process safety competence standard for your career phase defined?	Employer then IChemE were the most popular responses
6.	Where do you source information and support to help you develop and retain process safety competence?	• Literature • Employer internal and external training • Coaching /mentoring • Regulators • Professional networks • were the top 6 responses in terms of importance. Followed by:

Ref.	Survey Question	Response Summary
		• LPB • IChemE training • S&LP SIG • Internet search then • IChemE Safety Centre
7.	Please list the other professional bodies, industry associations and information sources which are important to you for developing and retaining process safety competence.	• Energy Institute • CCPS • HSE • Standards • Professional network • Company resource • Online resource were the most popular responses
8.	How do you support other chemical engineers in developing and retaining process safety competence?	• Coaching /mentoring • Professional network • Training development and /or delivery • Teaching /lecturing • IChemE training • LPB were the six most popular responses
9.	What do you think are key process safety competencies for a chemical engineer?	• Hazard identification • Systematic approach to safety in process design and operation • Understanding of risks to individuals, public and environment • Control of hazards • Risk assessment all scored 80% or greater for high importance.
10.	Please list any other key Process Safety Competencies for a chemical engineer	• Communication • Leadership • MOC • HAZOP were popular responses
11.	Which process safety competencies have you applied within the past six months?	• Risk assessment • Hazard identification • Understanding of risk to individuals, public and environment • Control of hazards • Assessment of consequences • Systematic approach to safety in process design and operation • Understanding process technology hazards were each chosen by more than 360 respondents.

Ref.	Survey Question	Response Summary
12.	To what extent do you think process safety competence requirements have changed (past) and will change (future)?	The great majority responded that they expected it would become significantly more demanding
13.	If you consider that requirements have changed and/or will change, please describe how and in what areas	Popular responses were: • New technology • Tighter regulations • Human factor • Public expectation • Sustainability goal
14.	What are the barriers to process safety competence?	• Not knowing what standard to aim for, insufficient time • Not a high priority for employer • Not knowing how to improve process safety competence • Insufficient money were selected by 190 or more respondents
15.	How could IChemE facilitate process safety competence better?	• Better definition of process safety competence requirements was the most popular response (over 60% selected) followed by • More guidance and resources available on the IChemE website then • More webinars
16.	Please list any other ways in which IChemE could facilitate process safety competence better	• Engage more of the membership in PS activities • Facilitate knowledge sharing between companies • Reduction in IChemE process safety course fees /more free sessions • Networking opportunities • Developing clearer process safety competency profiles • Ensure that Universities have the skills to train students on practical aspects of process safety • Helping regulators create standards • More emphasis on PPSE registration • Keep IChemE Safety Centre Competency framework up to date

Figure 12 compares the rankings for PS competencies from Question 9 (importance) and Question 11 (used in the past 6 months). It shows that there is generally strong agreement between PS competencies used in the past 6 months and their perceived importance, which suggests a potentially strong recency bias effect. The key differences in ranking were:

- Systematic approach to safety in process design and operation was ranked 2 for importance and 4 for past 6 months.
- Risk assessment was ranked 5 for importance and 1 for past 6 months.
- Protection of the Public was ranked 8 for importance and 14 for past 6 months.

- Understanding and application of relevant Regulations was ranked 14 for importance and 8 for past 6 months.

It is marked that Non-Technical Skills (NTS) have been ranked last (18) for importance and for use in past 6 months. However, other rankings and free text comments suggest that this may be due to lack of awareness and understanding of what NTS are and how they related to process safety activities /tasks and competence rather than objective assessment. N.B. A link to a website explaining what NTS are with examples was provided within the survey where the NTS option was listed (https://research.abdn.ac.uk/applied-psych-hf/non-technical-skills/). For example:

- Process safety management was ranked 10 for importance and for past 6 months
- Influencing process safety culture was ranked 11 for importance and for past 6 months
- Communication, leadership and ethics were popular free text answers for suggested other process safety competencies.

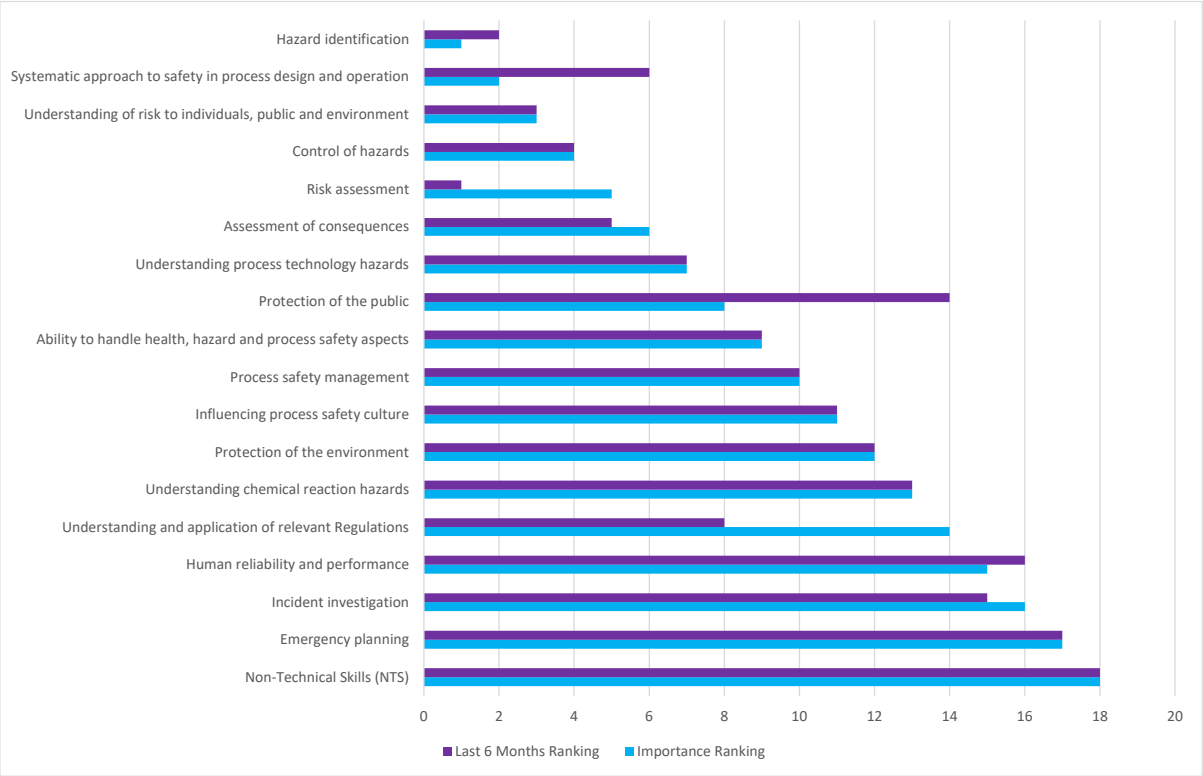


Figure 12 – Comparison of Rankings for PS Competencies, Importance and Within Last 6 Months

Several survey question responses (4, 14, 15) indicated that there is a need to improve the perceived availability of PS competence standards for all career phases and this provides an opportunity for IChemE to better support members.

Figure 13 illustrates the importance ranking from the member survey responses for the question asking how IChemE could facilitate PS competence better.

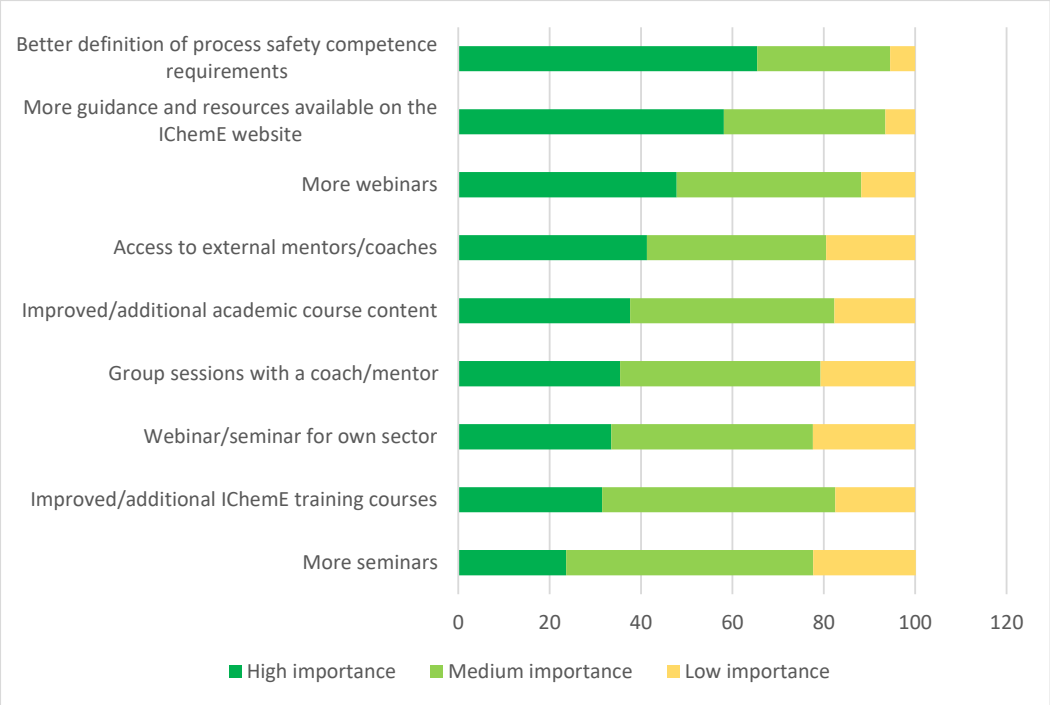


Figure 13 – Importance Ranking for How IChemE Could Facilitate PS Competence Better

There were several hundred further comments provided at the end of the survey and some recurring themes are summarised below:

- There is an overlap and a difference between professional chemical engineers and process safety professionals, it would be beneficial to understand the relationship better.
- There is very wide variability in the mix of process safety competences required by different roles and sectors and therefore any competence standards need to be sufficiently flexible.
- It would be beneficial for IChemE to provide more support and guidance on alternative potential career pathways with process safety competencies and training suggestions indicated.
- Undergraduate chemical engineering courses could improve and strengthen process safety content, engage more industry professionals to provide practical content and go beyond HAZOP.
- Availability and dissemination of incident investigation reports, case studies and lessons learned.
- IChemE providing /signposting access to other PS resources such as AIChE and CCPS.
- Concerns about deterioration in PS competence of chemical engineers and process safety professionals.
- Making Professional Process Safety Engineer (PPSE) registration available again including to non-chemical engineers.

4.8 ICHEME PROCESS SAFETY TRAINING COURSE DATA ANALYSIS

IChemE Training provided data for process safety training course attendance between 2019 and 2022. IChemE Training identified the courses they regard as process safety training. Five years data was requested, however IChemE Training did not have confidence in data held beyond the previous three years. Figure 14 shows attendance by Membership grade (for IChemE member attendance) and illustrates that 55% of IChemE members attending IChemE PS training course are Associate Members (versus 28.9% of IChemE 2022 membership being Associate Members), which would be expected as they work towards chartership. Chartered members make up the next largest group at 32% (versus 29.1% of IChemE membership being Chartered Members). It should be noted that for 2019 to 2022, 48% attendees of IChemE PS training courses were IChemE members and 52% were non-members.

Figure 15 shows the split of member /non-member attendance by PS training course. The five most popular courses were:

1. LOPA
2. Fundamentals of Process Safety
3. HAZOP Leadership and Management
4. Human Factors in the Chemical and Process Industries
5. HAZOP Study for Team Leaders and Team Members.

The combined numbers for the two HAZOP training courses make it the most popular subject during 2019 to 2022. All other PS training courses had <100 attendees between 2019 and 2022.

Figure 16 shows the split between IChemE members and non members by IChemE PS training course compared with the overall split of 48% member and 52% non member. Figure 16 shows that there is a wide variation either side of the overall split of 48% /52% for different IChemE PS training courses. This may be an indication of which courses are considered core to chemical engineers and process safety professionals (high member attendance) versus courses not considered core to either group (high non member attendance).

The two PS training courses with highest relative member attendance were Inherent Safety in Design and Operation Development (attendance 94.1% members) and Quantified Risk Analysis (attendance 92.3% members).

The two PS training courses with highest relative non member attendance were Process Safety Leadership and Culture (attendance 77.1% non members) and Hazard Identification Techniques (attendance 70.7% non members).

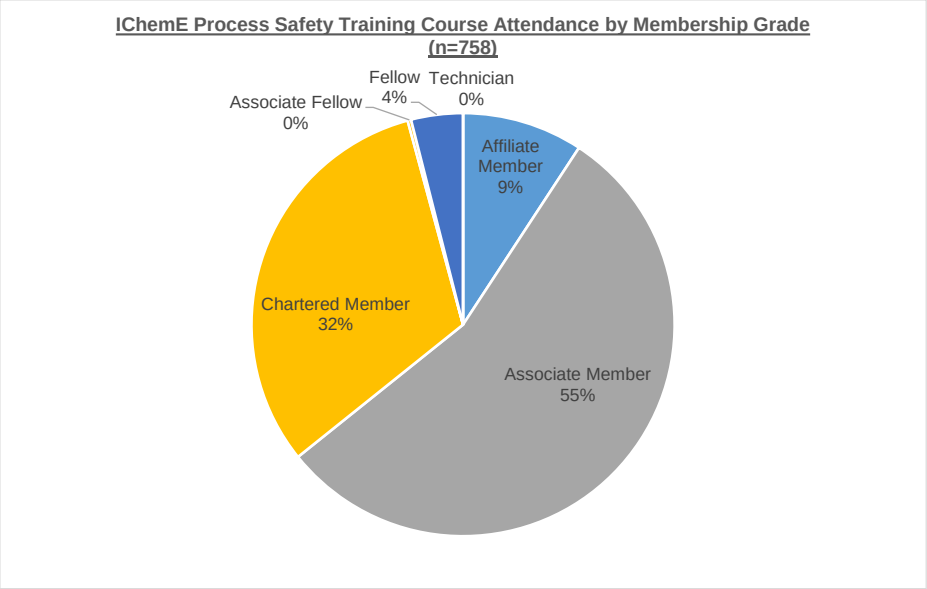


Figure 14 – IChemE PS Training Course Attendance by Membership Grade (2019 to 2022)

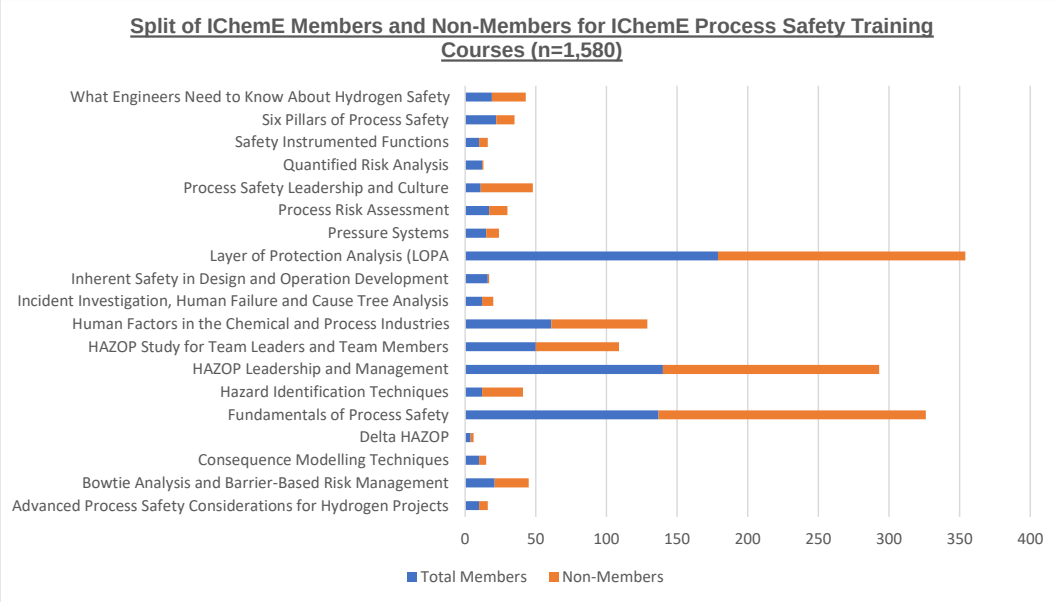


Figure 15 – Split of IChemE Members and Non-Members for IChemE PS Training Courses (2019 to 2022)

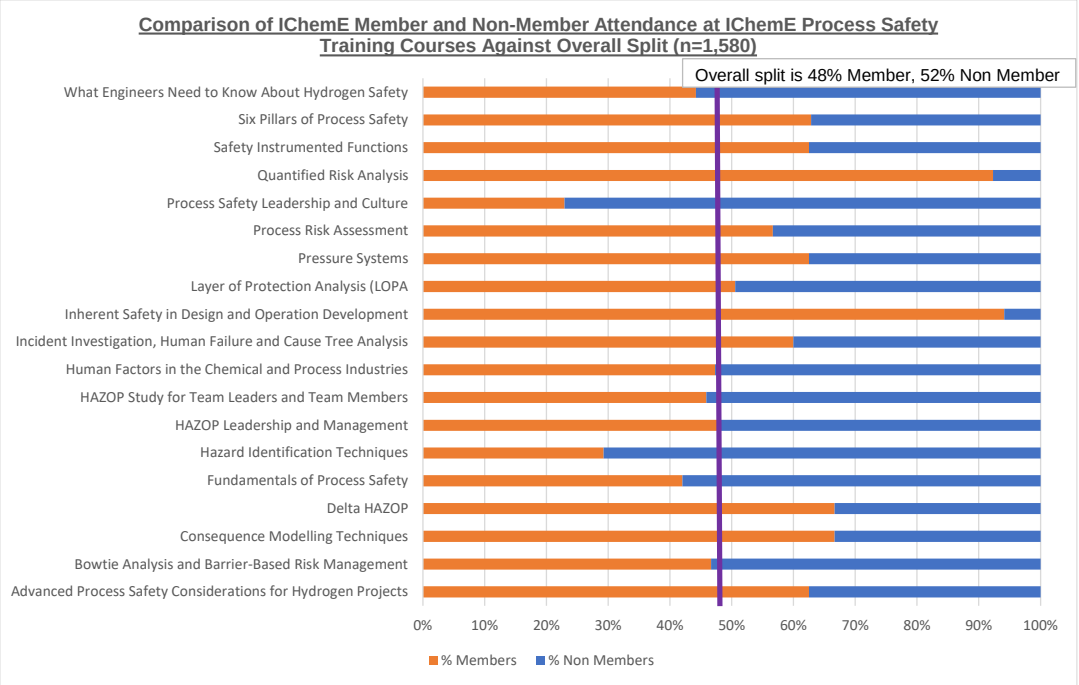


Figure 16 – Comparison of IChemE Members and Non Members Attending IChemE PS Training Courses Against Overall Split (2019 to 2022)

Figure 17 shows IChemE PS training course member attendance by location during 2019 to 2022. 68% of members attending were UK based (versus 64.5% of IChemE 2022 membership being UK based), 13% Europe based (versus 6.6% of IChemE 2022 membership being Europe based (outside UK), 5% Australasia (versus 9.2% of IChemE 2022 membership being Australia /New Zealand based) and 5% Middle East (versus 2.1% of IChemE 2022 membership being Middle East based).

Figure 18 shows the split between UK and non UK based members by IChemE PS training course and Figure 19 shows the UK /non UK split compared with the overall split of 68% UK and 32% non UK. Figure 18 shows that there is a wide variation either side of the overall split of 68% /32% for different IChemE PS training courses.

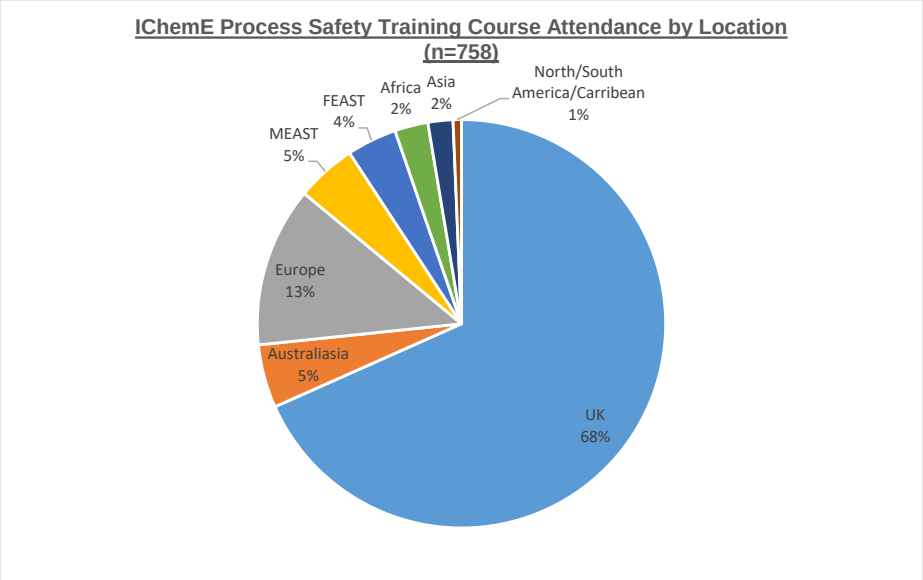


Figure 17 – IChemE PS Training Course Attendance by Location, Members (2019 to 2022)

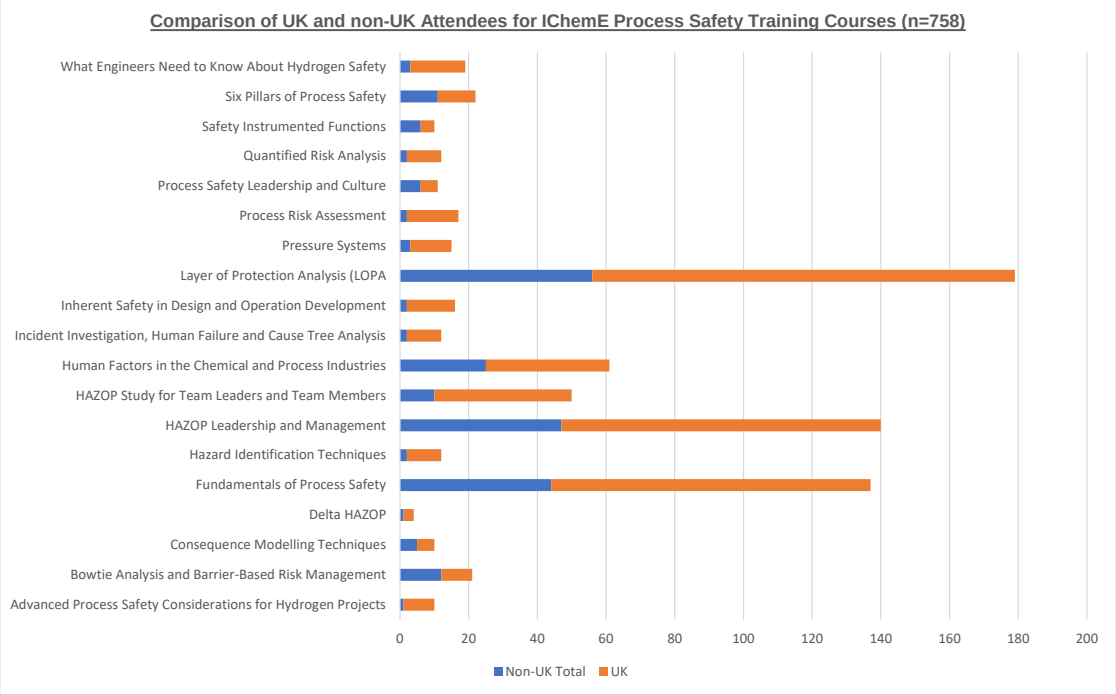


Figure 18 – Split of UK and Non UK Members Attending IChemE PS Training Courses (2019 to 2022)

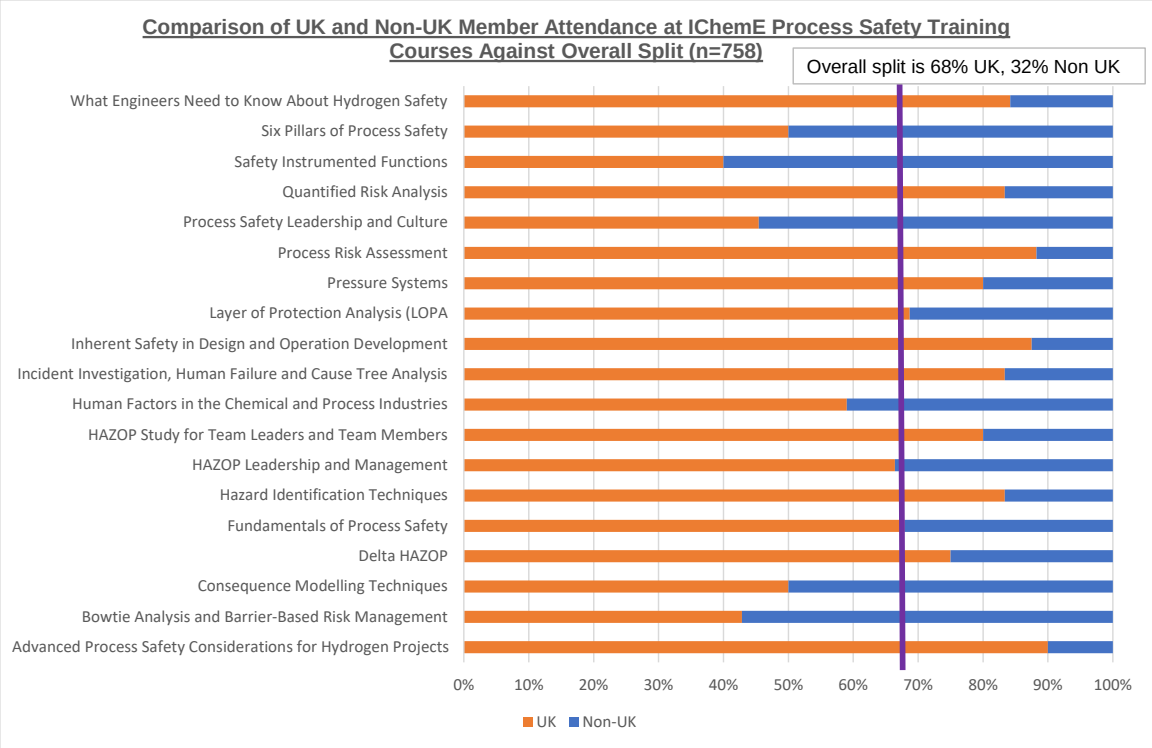


Figure 19 – Comparison of UK and Non UK Members Attending IChemE PS Training Courses Against Overall Split (2019 to 2022)

4.9 FEEDBACK ON INTERIM REPORT AND EMERGING RECOMMENDATIONS

The project Interim Report was shared widely and discussed as far as practicable with IChemE and non IChemE stakeholders. This section summarises the verbal and written feedback and comments provided.

4.9.1 IChemE

The (Past) Director of Qualifications provided the following feedback:

'*It is an excellent interim report with a wealth of information and evidence. I recognise and support the two career phases that have been identified for further work: undergraduate and late career professional. These two do stand out as phases that are perhaps not very well supported re process safety but for very differing reasons. The undergraduate phase is very important in the formation of a chemical /process engineer. There are invariably challenges with the variety and extent of material that needs to be addressed within university programmes particularly those that are accredited. The challenges of teaching process safety to undergraduates mirror those witnessed a number of years ago with giving civil engineering students practical context /experience around their studies. This led to 'Constructionarium' and a similar model could be developed for chemical engineering undergraduates. As noted in the report there are facilities such as CATCH that could possibly be used for summer placements and this could be trialled. Also, IChemE has developed a work placement passport for capturing initial professional development activities undertaken on student work placements /work experience realised over the course of a degree. Linking this with student engagement activities being promoted through the Regions team (who promote the use of the passport) could provide an effective means of pump-priming summer work placements that promote process safety. IChemE has also recently conducted a survey of chemical engineering students that reinforces some of the findings in the report and is giving rise to greater engagement with students. So, the time is right for looking for opportunities to develop*

work placement activities supporting process safety. Steven Gasser is the appropriate point of contact within the Regions Team to progress this.

I struggle a little with the late career professional phase. Of all the phases, this is the one that I would see as most difficult to categorise. It is, understandably, linked with Fellowship. However, it is not clear whether the suggestion or recommendation is that all those within the late career professional phase should be Fellows? IChemE's Fellowship is not linked with competence per se. Like many other Professional Engineering Institutions, IChemE's Fellowship is a means for the Institution to recognise seniority and contribution to the profession. So, not all those within the late career professional phase may necessarily meet the requirements for Fellowship as currently positioned. The Board of Trustees is keen to see Fellowship made available to a wider range of individuals who might necessarily have the traditional formation of a chemical engineer. There is a project currently underway to look at broadening the requirements for Fellowship. The points made within the interim report about the positioning and promotion of Fellowship on the website have been identified and work has been completed to enhance the website's material. The report appears to imply that there could be a set of process safety competences for those within the late career professional phase. However, I struggle to see how this might work given the very wide range of roles that late career professionals undertake. Some may have moved into management roles with little technical exposure. Some may be technical specialists /experts with more limited management responsibility. I can see opportunities to provide more guidance to members as to how they can develop into more senior roles and the reference in the report to the non-technical skills, e.g. process safety leadership and coaching /mentoring of undergraduates, early-career and mid-career professionals (particularly the latter) is very useful.

I also have a minor comment re the reference on page 15 to 'partially / actively retired professional'. I would be inclined to split these to distinguish those who are partially retired (whilst still professionally active) from those who are no longer professionally active. The former group would, for example, include a lot of volunteers providing support to the membership qualification processes for example.

So, whilst the undergraduate phase is nicely bounded and there are definite opportunities to develop process safety skills and improve the student experience, it is a little harder to see quite how this translates to the late career professional phase. I hope this helps?'

4.9.2 Professional Formation Forum Representative

A representative from the Professional Formation Forum provided the following feedback:

- '*Page 9 – are final year students undertaking final year design projects, as you would have expected process safety to be a key part of the design project?*
- *Page 9 – have you considered the use of mentors outside of the Chartered Engineer process?*
- *Page 10 – how can we encourage more academic organisations to become supporting partners of the ISC and thereby have access to the Case Studies?*
- *Page 10 – have you considered the addition of biographies of recent successful candidates on the IChemE website (this was done when PPSE was introduced), or the use of model submissions to help candidates at all stages of the process?*
- *Page 10 – within the Fellow application process, we are already considering the Non-Technical Skills (No.4) as part of the application process.*
- *Page 32 – within the Fellow application process, there is the option available for the PFF to complete a Fellow Interview as part of the application process*

- *Page 32 – within the Fellow application process, the PFF review considers the level of responsibility, with an initial assessment made by two members of the PFF, which is then typically reviewed by multiple other PFF members, prior to be discussed by the PFF at the panel meeting.*
- *Page 32 – 'Do IChemE want to keep Fellow small and select?' Not at all, if the candidate satisfies the criteria, then the Fellowship is awarded.*
- *Page 32 – when the PPSE qualification was introduced, there was discussions as to the equivalent level of membership and it was based on Chartered Engineer, rather than Fellow. Historically there had been discussions about a senior level of PPSE, but this was removed a number of years ago.*
- *Page 32 – 'The Fellow application guidance is not structured around competencies and demonstrating via evidence', as (7) above, multiple members of the PFF, are considering each application, which is discussed by at the PFF panel meeting. We do carefully review each candidates application, including what the comments of the referees, alongside the candidates application.*'

4.9.3 Hazards Forum and Process Safety Forum

The Interim Report findings and recommendations have been discussed and shared with the Hazards Forum and the Process Safety Forum (PSF). All were supportive of the findings and the opportunity to engage

Hazards Forum provides a potential vehicle for assisting IChemE in taking forward recommendations as process safety cuts across disciplines. IChemE appears to be severely resource constrained and therefore working with other professional bodies via Hazards Forum may make improvements easier and quicker to achieve.

PSF are keen to be kept up to date of project outcomes. The following points summarise the discussion at PSF:

- CIA representative – ChemTalent established a few years ago of a range of backgrounds
    - Would like to share Interim Report – yes please!
    - Would like to share contacts in ChemTalent – yes please!
- TSA representative – Terminal Operators been engaging with IChemE for engineering technicians
    - Does the project want their feedback – yes please!
    - Establishing a new skills committee – will invite HC to this
- Chair – What does the project want from PSF?
    - Feedback, comments and suggestions on Interim Report – validation, expansion, refinement of emerging findings and recommendations
    - Wider dissemination and expanding stakeholder engagement as move into evaluation of emerging recommendations feasibility
    - Support and involvement in next steps including feasibility evaluation of recommendations developing proposals for evaluation and implementation

4.9.4 University Lecturers and Students

Notes from an online meeting with lecturers at UK IChemE Accredited University courses to discuss the Interim Report and emerging recommendations is included in Appendix E. The discussion explored the following topics:

1. Should Process Safety be integrated across the modules, or be a stand-alone module?
2. When is the right time to start talking about process safety?
3. What are the teaching resource challenges?
4. What is done around practical application?
5. Is there wider value in process safety content in Chemical Engineering courses?

The following potential opportunities for IChemE linked to the above topics were identified during the discussion:

1a) Setting a clear standard for integration of process safety within the syllabus of accredited courses

3a) Resource library – anonymised industry information, drawings, data sheets etc to be used.

3b) Discussion forum for lecturers.

3c) Provide links, to give universities access to people from industry

4a) Provide links so universities can partner with industrial organisations

4b) Provide links for work placements

4c) Provide links for site visits

4d) Develop links between universities and FE facilities

5a) Showcase these (process safety) transferable skills

5b) Showcase the role of process safety across industry

Students are very keen for greater opportunity to develop and apply practical process safety knowledge and skills via placements and other means. Students and recent graduates engaged with felt that their process safety knowledge and skills was mostly developed outside their undergraduate course whilst working in industry.

Feedback provided from a recent graduate (from Leeds) who is now on an ACTS:

'*Thanks for sending this across. Some interesting points. The following findings were of significance for me:*

- *Students and recent graduates appeared to feel that they developed limited PS competence during their academic studies. Instead, the bulk was developed during placement /post-graduation work experience*
- *Students appeared to be unsure what the benefit of IChemE membership was*
- *Students and tutors present considered that more practical PS content earlier would be beneficial*

I would agree with the first bullet point – there was limited process safety teaching at university, I have gained most of my knowledge from professional experience.

I became a student member of the IChemE at university, however, looking back, I'm not sure if there was any benefit in doing so. There was little interaction with the IChemE in all honesty.'

Feedback from a current Chemical Engineering post graduate Masters student who has an undergraduate chemistry degree, is working as a process engineer in the chemical industry and who volunteered at one of the 2023 S&LP SIG University Process Safety Workshops:

'I read the report, and I think it makes some good points about the career phases that could benefit from a structured process safety development. Starting with undergraduates, after speaking with young students at XXXX, many agree that process safety is not adequately

covered in undergraduate degrees. Having studied while working as a process engineer, I have come to the realisation over the past few years about the significance of process safety in industry. I believe that the current university curriculum does not adequately address process safety. For instance, if we examine the current course structure for undergraduate chemical engineering at a prestigious institution such as Imperial College London, the following modules comprise their four-year curriculum:

Imperial College London 2023 MEng Chemical Engineering Undergraduate Programme			
Year 1	**Year 2**	**Year 3**	**Year 4**
Core modules	Core modules	Core modules	Core modules
Mastery 1	Mastery 2	Mastery 3	Chemical Engineering Practice 4
Process Analysis	Transfer Processes 2	Reaction Engineering 2	Optional modules - Group A
Chemical Engineering Practice 1	Chemical Engineering Practice 2	Particle Engineering	Colloids and Interface Science
Transfer Processes 1	Reaction Engineering 1	Process Design	Product Characterisation
Thermodynamics 1	Thermodynamics 2	**Safety and Loss Prevention**	Applied Spectroscopy
Separation Processes 1	Process Dynamics and Control	Environmental Engineering	Biochemical Engineering
Chemistry 1	Separation Processes 2	Chemical Engineering Practice 3	Optional modules - Group B
Mathematics Fundamentals	Engineering Mathematics	Process Optimisation	Advanced Process Operations
Physical Chemistry	Chemistry 2	I-Explore	Advanced Process Optimisation
		Optional modules - Group A	Dynamic Behaviour of Process Systems
		Membrane Science and Membrane Separation Processes	Dynamical Systems in Chemical Engineering

Imperial College London 2023 MEng Chemical Engineering Undergraduate Programme			
Year 1	**Year 2**	**Year 3**	**Year 4**
		Nuclear Chemical Engineering	Pharmaceutical Process Development
		Carbon Capture and Clean Fossil Fuels	Modelling of Biological Systems
		Sustainable Energy Technologies	Advanced Bioprocess Engineering
		Biochemical Sensors	Transport Processes in Biological Systems
		Optional modules - Group B	Molecular Modelling of Fluids
		Process Heat Transfer	Machine Learning for Chemical Engineering
		Advanced Fluid Mechanics	

As can be seen, only one of the course's 49 modules including optional modules covers some aspect of process safety. As many would agree, this is insufficient given that a significant portion of a process engineer's day-to-day duties involve process safety. University College London is another example of a prestigious university, similar to Imperial College London , they only list 1 out of 36 module on a process safety-related topic:

University College London 2023 MEng Chemical Engineering Undergraduate Programme			
Year 1	**Year 2**	**Year 3**	**Year 4**
Introduction to Chemical Engineering	Design and Professional Skills II	Process Plant Design Project	Advanced Process Optimisation
Transport Phenomena	Engineering Experimentation	Process Dynamics and Control	Process Systems Modelling and Design
Thermodynamics	Process Heat Transfer	Chemical Reaction Engineering II	Advanced Materials Processes and Nanotechnology

University College London 2023 MEng Chemical Engineering Undergraduate Programme			
Year 1	**Year 2**	**Year 3**	**Year 4**
Physical Chemistry	Separation Processes I	Transport Phenomena II	Chemical Engineering Research Project
Computational Modelling and Analysis	Particulate Systems and Separation Processes II	**Advanced Safety and Loss Prevention**	Chemical Engineering with Chemistry Research Project
Engineering Challenges	Chemical Reaction Engineering I		Chemical Engineering with Engineering Mathematics Research Project
Design and Professional Skills 1	Process Design Principles		Integrated Downstream Processing
Mathematical Modelling and Analysis 1	Mathematical Modelling and Analysis II		Sustainable Industrial Bioprocesses and Biorefineries
			Bioprocess Systems Engineering
			Fundamental Biosciences
			Bioprocess Research Project
			Advanced Bioreactor Engineering
			Biochemical Engineering Laboratory
			Topics in Modern Chemistry
			Mathematical Methods 4

As you can see, these two universities are ranked among the top five in the United Kingdom for chemical engineering. Also there may be some of these core modules such as design that may incorporate process safety but I personally don't think it's sufficient. I believe that our universities could place a bit more emphasis on integrating process safety content into the curriculum for undergraduates. Students wanting to pursue careers in operations management will benefit from all of the core chemical engineering modules, but it is the application of process safety that will make them effective leaders in operations.

As the report highlights that students developed the bulk of process safety competence during placement /post-graduation work experience. However, due to the competitive nature of the

placement industry, not all students will be able to obtain a placement, putting them at a disadvantage in terms of process safety competence when they are working as early professionals in industry.

From the report, it's good to see that there is an interest from Chemical Engineering departments on involvement in teaching Process Safety to undergraduates. Seminars such as the S&LP SIG University Process Safety Workshop will be very useful not just for the students but also the volunteering participation, particularly by young professional volunteers as they can pass on their experiences. Overall, increased IChemE member involvement in undergraduate process safety teaching will help bridge the gap. Regarding early and mid-career professionals, I believe mentoring and, as the report notes, application of a flexible competence framework will be useful.'

These are some of my thoughts, and overall it was a good detailed report!

4.9.5 Other Professions

A past nominee from the Chartered Institute of Ergonomics and Human Factors (CIEHF) Professional Affairs Board (and past regulator) was struck by the similarity of findings and recommendations within the Interim Report and their concerns within CIEHF at the time. They provided the following feedback:

'*I am in awe of your competence project – you've clearly put a huge amount of work in and still intend to do much more. It's interesting that your recommendations from this first phase tally very closely with the concerns of the CIEHF's Professional Affairs Board (when last I was on it) i.e.:*

- *A need for greater involvement of HF professionals in undergraduate teaching on engineering courses (as well as HF /Erg courses). This has been reinforced recently in conversation with some MSc Process Safety students bemoaning the lack of HF on their formal course! However, I think one of the issues for university departments is that they just don't pay competitively so it depends on them finding contacts with people prepared to give back to the industry.*
- *A need to engage and provide development for semi-retired professionals, doing much of the volunteering and engaging with driving the profession forward I had a concern that it's mostly men doing this and there is some self-selection going on amongst experienced female professionals not wishing to put themselves forward as experts – or perhaps just not nerding out on the minutiae. I don't know if you spotted a gender difference?*
- *Low uptake of technical membership routes (linked to a difficulty in getting mentors and lack of knowledge of opportunities I think). The Energy pathway has changed this somewhat as it qualifies people to technical membership level and beyond. As a regulator we pushed it to the chemical industry and they've had quite a lot of uptake. I think there's about 400 people on it now. Simon Monnington developed it when at BP, and the CIEHF and Energy Institute have cooperated on making it available to the wider public. Simon's a genius! Basically it's a way of developing in-house competence without having to pack people off to university for a year. It's intensive and it's good quality. Is there room for IChemE to develop a similar on-line learning provision for Process Safety?*
- *A need to explain the requirements for Fellowship – which I think they have done quite a lot of work on, but still remains something of a grey area. The main criteria are in leading teams and having supervisory responsibility; and making a difference to the profession as a whole.*

*I really like the concept of journey maps as a data collection method – I'd love to see them if you manage to sort that ou*t.'

5. DISCUSSION

The member survey results combined with the wider findings from Part 1 of this project support the conclusion that:

Process Safety is core to Chemical Engineering.

Therefore, if the above conclusion is true then it is key for IChemE to provide leadership.

IChemE resource constraints are recognised by the project, therefore it is necessary to determine how to facilitate improvement by harnessing and organising all available resources, relationships and networks efficiently and effectively.

Five cross cutting themes which apply to all career phases project that can assist IChemE in providing leadership are:

1. The need to review, evaluate and understand the relationship of PS to and within chemical engineering
2. Provision of a competence framework for the whole career of a chemical engineer
    a) Recognising that there are many pathways and the framework must be have adequate breadth and depth
    b) Facilitating and supporting the overlap /crossover and pathways between chemical engineering and process safety
    c) Recognising that PS is a very broad topic and can be studied in depth for life, in many different ways
    d) A framework that is capable of being applied to recognise depth and PS specialisation as well as broader contribution via being a chemical /process engineer or being a manager /director of process safety /HSSE /Operations /Engineering /Company /Regulator.
3. What is the PS competence standard applicable for a particular individual at a particular career phase?
    a) Where is it defined?
    b) How is it communicated?
    c) How does it evolve and adapt?
    d) Use whole career competence framework to address gaps and inconsistencies
4. Are the pathways to PS competence development and assurance for chemical engineers adequate?
    a) Balance of theoretical and practical (experiential and applied) learning and assessment
    b) Technical and Non Technical Skills
    c) How do pathways evolve and adapt?
    d) Use whole career competence framework to address gaps and inconsistencies
5. Professional networks and member engagement and support
    a) Role of IChemE
    b) Role of IChemE members
    c) Role of Universities
    d) Role of employers
    e) Role of Industry and Professional Forums
    f) How can IChemE improve effectiveness for all members?

5.1 RELATIONSHIP BETWEEN CHEMICAL ENGINEERING AND PROCESS SAFETY

Prior to the Professional Process Safety Engineer (PPSE) qualification, process safety was integral to professional chemical engineer career development. Chemical engineers who wanted to become chartered were required to demonstrate minimum core competencies for process safety and environmental protection combined with a minimum of further competencies to demonstrate sufficient breadth and depth. Chartered chemical engineers could then choose to specialise in safety and loss prevention (process safety) and /or environmental protection and apply to join the respective specialist register(s). Therefore, meeting chartered chemical engineer competence requirements was required prior to applying for such specialist recognition. The safety and loss prevention register required competence to be demonstrated, refereed and attested similarly to PPSE and the range and depth of competencies was very similar. This pathway presented process safety and environmental protection as further development pathways for professional chemical engineers rather than as a 'different' development pathway purely focussed on process safety and potentially bypassing demonstrating the range of competencies required of a professional chemical engineer. This change in professional qualification pathways available for professional chemical engineers and process safety raises some interesting discussion questions:

1. Is there a possibility that the divergence of process safety from chemical engineering by introducing the PPSE direct qualification option has diluted /weakened the links between chemical engineering and process safety?
2. How to ensure that there is adequate process safety within chemical engineering career pathways without (necessarily) specialising in process safety?
3. Has this change in pathways separated the 'risk assessment' aspects of process safety from the core inherent safety design principles and understanding of hazards, design basis and basis of safety at the core of chemical engineering?
4. Has it become less clear to IChemE, members and wider stakeholders how chemical engineering relates to process safety?
5. How can IChemE ensure that the different varieties ('flavours') of process safety are incorporated within professional pathways available via IChemE?
6. Is the PPSE a process safety qualification for non-chemical engineers? i.e. able to achieve PPSE without fulfilling the requirements of a chartered chemical engineer?
    a) Is the above an odd thing for IChemE to have done? (However inadvertently)
7. Will offering chartered engineer status for PPSE further exacerbate any current divergence and weakening of links between chemical engineering and process safety?

Further to the above discussion points, it was reported at the November 2023 MHC meeting that 65% of abstracts received for Hazards conferences are from non-IChemE members. Historical data has not been requested or reviewed, however this is quite a striking figure.

The above discussion points suggest that IChemE should review how it presents PPSE in relation to MIChemE and ensure that the core chemical engineering content of process safety does not get lost from the development pathways available to chemical engineers or process safety professionals who want to obtain an IChemE professional process safety qualification as opposed to (for example) a safety and reliability professional qualification from SaRS that is not engineering discipline specific. IChemE's process safety competence standard would be expected to be different to that of non chemical engineering focussed professional bodies as it should include sufficient overlap between chemical engineering and process safety competencies demonstrating understanding and application in topics such as:

- Design Envelope (Basis of Design)

- Safe Operating Envelope (Basis of Safety)
- Inherent safety design principles
- Chemical, physical, toxicological properties and how they relate to process hazards
- Chemical reaction hazards
- Overpressure and underpressure hazards
- High and low temperature hazards
- Material and substance compatibility
- Hazards arising from particular unit operations, substances and process /plant equipment
- Benefits and limitations of alternative protective measures in terms of engineering attributes and considerations
- Engineering substantiation of processes, equipment and protective measures.

5.2 CHEMICAL ENGINEER CAREER COMPETENCE FRAMEWORK

Figure 20 provides a summary illustration of the various pathway options during a Chemical Engineer's career. It is recommended that a competence framework is developed that is sufficiently flexible to be applied throughout. Guidance and support should guide IChemE members to the appropriate career phase as AIChE and CIEHF competence frameworks do. Individuals may leave and return to chemical engineering throughout their career for professional or personal reasons. IChemE's competence framework should support individuals to refresh and re-establish their competence. Similarly, individuals who choose to specialise, start a business or change their employer /sector /role should be able to access guidance and support which enables them to develop /retain appropriate PS competence.

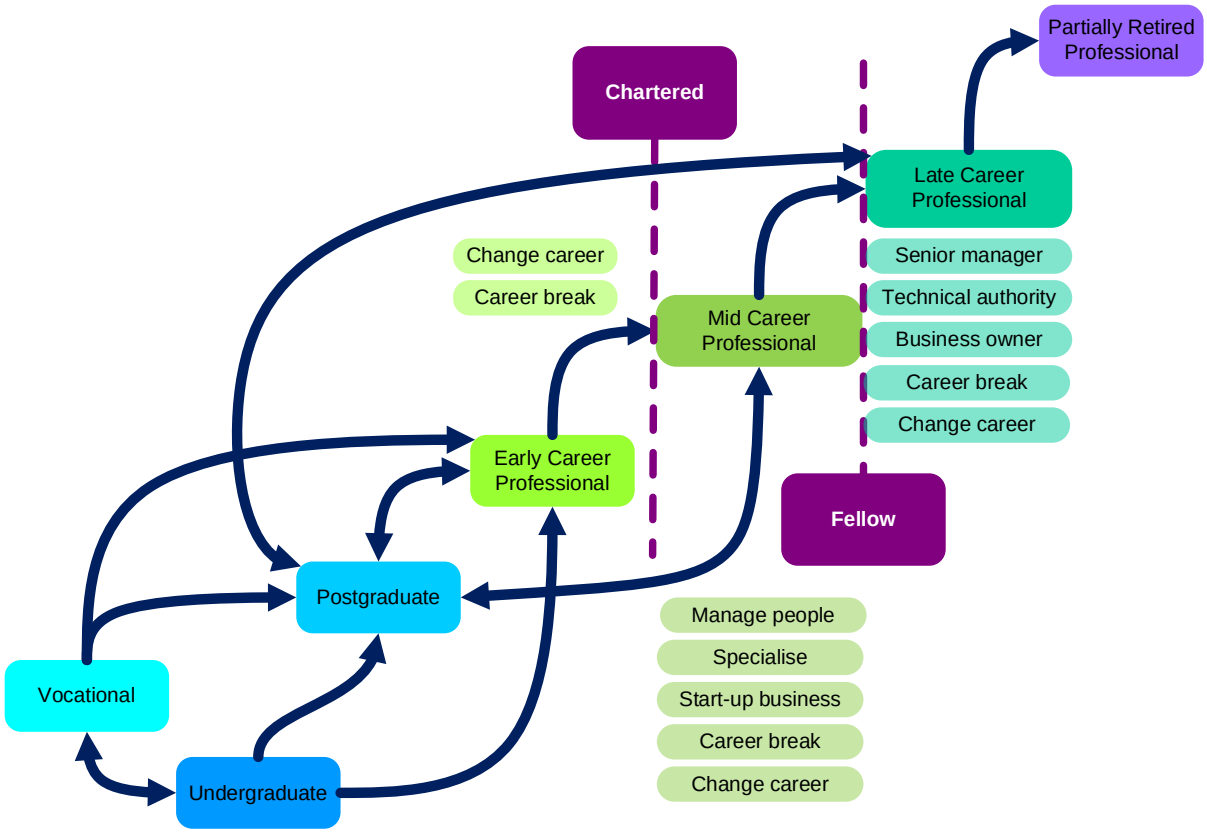


Figure 20 – Summary Illustration of the Various Pathway Options During a Chemical Engineer's Career

It is suggested that IChemE could learn from other professional institutions such as CIEHF to develop a whole career competence framework that can be applied to all membership grades and with reference to PS competence standards available inside IChemE and external to IChemE such as AIChE /CCPS.

5.2.1 CIEHF

Appendix F includes the CIEHF's Professional Competencies Checklist which covers all career phases and can be used in conjunction with a (provided) proficiency scale to show progress in breadth and depth of skills and expertise as an individual's career develops. The framework covers all membership categories of:

- Student Member
- Graduate Member
- Registered Member (Chartered)
- Technical Member and
- Fellow (also confers chartered status if not held already)).

The framework enables individuals to keep an ongoing record of the breadth and depth of competencies and to identify gaps and priorities for CPD. This approach to a competence framework that is flexible with respect to the combination of competencies, breadth and depth is common within major hazard sectors that have developed a competence framework across job roles and grades. The framework is used for designating qualifying degree courses and the expectation is that graduates should have at least an awareness of each competency. Six

levels of proficiency are defined that apply for each competency and in terms of the focus for professional development:

0 – Unaware

1 – Aware

2 – Novice

3 – Intermediate

4 – Advanced

5 – Expert

The above proficiency levels and breadth of professional competencies are then mapped (as a guide) to each membership grade along with indicative expected length of time in practice as reproduced below in Table 12.

Table 12 – CIEHF Guide to Competency Proficiency Against Membership Grades

Grade of membership being applied for	Expected length of time in practice	Breadth of professional competencies	Expected range of proficiency level
Student Member	–	–	0 – 1
Graduate Member	On graduation	100%	1 – 3
Technical Member	2 years	60%	1 – 4*
Registered Member	Minimum 3 years	100%	2 – 4**
Fellow	10 years	100%	3 – 5

* Applicants must have proficiency levels 4 – 5 in all competencies in one section and at least proficiency level 1 across the other sections

** Applicants must have proficiency levels 3 – 5 in the majority of competencies and at least proficiency level 2 in all the rest

The competencies are organised into five groups:

1. Ergonomics /Human Factors principles
2. Ergonomics /Human Factors theory and practice
3. Human capabilities and limitations
4. Design and development of systems
5. Professional skills and implementation

CIEHF encourages membership applications by career phase:

- Early career professional (Graduate Member)
- HF specialist in a particular sector (Technical Member)
- Working across the discipline (Registered /Chartered Member) and
- Leader in human factors (Fellow and Chartered).

5.2.2 AIChE

AIChE provide recognition of process safety competence via the CCPS Process Safety Fundamentals Certificate (CCPSf). It provides a means to recognise further development of process safety competence for chemical engineers. Note, this is different to the specialised process safety qualification provided by CCPS of CCPS Certified Process Safety Professional, which is analogous to the IChemE PPSE qualification and is open to all that meet the

requirements i.e. it is not focussed on chemical engineers. However, the CCPSf can provide a pathway for chemical engineers who are working towards CCPSC. The CCPSf requires completion of 24 Safety and Chemical Engineering Education (SAChE) courses grouped into five sections of 3 to 6 courses each:

- Level 1: Process Safety Basics
    - ELA 950 Introduction to Process Safety
    - ELA 951 Hazard Recognition
    - ELA 952 Identifying and Minimizing Process Safety Hazards
    - ELA 953 An Introduction to Managing Process Safety Hazards
    - ELA 954 Introduction to Lab Safety
    - ELA 975 Process Safety Ethics – A Brief Introduction (Level 3)
- Level 2a: Introduction to Hazards
    - ELA 961 Toxicological Hazards
    - ELA 962 Chemical Reactivity Hazards
    - ELA 963 Fire Hazards
    - ELA 964 Explosion Hazards
    - ELA 965 Source Models
    - ELA 967 Atmospheric Dispersion
- Level 2b: Understanding Risk
    - ELA 969 Understanding Hazards & Risk
    - ELA 970 Hazards and Risk: What Can Go Wrong?
    - ELA 971 Hazards and Risk: Introduction to Pressure Protection
    - ELA 973 Hazards and Risk: Safeguards Other Than Relief Systems
    - ELA 974 Hazards and Risk: Introduction to Hazard Identification and Risk Analysis
- Level 3a: Practical Applications for Managing Risk
    - ELA 980 Review Using Layer of Protection Analysis (LOPA)
    - ELA 984 Inherently Safer Designs
    - ELA 985 Practical Process Safety 1
    - ELA 987 Practical Process Safety 2
- Level 3b: RBPS (Risk Based Process Safety) Pillars
    - ELA 995 Risk Based Process Safety – Commit to Process Safety
    - ELA 997 Risk Based Process Safety – Manage Risk: Operations
    - ELA 999 Risk Based Process Safety – Learn from Experience

There is much overlap between the above list and the suggested topics for undergraduate chemical engineering process safety content and delivery provided in Appendix G (topics reproduced below):

- Key process hazards and underpinning science (overpressure, underpressure, toxicity, eco-toxicity, radiation, flammability limits, fire, explosion, ignition energy)
- Design Envelope (Basis of Design) and Safe Operating Envelope (Basis of Safety)
- Process safety through a facility lifecycle (Hazard Studies 1 to 6)
- Professional engineering ethics, non-technical skills, performance standards
- Hazard identification (Hazard Study 1, 2, 3 (HazOp), FMEA, What-if)
- Chemical reaction hazards
- Inherent safety
- Consequence assessment (harm criteria, types of people and environmental receptor, use of simple models to determine extent and severity, source pathway receptor model)
- Likelihood assessment (reliability, availability, maintainability, survivability, redundancy, diversity, independence, interdependence, fault and event trees)
- Hazard evaluation (barrier analysis, hierarchy of controls, design of protective measures)
- Risk assessment (with and without Risk Reduction Measures, ALARP, SFAIRP, IChemE 'Guidance on Risk')
- Different forms of protective measures: Mechanical, Instrumented Functions, Programmable
- Human and organisational factors (human performance models, PIFs /EPC, PSMS models, PDCA, performance metrics, process safety culture, control of work (PTW), management of change)
- Incident investigation and learning from incidents
- Regulatory framework
- Case studies illustrating all of the above

5.2.3 Non-Technical Skills

Non Technical Skills have long been established as required for effective execution of critical roles, activities and tasks within sectors such as aviation, offshore oil and gas and healthcare.

Flin et al (2008) summarise NTS as '*the cognitive, social and personal resource skills that complement technical skills, and contribute to safe and efficient task performance*.'

Flin and Maran (2015) summarises NTS main categories as:

- Situation Awareness
- Decision Making
- Communication
- Team Working
- Leadership
- Managing Fatigue

The above NTS can apply to front line response to incidents and also planned and proactive work such as facilitating /chairing multi-discipline process safety studies or process design and project management.

Essentially NTS can constrain or enhance technical skills and knowledge during task execution. Therefore, NTS should be incorporated within a whole career competence framework for chemical engineers. Note: The IChemE Undergraduate and Postgraduate Programme Accreditation guidelines do include learning outcomes related to NTS in a general way rather than relating to specific tasks and it is unclear how they are assessed e.g. use of

behavioural markers is the proven means to assess NTS proficiency within other disciplines and fields.

5.2.4 Summary

Combining a whole career approach to chemical engineering process safety competence, including specialisation, with a set of suitable overarching PS competencies could greatly simplify, streamline and make more accessible the defined competence standard for each career phase and individual members. The development of such a career competence framework and incorporating content from existing IChemE and external competence standards would enable provision and application of clear competence standards for all career phases and career pathways.

5.3 PROFESSIONAL NETWORKS, MEMBER ENGAGEMENT AND SUPPORT

A strong theme throughout Part 1 of the project has been the importance of professional networks to support a wide range of activities including coaching, mentoring, discussion of career and professional development options. The changed employment landscape for chemical engineers over the past 20 to 30 years has led to many more being employed by SMEs and by non-traditional chemical engineering employers.

IChemE as the professional institution has many options for members to become involved and to network via SIGs (now free to join), regional groups, editing journals, organising events, forum membership, peer review, member application assessment, external mentoring and other committees and groups. However, a look at the IChemE's volunteering opportunities webpage suggests that there is a lack of available volunteers versus the roles available.

Time constraints are often the reason that members do not choose to seek volunteering roles in addition to a full time job and non work commitments /activities. However, when approached directly, individual members are often keen to get involved and support clearly defined and discrete activities such as the S&LP SIG University Process Safety Workshops. Often early and mid career professionals are reluctant to put themselves forward as they can feel intimidated by late career or partially retired professionals. It is essential that the need for a diverse volunteer base is emphasised and reinforced.

Volunteer recognition by IChemE is recommended to facilitate increased and wider member engagement. The recent (December 2023) IChemE Volunteer digital badge scheme was a good initial step.

Facilitation of member to member networking, particularly across career phases could be a key role for IChemE. Early, mid, late career and partially retired professionals could all usefully and beneficially contribute to supporting greater engagement of undergraduate students and their tutors. It is emerged during the project that there are multiple examples of individual members lecturing and tutoring at one or more universities via arrangements they have organised directly.

Professional networks evolve and adapt throughout an individual's career but remain present. Therefore, they provide a consistent vehicle for IChemE to engage with the whole membership if able to aid facilitation and development.

IChemE is a member of networks such as the Hazards Forum, PSF and CDOIF with varying levels of engagement and links into the wider membership communities and membership. Given IChemE resource constraints, leveraging improvement via these wider networks and ensuring IChemE representation could achieve greater impact than IChemE can acting alone.

Findings from the project indicate that members would like more resources to be available from IChemE. There are many resources available via the IChemE website, however it can be difficult to navigate and find useful search results and /or a particular item. There could be greater consolidation of resources available for learning and career support organised more

by potential user groups. For example, AIChE has the Institute for Learning and Innovation (ILI) with resources organised for the three user groups:

- **Learners** by career phase from school student through undergraduate, graduate, early career, mid career, leadership
- **Educators** from school teachers onwards, providing resources to enhance engineering and STEM education
- **Employers** for AIChE training courses with a link to recruitment.

The ILI comprises four 'pillars' of the following services /resources:

- **Career Discovery** – Aids members to identify and achieve their career path including tools for career coaching, networking, interviewing and career insights.
- **Academy** – Training courses and webinars
- **Practice+** – Provides learners with industry placement and competition opportunities
- **Credential** – Certification of proficiency in particular topics including process safety as an area of specialisation.

5.4 FINDINGS FOR SPECIFIC CAREER PHASES

The project so far has highlighted two career phases in particular that could benefit from further strengthening of arrangements for competence development and assurance:

- Undergraduate
- Late career professional

These are discussed further below.

The vocational IChemE route currently has limited use, there were 38 Technician Members in 2022. This could be a growth area for IChemE and for developing and assuring process safety competence within industry via IChemE interactions and engagement and this career phase is discussed further below.

The career phase that appears to be the best defined, understood in terms of process safety competence standard and the means to achieve; it is the early career professional the goal of chartership provides the clear requirements and also guidance on how to achieve them.

Mid-career professionals are typically supported by IChemE and employer CPD arrangements and this is a phase of consolidation after achieving chartership (or equivalent).

Several of the points and suggested recommendations for undergraduates apply to postgraduates.

Partially retired professionals provide valuable volunteering time across a wide range of SIGs as well as often delivering IChemE training courses. Therefore, this IChemE member population is important to develop and retain engagement for as long as they wish to contribute.

5.4.1 Vocational Career Phase

The vocational career phase has very low membership currently (38 in 2022) and is a potential touchpoint for IChemE via Level 3 (Technician level as opposed to Operator level (2)) Apprenticeships and professional qualification under the broad heading of Science Manufacturing Technician as is the case for bulk storage technicians via Reynolds Training.

In the UK, currently all process sector apprenticeships funded via the Apprenticeship Levy scheme are under review and revalidation. Therefore, there is an opportunity for IChemE to

link with other Level 3 Technician apprenticeships that are currently going through the process including:

- Polymers
- Pharmaceutical
- Life sciences

Many of the most proficient and effective engineers in other disciplines began their career as a technician and progressed through to chartered engineer. Interacting directly with processes and equipment provides an excellent foundation for a professional chemical engineer.

The vocational career phase has been discussed with multiple stakeholders including the PSF, CIA, TSA, Reynolds Training, Cogent Skills and individual chemical engineering technicians. There was unanimously strong support for IChemE supporting and promoting this career phase much more and recognising the great value that a more diverse IChemE membership would bring to the profession.

5.4.2 Undergraduate Career Phase

The project has several findings relating to this phase that suggest that there are opportunities for improvement:

- Engagement with IChemE is often low amongst the student population. This means that they are often unlikely to engage with member bodies such as the S&LP SIG, EdSIG or regional member groups and unlikely to attend webinars and events. Therefore, student interaction with chartered members is limited, which reduces opportunities to network and to develop process safety relevant knowledge and skills. Improving engagement will benefit students, IChemE (as a Learned Society and as a membership based organisation) and graduate employers.
- The process safety content within UK accredited courses is often dependent on staff industrial experience. Therefore, the process safety content shared with students varies and is often limited to discrete subjects and applied tasks (such as HazOp) associated with the final year design project.
- UK students and recent graduates sampled thought that they developed limited process safety competence within their undergraduate degree and developed most of their process safety knowledge and skills during a placement year and /or their first graduate role. However, industrial placements are much fewer since the move to paid tuition fees (students typically are still charged by the University during their placement year) and four year taught MEng degrees (increasing the overall course length to five years if a year industrial placement is included).
- UK chemical engineering departments would welcome IChemE involvement in organising process safety related seminars. The S&LP SIG University Process Safety Workshops are well regarded and received by participating institutions. The career snapshots by early career professionals are a highlight for the students combined with the presentation topics and volunteer supported HazOp workshop session.
- Appendix G includes a proposal for undergraduate chemical engineering process safety content and delivery.

5.4.3 Late Career Professional Phase

There was specific WG discussion session requested and conducted on the Fellow membership grade. The main points from this discussion are summarised below:

- Perceived barriers to Fellowship:

    - Understanding of what is a senior enough role and holding a position of responsibility. How the requested organisation chart is used in the evaluation process.
    - The way that the requirements are written including the importance of having a number of direct and indirect reports.
    - On the IChemE website it can be perceived that almost have to be a professor (if working in academia) to apply for Fellow and this deters applicants.
    - What is the point of Fellow? This does not appear to be well understood.
    - What is the value that Fellow adds? To members, the chemical engineering profession, IChemE, society.
    - Many late career professionals do not feel that Fellow applies to them.
    - One example was provided of a rejected colleague who was very demotivated by the impersonal experience There was no conversation or interview. The feedback received was that they had not been in a senior position long enough. On the application, they had not written that they had been in a specific role for a defined number of years, however it was in the provided CV. The feedback e-mail stated that the time period must be 5 years.
    - A WG member was rejected first time and received a one line e-mail. They re-applied after a little more experience in the same role and were successful.
- For more senior positions, having Fellow can differentiate applicants as can chartered.
- As a Fellow, there is the opportunity to give back to the profession.
- Could requirements be rephrased?
- Do IChemE want to keep Fellow small and select?
- Or do IChemE want to encourage people to develop into and apply for Fellow?
- Fellow requirements appear to be written to indicate that the grade does not have a technical focus but is leadership focussed; this can be perceived as a barrier by late career professionals who provide technical leadership e.g. Technical Authority.
- Is the Fellow grade perceived as elitist /exclusive rather than inclusive?
- There is a danger of turning people off IChemE post Fellow rejection and they may switch professional institution /reduce or stop volunteering.
- There is no process safety competence requirement within Fellow grade guidance or application form questions.
- The Fellow application guidance is not structured around competencies and demonstrating via evidence.

The above points were discussed with IChemE's Director of Qualifications and the potential for reviewing Fellow requirements explored. There is potential scope and appetite for IChemE reviewing approaches for improving engagement of late career professionals and providing an objective beyond chartered status, such as Fellow that is:

- Understood;
- Is accessible to appropriate candidates; and
- Potentially more competence based (in particular utilising a flexible competence standard that includes Non Technical Skills such as leadership).

Comparison with other professional bodies:

- See Appendix F for how CIEHF defines Fellow grade competence (NB also registered and chartered professional).
- As another comparison, the AIChE describes Fellows as:

    - An important resource for AIChE in providing experience-based guidance to leadership and members, as well as contributing to the activities of many AIChE entities.
- AIChE election to Fellow is based on contributions made to the engineering profession and significant accomplishments in engineering. Both ‘professional attainment’ and ‘engineering achievement’ were used in the criteria. The former included contributions to the advancement of fellow chemical engineers and the engineering profession. The latter was to be based on engineering practice, process developments, or leadership in projects or product development, and managerial techniques for bringing engineering efforts to fruition. Technical publications, patents, and theoretical developments also would be satisfactory evidence of engineering accomplishments. The major contribution could be in either engineering or service to the profession, but it was preferred that some accomplishments be present in both areas.

6. RECOMMENDATIONS

Recommendations from Part 1 of the Project are summarised in Table 13 by Theme or Career Phase.

Following conclusion of Part 1, it is intended to agree the basis for Part 2 – Assuring Competence in Process Safety for Process Safety Professionals and for Part 3 (Organisational Process Safety Competence) to follow on from conclusion of Part 2.

Table 13 – Summary of Recommendations from Part 1 of the Process Safety Competence Project

Ref.	Theme /Career Phase	Recommendation
1.	**Relationship between chemical engineering and process safety**	
1.1		Review, evaluate and understand relationship of process safety to and within chemical engineering e.g. by mapping knowledge, skills and behaviours
1.2		Feed forward into Part 2 of the project: Assuring Competence in Process Safety for Process Safety Professionals, consideration of the different varieties (flavours) of process safety professional dependent on their background discipline and professional development pathway.
2.	**Chemical Engineer career competence framework and competence standards**	
2.1		Develop and provide a competence framework for the whole career of a chemical engineer that incorporates process safety competence standards: a) Utilising assessment of breadth and depth of competencies b) Facilitating and supporting the overlap /crossover and pathways between chemical engineering and process safety c) Recognising the breadth and depth available in process safety and chemical engineering d) Capable of being applied to recognise depth and process safety specialisation as well as broader contribution via being a chemical /process engineer or being a manager /director of process safety /HSSE /Operations /Engineering /Company /Regulator e) Utilise examples from other professional bodies such as CIEHF
2.2		Review the process safety content of chemical engineer career phase competence standards using existing IChemE competence standards and guidance and relevant competence standards external to IChemE IChemE's process safety competence standard should include sufficient overlap between chemical engineering and process safety competencies demonstrating understanding and application in topics such as: a) Design Envelope (Basis of Design) b) Safe Operating Envelope (Basis of Safety) c) Inherent safety design principles d) Chemical, physical, toxicological properties and how they relate to process hazards e) Chemical reaction hazards f) Overpressure and underpressure hazards

Ref.	Theme /Career Phase	Recommendation
		g) High and low temperature hazards h) Material and substance compatibility i) Hazards arising from particular unit operations, substances and process /plant equipment j) Benefits and limitations of alternative protective measures in terms of engineering attributes and considerations k) Engineering substantiation of processes, equipment and protective measures.
2.3		Ensure that the developed competence framework provides adequate pathways to process safety competence development and assurance for chemical engineers including: a) Balance of theoretical and practical (experiential and applied) learning and assessment b) Technical and Non Technical Skills c) The flexibility to allow pathways evolve and adapt
3	**Professional networks, Member engagement and support**	
3.1		Review how IChemE facilitates professional networks for individual members and opportunities to increase the span and improve the quality of engagement. This recommendation is expected to tie into ongoing work by IChemE on member engagement.
3.2		Review IChemE participation and leverage within wider networks such as the Hazards Forum, PSF and CDOIF and the extent and quality of links into the wider membership communities and membership.
3.3		Review how resources provided by IChemE online could be consolidated and organised more by potential user group and service /resource offering to aid navigation and increase access and application by the membership. Utilise examples and learning from other professional bodies e.g. AIChE
3.4		Contribute to Hazards Forum Group of Interest 2 (Engineering Systems Hazards) including an event on NTS in 2023 and on the new Building Safety Regulator in 2024. Note: this is progress as an outcome of this project.
4	**Vocational**	
4.1		Review priority and approach to IChemE support and promotion of the Engineering Technician membership grade within the vocational career phase. In particular all Level 3 Science Manufacturing Technician UK Apprenticeships and Professional Qualifications.
5	**Undergraduate (and Postgraduate)**	
5.1		Make the training materials of the IChemE Training Course Fundamentals of Process Safety (FOPS) available to institutions offering IChemE accredited chemical engineering undergraduate and postgraduate courses
5.2		Embed the ISC recommended learning outcomes in process safety education (ISC, 2018) within IChemE accredited undergraduate and postgraduate courses.

Ref.	Theme /Career Phase	Recommendation
		It is recommended that institutions undertake a gap analysis similar to Imperial's as the first step[3].
5.3		IChemE to work with internal and external stakeholders to: a) Identify available facilities and delivery methods b) Develop and c) Provide opportunities for practical, experiential learning (e.g. as a summer school) at a facility /facilities such as CATCH (expanding and scaling the initiative already introduced by Leeds University and similar to the civil engineering /built environment initiative at Constructionarium). This initiative has the potential to: • Improve IChemE engagement amongst the student population • Provide a wide range of opportunities for developing and improving practical chemical engineering and process safety knowledge and skills • Provide an opportunity for engaging with potential employers who may sponsor such an initiative • Provide an opportunity for interacting with other engineering disciplines
5.4		Increase and improve IChemE member involvement in undergraduate process safety teaching (e.g. via recommendation 5.3 and 5.5) and experience provision (e.g. year or summer placements). Volunteer recognition by IChemE is recommended to facilitate increased and wider member engagement. The recent (December 2023) IChemE Volunteer digital badge scheme was a good initial step.
5.5		Increase S&LP SIG University Process Safety Workshops in the UK and internationally. There were two additional institutions (to the three existing London institutions) in 2023: • UAE • Lancaster
6	**Fellow**	
6.1		Review and revise Fellow competence standard to include defined competencies relevant to process safety including Non-Technical Skills (NTS) e.g. process safety leadership, coaching and mentoring of undergraduates, early and mid-career professionals as well as technical process safety knowledge, understanding and skills. The Fellow application process should require demonstration of meeting the required competence standard. a) It is recommended that it is a flexible competence framework, with respect to breadth and depth, that can be applied to the very wide range of roles that apply to become a Fellow of IChemE. b) Utilise examples and learning from other professional bodies e.g. CIEHF, AIChE

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APPENDIX A – MEMBER SURVEY QUESTIONS

1. Which phase best describes your current career stage?
    - Undergraduate
    - Postgraduate
    - Vocational
    - Early Career Professional
    - Mid-Career Professional
    - Late Career Professional
    - Partially Retired Professional

2. Do you agree with this definition of competence (Source IAEA 1996, emphasis added)?

> The **ability** to put **skills** and **knowledge** into **practice** in order to perform a job in an **effective** and **efficient** manner to an **established standard**

    - Strongly agree
    - Agree
    - Disagree
    - Strongly disagree
    - Yes

3. How important do you think Process Safety Competence is to a Chemical Engineer? Please select your level of agreement for each statement
    - Essential and core throughout
    - Dependent on role
    - Dependent on sector
    - Dependant on career stage
    - Minimal, leave to the process safety specialists

4. Do you agree that the process safety competence standard for your career phase is clearly defined?
    - Strongly agree
    - Agree
    - Disagree
    - Strongly disagree

5. Where is the process safety competence standard for your career phase defined? Please select all that apply
    - IChemE
    - Academic curriculum
    - Employer
    - Industry Association
    - Other

6. Where do you source information and support to help you develop and retain process safety competence? Please select importance for all items (High / Medium / Low Importance)
    - IChemE Training
    - Academic courses
    - Safety and Loss Prevention Special Interest Group

- Loss Prevention Bulletin
- Hazards Conference
- PSEP journal
- IChemE Safety Centre
- Employer internal training
- Employer external training
- Regulators
- Professional network
- Coaching /mentoring
- Literature (standards, guidance, books and papers)
- Internet search
- Other professional body – Please define below
- Industry association – Please define below
- Other – Please define below

7. Please list the other professional bodies, industry associations and information sources which are important to you for developing and retaining process safety competence.
   Free text

8. How do you support other chemical engineers in developing and retaining process safety competence? Please select all that apply
   - Professional network
   - Coaching /mentoring
   - Teaching /lecturing
   - Training development and /or delivery
   - IChemE training
   - Safety and Loss Prevention Special Interest Group
   - Loss Prevention Bulleting
   - Hazards conference
   - PSEP journal
   - IChemE Safety Centre
   - Other professional body – Please define below
   - Industry association – Please define below
   - Other

9. What do you think are key process safety competencies for a chemical engineer? Please select importance for all items (High / Medium / Low Importance)
   - Understanding chemical reaction hazards
   - Understanding process technology hazards
   - Understanding of risk to individuals, public and environment
   - Systematic approach to safety in process design and operation
   - Ability to handle health, hazard and process safety aspects
   - Hazard identification
   - Assessment of consequences
   - Control of hazards
   - Risk assessment
   - Understanding and application of relevant Regulations
   - Protection of the public

- Protection of the environment
- Incident investigation
- Emergency planning
- Process safety management
- Influencing process safety culture
- Human reliability and performance
- Non-Technical Skills (NTS) https://research.abdn.ac.uk/applied-psych-hf/non-technical-skills
- Other – please define below

10. Please list any other key Process Safety Competencies for a chemical engineer

    Free text

11. Which process safety competencies have you applied within the past six months? Please select all that apply
    - Understanding chemical reaction hazards
    - Understanding process technology hazards
    - Understanding of risk to individuals, public and environment
    - Systematic approach to safety in process design and operation
    - Ability to handle health, hazard and process safety aspects
    - Hazard identification
    - Assessment of consequences
    - Control of hazards
    - Risk assessment
    - Understanding and application of relevant Regulations
    - Protection of the public
    - Protection of the environment
    - Incident investigation
    - Emergency planning
    - Process safety management
    - Influencing process safety culture
    - Human reliability and performance
    - Non-Technical Skills (NTS) https://research.abdn.ac.uk/applied-psych-hf/non-technical-skills
    - Other

12. To what extent do you think process safety competence requirements have changed (past) and will change (future)? Please select all that apply
    - Minimal
    - It is unclear
    - Limited change in specific aspects
    - Significantly less demanding
    - Significantly more demanding
    - Significantly different in content
    - Other

13. If you consider that requirements have changed and/or will change, please describe how and in what areas

    Free Text

14. What are the barriers to process safety competence? Please select all that apply
    - Not knowing what standard to aim for
    - Not knowing how to improve process safety competence
    - Insufficient availability of content and information
    - Insufficient time
    - Insufficient money
    - Not a high priority for current role
    - Not a high priority for employer
    - Other

15. How could IChemE facilitate process safety competence better? Please select importance for all items (High / Medium / Low Importance)
    - Better definition of process safety competence requirements
    - Improved /additional academic course content
    - Improved /additional IChemE Training courses
    - More guidance and resources available on the IChemE website
    - More webinars
    - More seminars
    - Webinar /seminar for own sector
    - Group sessions with a coach /mentor
    - Access to external mentors /coaches
    - Other – Please define below

16. Please list any other ways in which IChemE could facilitate process safety competence better
    Free Text

17. Is there anything else you would like to add on the subject of process safety competence for chemical engineers?
    Free text

APPENDIX B – CAREER PHASE TABLES (END OF DEC 2022)

Undergraduate	Chemical Engineering degree			
Expectations and Goals (What want to achieve)	**Individual Mindsets, Actions and Emotions**	**Opportunities, insights, inputs, measurements /assessments (The offering)**	**How differs for different users? (Need for more than one map)**	**Applicable /Available Process Safety Competence Standards**
Start				
Finding one's passion/interests	May feel lost and overwhelmed by the amount of options and not knowing what they want. Talking to other students, seniors, and alumni.	Mentoring program may be helpful to guide undergrads to the resources they need to learn more about themselves.	Exceptionally motivated individuals who know their goals well may also seek to take electives appropriately.	Plan a course curriculum with incorporated process safety modules/lessons.
Seeking to learn more about the roles and responsiblities of a chemical engineer	Looking up online the industries and job roles a chemical engineering degree can take them. Possibly, sign up to summer camps run by faculty to take to academics.	A sample job description or an opportunity to shadow a process safety professional. These days, "a day in a life" videos are handy to show a lot of undergrads at the same time a glimpse into a process safety role.	Those that grow up in a family of engineers or STEM professionals may have better connections to maybe attend a site visit, talk to professionals, or even an internship.	Plan a course curriculum with incorporated process safety modules/lessons.
Engienering Degree - don't know what I want to study within engineering	Feeling like you have no idea of what is to come, no idea wha	Courses that start to give you an idea eg. Thermodynamics, university site tours	Geography and different courses, different interests, life experience and purpose.	
		Student societies provide networking and industry insights. Student membership to EA and iChemE		
Middle				
Aiming to learn basic process safety tools and procedures	Anxious about conducting HAZOP studies.	IChemE's official HAZOP study videos/samples to assist undergards in conducting their own studies.		Plan a course curriculum with incorporated process safety modules/lessons.
Associate with recognised body (i.e. IChemE)		Student IChemE Membership.		
Gain understaning of Process Safety		S&LP SIG University Roadshow material		
	people, because what I want to do doesn't exactly exist or its hard to find and I don't 100% understand it myself.			
	lifecycle analysis, system design quanitifation of carbon, energy, waste stream flows.			
	Interested in circular economy and reducing waste, interested in sustainable economies rather than growth economies.			
End				
Looking to learn more on the steps to become a process safety professional	Reaching out to process safety professionals in the industry to find job opportunities and learn how to become certified/qualified for the position	Produce a career pathway brochure/flyer to share with universities or on the IChemE website	- Go on to do a Master's degree - Go on to become an operator or similar roles - Go on to do a graduate programme	Potentially a training course for undergraduates to specialise in process safety
	Really enjoyed design course overall. Felt disparate and stressed, but overall found the topic challenging and motivating that I can achieve and learn so much independently in such a short amount of time.			

Post Graduate	Chemical Engineering Masters or PhD			
Expectations and Goals (What want to achieve)	Individual Mindsets, Actions and Emotions	Opportunities, insights, inputs, measurements /assessments (The offering)	How differs for different users? (Need for more than one map)	Applicable /Available Process Safety Competence Standards
Start				
Seeks to learn as much as possible and be on as many new projects/opportunities as possibles	May seem themselves as "only a graduate" (have heard them say this so many times, self doubt)	Company graduate training programme (sometimes is offered). Opportunity for IChemE to develop a sample graduate training programme where there is not one, to help and provide direction at the start of their career	Exposure to process safety is dependent on the type of role they may have (e.g. engineering design v's operations), and the scale of project (e.g. small fee projects v's large international projects). May be in a team of only process engineers, may have limited exposure to process safety	Is this list likely the same for all users, as it is what we are trying to create? (i.e. list of competencies, and then level they need to meet at each stage of their career)
	May be living in a new city, move out of home, worried about fitting in and paying off student loan			
Gain Masters in Process Safety		IChemE accredited MSc Courses: University of Sheffield Risktec (online) University of Aberdeen		
Middle				
End				

Vocational Route (optional addition for later)	Apprenticeship / Technician		
Expectations and Goals (What want to achieve)	**Individual Mindsets, Actions and Emotions**	**Opportunities, insights, inputs, measurements /assessments (The offering)**	**How differs for different users? (Need for more than one map)**
Start			
Finding one's passion/interests	Shows clearly that he/she expects keeping to the procedures	Undertakes Process safety training course	Knows the operating procedures and that they may implement corporate or legal requirements
Seeking to gain knowledge and skills about the roles and responsibilities of competent process operator	Encourages reporting of deviations with regards process Safety	Participates in ICHemE Process safety spatial Interest groups	Ables to use process related knowledge and understanding to apply technical and practical skills.
looking forward to Obtain a qualification certificate in process safety	Demonstrates clear commitment to Process Safety standards	Undertakes undergraduate collage degree in chemical engineering	Ables to review, select and use appropriate technical techniques, procedures and methods to undertake (process or chemical engineering) tasks.
Gaining the basic knowledge of chemical engineering	Identifies how to deal with new ideas that affect own actions and work environment.	Submits application to Technician Member (TIChemE)	Ables to use appropriate scientific, technical and chemical or process engineering principles.
to be ablle to demonstrates his/her abilities against the five areas of competence required by IChemE for EngTech registration.	keens to follow the in-place practices and conventional approaches and seek alternatives that will improve own area of responsibility.	Learns about the different Process Hazard Analyses (PHA) techniques used at the workplace.	
	Recognizes personal responsibilities concerning compliance with the company' Process Safety Management standard.	Completes the additional training needed for aspects of work during the work placement (e.g. if special training is need before entering particular parts of the workplace).	
	Recognizes and uses formal structure, rules, processes, methods or operations to accomplish work.	Identifies how to use applicable professional standards and established procedures, policies and/or legislation when taking action and making decisions.	
	Demonstrates knowledge of workplace process safety culture		
Middle			
Aiming to learn basic process safety tools and procedures	Is adapted alternate solutions based on precedents within own department and areas of responsibility.	to be Involved in supporting existing Operations demonstrate knowledge about how Process Safety Hazards and Major Incident Hazards (process and non-process) are impacted through the performed work.	Plans a course curriculum with incorporated process safety modules/lessons.
Associatting with recognised body (i.e. IChemE)	Applies listening techniques and how to employ them.	Participates in Process Safety Hazard identification and Risk Assessment workshops (e.g. Process Hazard Analysis), Audits and assessments for their operations and projects (where practicable).	Ables to accept and exercise personal responsibility.
To Gain understanding and implementation of PHA techniques	Works effectively with colleagues, clients, suppliers or the public, and showed awareness of the needs and concerns of others, especially where related to diversity and equality.	Receives the employer's formal training in any specific hazards which apply to the work assigned during the work placement.	Ables to work reliably and effectively without close supervision.
To have the technical know-how to do the job and demonstrate that he/she use initiative and experience to solve a process problem or improve a process.	Has personal commitment to appropriate codes of professional conduct; recognising obligations to society, the profession and the environment.	Mentors or coach a junior professional to help them understand the importance of visible safety leadership	accepts responsibility for your work and that of others.
	Undertakes appropriate safety interventions to control risks	Actively engages in Process Safety activities throughout the organization in order to demonstrate a tangible commitment.	Reaching out to process safety professionals in the industry to find job opportunities and learn how to become certified/qualified for the position
	Involves his team and behaves in a manner that builds positive relationships within the workforce	Undertake appropriate infield safety conversations as part of a behavioural safety programme	

Early Career Professional	Working towards chartered status			
Expectations and Goals (What want to achieve)	**Individual Mindsets, Actions and Emotions**	**Opportunities, insights, inputs, measurements /assessments (The offering)**	**How differs for different users? (Need for more than one map)**	**Applicable /Available Process Safety Competence Standards**
Start				
Wish to become a chartered process safety engineer	May be seeking more/new experience in engineering design/chemial engineering to ensure they are gaining the skills needed to become chartered	IChemE mentoring programme, to put chartered engineers in-touch with early career professionals, to gain insight in others career pathways and opportunities, and advice on how to become chartered (this typically is offered within the engineering company, but may not be).	Exposure to process safety as an early career professional is dependent on the type of role they may have (e.g. engineering design v's operations), and the scale of project (e.g. small fee projects v's large international projects). May be in a team of only process engineers, may have limited exposure to process safety	At this point they will be focusing on the requirements of becoming chartered, so if there are elements of process safety that need to be met as a chartered chemical engineer, they should be included in the assessment
May not seek to become a chartered engineer, may wish to move more into a management role or other, depending on the opportunities the company provides	May be feeling limited in their role and seek new opportunities to continue to develop and beable to become chartered	Ensure there is a way to include process safety competency as part of the chartered memebership application		Is this list likely the same for all users, as it is what we are trying to create? (i.e. list of competencies, and then level they need to meet at each stage of their career)
		Engineering Council UKSPEC includes reference to safety - but IChemE could add clearer requirements around process safety for Chemical Engineers		
Become associate member if IChemE	Want to show commitment to continued growth and professionalism	Note: historically there was a process safety specific associate membership. No longer the case?		
Join company with clear training and competence committment - Chemical Engineering	Want to know that they are on a good path for development and opportunity	IChemE Accredited Company Training Schemes - helps trainees work to chartership		
Join company with clear training and competence committment - Process Safety Specialism	Want to know that they are on a good path for development and opportunity	IChemE Accredited Company Training Schemes - helps trainees work to chartership IChemE could offer more support.		
Find and develop interests in specific areas.	Be attentive, reflective and aware.	Courses		
Professional status – need clear requirements for what is needed/expected to reach professional status.	Pressure, finding time / lack of time for PDP, motivation.	Information on IChemE website, memberships. Example timeline or plan?		
Recognised qualifications in the industry.	Potential difficulty of courses, lack of experience.	Courses		
• Feel confident and happy in chosen career • Find personal niche/specialisation • Gain certification/recognition in that niche	• Overwhelming number of options/opportunities which can be difficult to figure out best choice • Self-doubt in own ability • External societal pressures to develop rapidly and stereotypically vertically up the management route rather than horizontally • Money worries re: course costs	• Courses/Workshops (online and face to face) • Industry mentor scheme • Networking events	I'm not sure if I've answered in the way that was expected as it's not very specific but being early in my career, my goals are fairly generic at this point.	
Graduate program	Feeling like I have so much to learn with my new job. New responsibilities are a little daunting. Want to find a mentor to help guide me through my career.	Finding a mentor through programs.	Consulting vs onsite graudate employement	
	Feeling overwhelmed everyone at work seems to be so efficient and capable and that I'm at the tip of an iceberg	Engineers Australia events on how to become accredited	Supportive seniors at work who help develop and invest time in their graduates	
		Internal company opportunities to develop skills whether technical, client based, communications, ect.		

Early Career Professional	Working towards chartered status			
Expectations and Goals (What want to achieve)	**Individual Mindsets, Actions and Emotions**	**Opportunities, insights, inputs, measurements /assessments (The offering)**	**How differs for different users? (Need for more than one map)**	**Applicable /Available Process Safety Competence Standards**
Middle				
Looking to grow Process Safety awareness	Recognise that Process Safety is Important part of Chem Eng	IChemE fundamentals of process safety training		
Looking to develop specific skills - human factors	Recognise that Human Factors is important	IChemE & Keil Centre Training https://www.icheme.org/career/training/human-factors-in-health-and-safety/		
Looking to identify what key skills are needed to be a competent process safety professional	I don't know what i don't know	The competence and committment guide for the Professional Process Safety Engineer provided some hint into what was expected - but this is no longer available on line that I can find. ISC - Process Safety Competency Guidance https://www.icheme.org/knowledge/safety-centre/framework/knowledge-and-competence/		
To make a meaningful impact to the safety risk of chemical processes at a plant, especially a change that can be seen in practice.	Desire to get the job done well and ensuring time pressures do not get in the way of safety. Working well in a team. Making sure pride does not get in the way and to utilise advice from people at all levels of a plant operation (from management to onsite operators).	Work on engineering projects where one can have input on the inherent safety from the ground level. Make suggestions, either during a meeting or outside of meetings via memos or email, that can improve the safety of a chemical process.		
End				
Apply for chartership having gained experience in many different areas.	become an 'intelligent customer' and understand enough to direct specialists to undertake the task on my behalf.	New job roles, new specialisms. Learning from peers and mentoring junior peers.	Contract or staff role, different types of businesses/sectors.	Not just formal training. Many job roles do not provide formal training or budget for it.

Mid Career Professional (Chartered)	Gaining further influence and responsibility			
Expectations and Goals (What want to achieve)	Individual Mindsets, Actions and Emotions	Opportunities, insights, inputs, measurements /assessments (The offering)	How differs for different users? (Need for more than one map)	Applicable /Available Process Safety Competence Standards
Start				
to be a recocnised process safety expert	Perform ideas or solutions that have worked in other work environments and apply them to own areas of responsibility. Appraise existing solutions in innovative ways to solve problems within own department and areas of responsibility. Review long-term consequences and secondary effects of potential solutions and ensure minimal conflict with in-place methods and	Promotes organizational mission and goals, and shows the way to achieve them.	Chartered member grade is widely recognized and demonstrate professional competence and commitment to employers, policy makers, regulators and society.	ICHEME performance standerds as the follwing: Applying process safety knowledge and understanding to practical situations Handling the wider implications of work as an PS engineer Gainstrong interpersonal, leadership and communication skills
	Verify compliance with The Company's process safety procedures. Achieve solutions acceptable to varied parties based on understanding of issues, climates and cultures in own and other organizations. Implement processes and structures to deal with difficulties in confidentiality and/or security. Ensure that decisions take into account ethics and values of the organization and Public Service as a whole.	attend process safety related conferences webinars to be UpToDate with the latest process safety studies, event, accident.	will gain strong knowledge and skill that help in performing your roles as process safety professional	
	Continuously adapts priorities in response to changing needs. Consistently achieve established expectations through personal commitment.	participate in conducting process safety awareness workshop to the liner manager to emphasize the importance of process safety in maintain safe operation.		
	Builds constructive working relationships characterized by a high level of acceptance, cooperation, and mutual respect.	lead process safety studies such as HAZID, Hazop, LOPA workshops, develop process safety report. and follow up the effective implementation of the recommendation arises from the process safety studies.		
	Lead staff/younger engineers in ways that improve their ability to succeed on the job. Leads and guides group efforts by providing guidance, direction, and support for the purpose of achieving a goal.			
Middle				
End				

Late Career Professional (Fellow)	Mentoring and coaching less experienced engineers			
Expectations and Goals (What want to achieve)	**Individual Mindsets, Actions and Emotions**	**Opportunities, insights, inputs, measurements /assessments (The offering)**	**How differs for different users? (Need for more than one map)**	**Applicable /Available Process Safety Competence Standards**
Start				
Share expertise, contribute to industry and wider profession	Confident, well connected, established in career, skilled communicator and collaborator	Chairing or invited to contribute to industry/professional panels, committees, research	Purely technical / managerial / academic ?	
Regularly contacted for technical opinion, provides clear direction		Sponsor for professional development programmes		
		Ambassador for profession, media presence		
		Greater levels of managerial responsibility / executive level		
		Technical Authority, responsible for setting professional standards		
Provide chemical engineering and process safety leadership internally and externally	Focussed, clear priorities and outcomes that want to achieve. Understand organisational and professional context and drivers by listening and researching. Calm and considered	IChemE and other professional and industrial networks	Core role will determine whether technical, managerial or academic focus	IChemE Fellow - retain and continually develop competence via CPD internally and externally
Develop organisational chemical engineering and process safety capability		Write papers, present at conferences, conduct peer review		
		Expert witness		
		Develop Relevant Good Practice		
Middle				
Encourage and support mentees and trainees to develop and progress professionally via IChemE /other professsional institutions and in their career	Generous, patient, supportive, listen and observe Positively reinforce and constructively influence to correct as required Open mind	As above		
End				
Witness mentees and trainees achieving chartered and fellow status and move into leadership positions (including Technical Authority)	Proud, positively reinforce achievement and use to encourage others	As above		

Partially Retired Professional	Volunteering to support the profession's development and share experience			
Expectations and Goals (What want to achieve)	**Individual Mindsets, Actions and Emotions**	**Opportunities, insights, inputs, measurements /assessments (The offering)**	**How differs for different users? (Need for more than one map)**	**Applicable /Available Process Safety Competence Standards**
Start				
Middle				
End				

APPENDIX C – CAREER PHASE JOURNEY MAPS (END OF SEPTEMBER 2023)

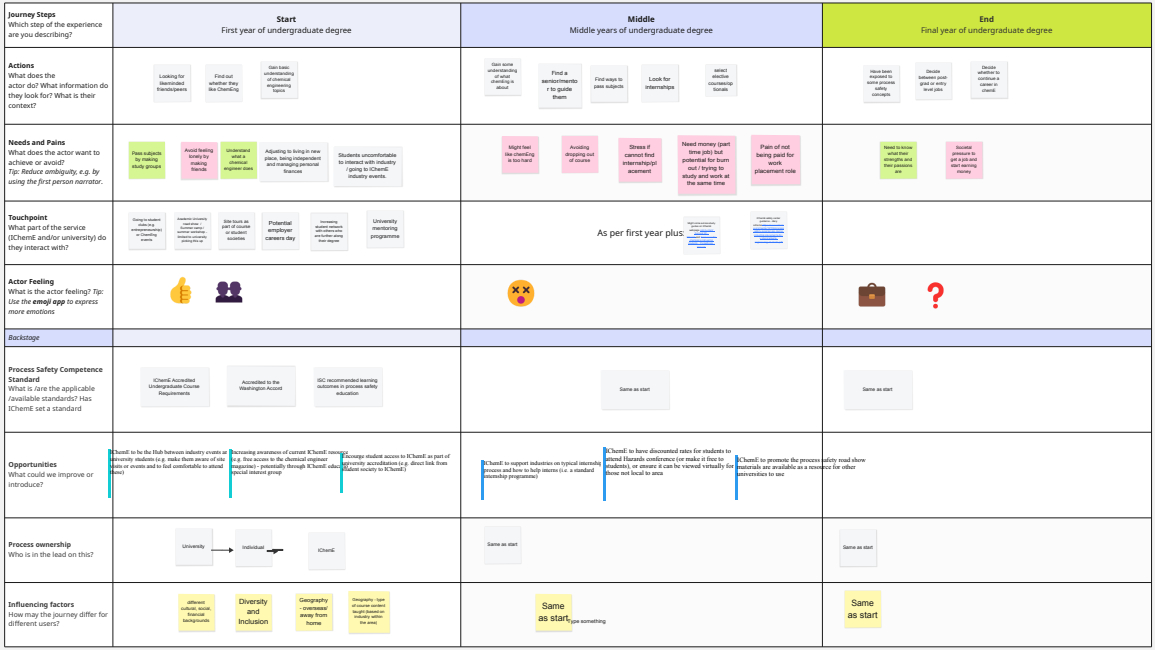


Figure C1 – Undergraduate Journey Map

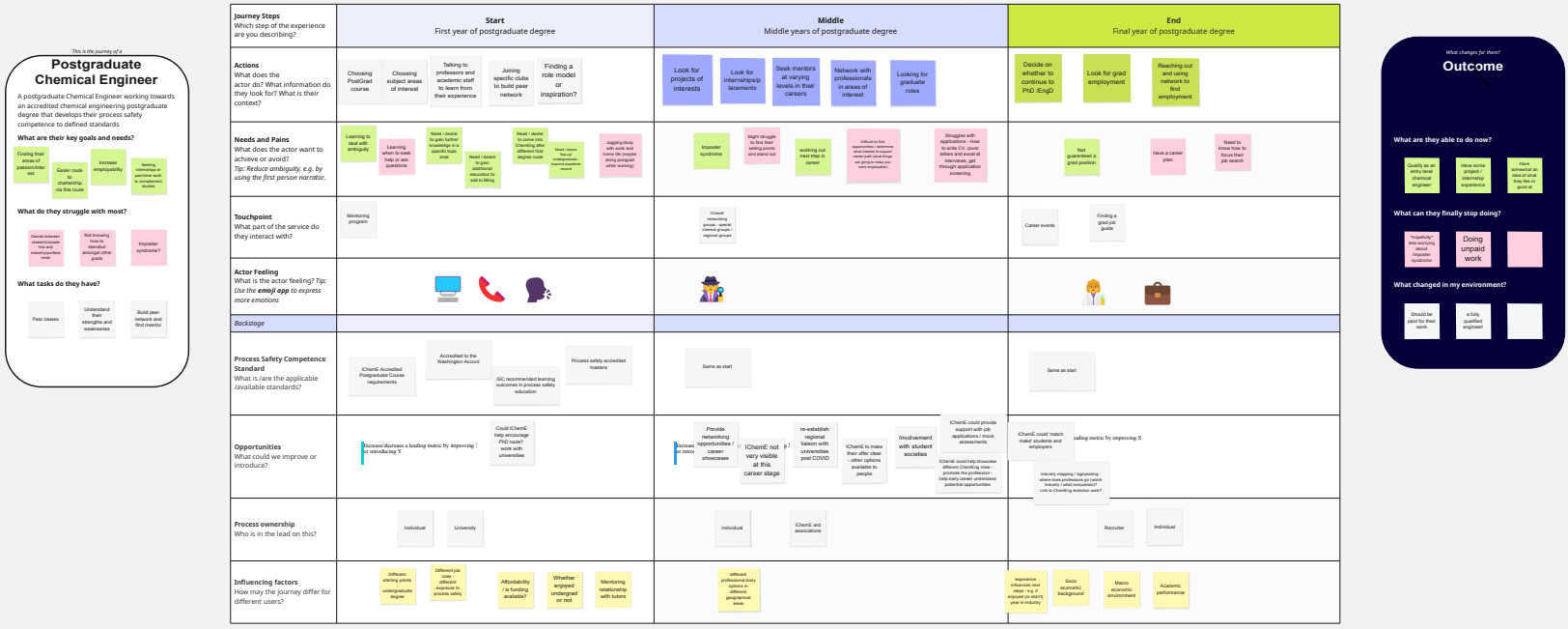


Figure C2 – Postgraduate Journey Map

This is the journey of a

Chemical Engineering Technician

A chemical engineering technician working towards Engineering Technician status that develops and maintains their process safety competence to defined standards

What are their key goals and needs?

- To be registered Technician Member (TIChemE)
- To gain technical knowledge and skills in Chemical engineering
- To gain knowledge and skills in process safety system

What do they struggle with most?

- where and how to develop career
- finding out the leader to guide
- finding process safety learning library

What tasks do they have?

- Undertaking Process safety training course
- Undertake undergraduate collage degree in chemical engineering
- continue with appropriate CPD activity
- engaged in Process Safety activities

Journey Steps Which step of the experience are you describing?	Start First year of chemical engineering technician	Middle Working towards chemical engineering technician status	End Apply for chemical engineering technician status
Actions What does the actor do? What information do they look for? What is their context?	Undertaking Process safety training course Participate in IChemE S&LP SIG Undertake undergraduate collage degree in chemical engineering Submit application to Technician Member (TIChemE) Learned about the different Process Hazard Analyses (PHA) techniques used at the workplace.	Involved in supporting existing engineers to demonstrate knowledge about how Process Safety Hazards Participate in Process Safety Hazard identification and Risk Assessment workshops Undertake appropriate infield safety conversations as part of a safety improvement program - process safety focus?	continue with appropriate CPD activity, develop ongoing plans, and keep a CPD record whilst you remain professionally active Prepare training material on any new hazard which could be introduced by a the operation Undertakes regular in-field verification of controls and lessons learned from process hazard incidents Identify process safety controls related to his/her discipline and undertake appropriate in-field verifications. Attend conferences and/or work with industry groups relating and process safety
Needs and Pains What does the actor want to achieve or avoid? *Tip: Reduce ambiguity, e.g. by using the first person narrator.*	Finding one's passion /interests to gain knowledge and skills about the roles and responsibilities of competent process operator Gain the basic knowledge of chemical engineering to find competent source for learning the basic process safety stranded and procedures	to gain a qualification certificate in process safety Associate with recognised body (i.e. IChemE) Gain understanding of Process Safety	have the technical know-how to do the job and demonstrate that you have the skills, tools and experience to solve a process problem or improve a process. to become a process safety professional to become part of the profession and uphold the standards to which IChemE members subscribe to be eligible to register as a qualified EngTech with Engineering Council. Overstretch/take on too many responsibilities
Touchpoint What part of the service do they interact with?	Academic institution websites IChemE website the company operating procedure Class rooms	the company operating procedure Special interest groups committees process training sessions	process safety studies IChemE website Special interest groups committees
Actor Feeling What is the actor feeling? *Tip: Use the **emoji app** to express more emotions*	Stress, burnout HELP!		Confident, well connected, established in career
Backstage			
Process Safety Competence Standard What is /are the applicable /available standards?	CCPS Risk based Process safety Management, training and Competency High level framework for process safety management, Energy Institute, UK, 2010 European Process Safety Centre, Process Safety Competence – How to set up a Process Safety Competence Management System, EPSC, UK, 2013 IChemE Engineering Technician member standard	CCPS Risk based Process safety Management, training and Competency High level framework for process safety management, Energy Institute, UK, 2010 European Process Safety Centre, Process Safety Competence – How to set up a Process Safety Competence Management System, EPSC, UK, 2013 IChemE Engineering Technician member standard	CCPS Risk based Process safety Management, training and Competency High level framework for process safety management, Energy Institute, UK, 2010 IChemE Engineering Technician member standard European Process Safety Centre, Process Safety Competence – How to set up a Process Safety Competence Management System, EPSC, UK, 2013
Opportunities What could we improve or introduce?	Increased process safety skills and knowledge	works effectively without close supervision.	Increase works effectively without close supervision.
Process ownership Who is in the lead on this?	Individual Employer	Individual Employer	Individual Employer
Influencing factors How may the journey differ for different users?	social, financial backgrounds gaining additional knowledge and skills	Motivation accepts responsibility	confidance social, financial backgrounds professionalism

Figure C3 –Vocational Journey Map

What changes for them?

Outcome

What are they able to do now?

- Uses process-related knowledge to apply technical and practical skills.
- Selects and uses techniques, procedures and methods to undertake tasks.
- works effectively without close supervision.
- Identifies problems and applies diagnostic methods to identify causes and achieve a technical solution.
- Identifies, organise and uses resources effectively to complete tasks, with consideration for cost, quality, safety and environmental impact.
- Allocates and supervises technical and other tasks.

What can they finally stop doing?

- reliant on direct supervision
- Worrying about learning chemical engineering

What changed in my environment?

- safe working environment
- more job offers
- trust, respect and professionalism in all interactions

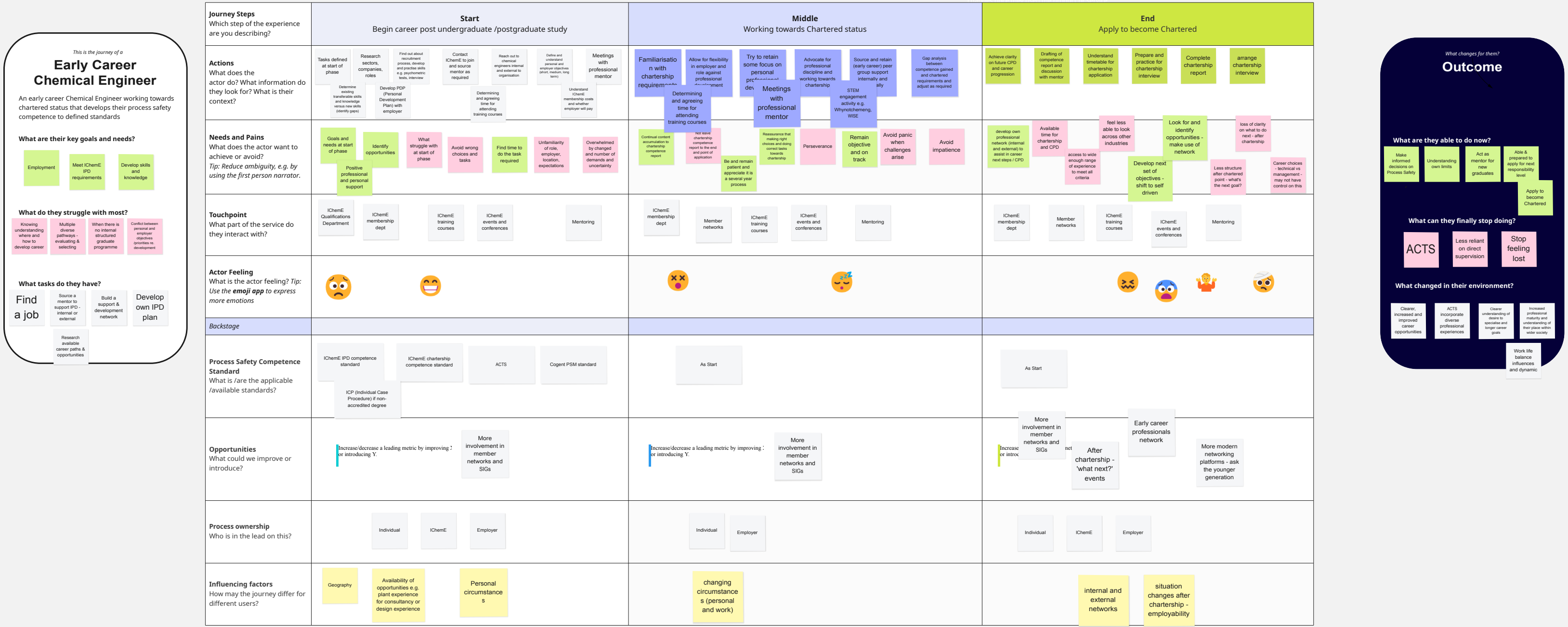


Figure C4 – Early Career Professional Journey Map

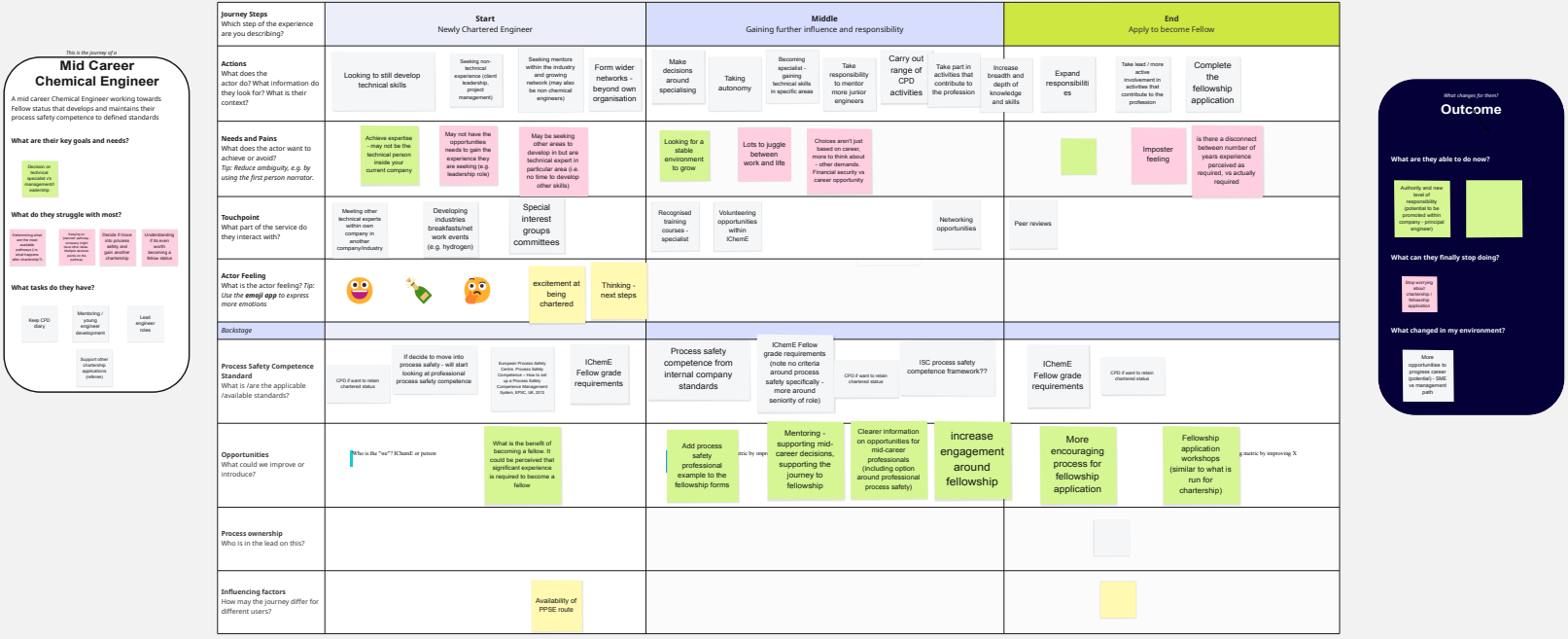


Figure C5 – Mid Career Professional Journey Map

This is the journey of a

Late Career Chemical Engineer

A late career Chemical Engineer mentoring and coaching less experienced engineers that develops and maintains their process safety competence to defined standards

What are their key goals and needs?

Share expertise, contribute to industry and wider profession

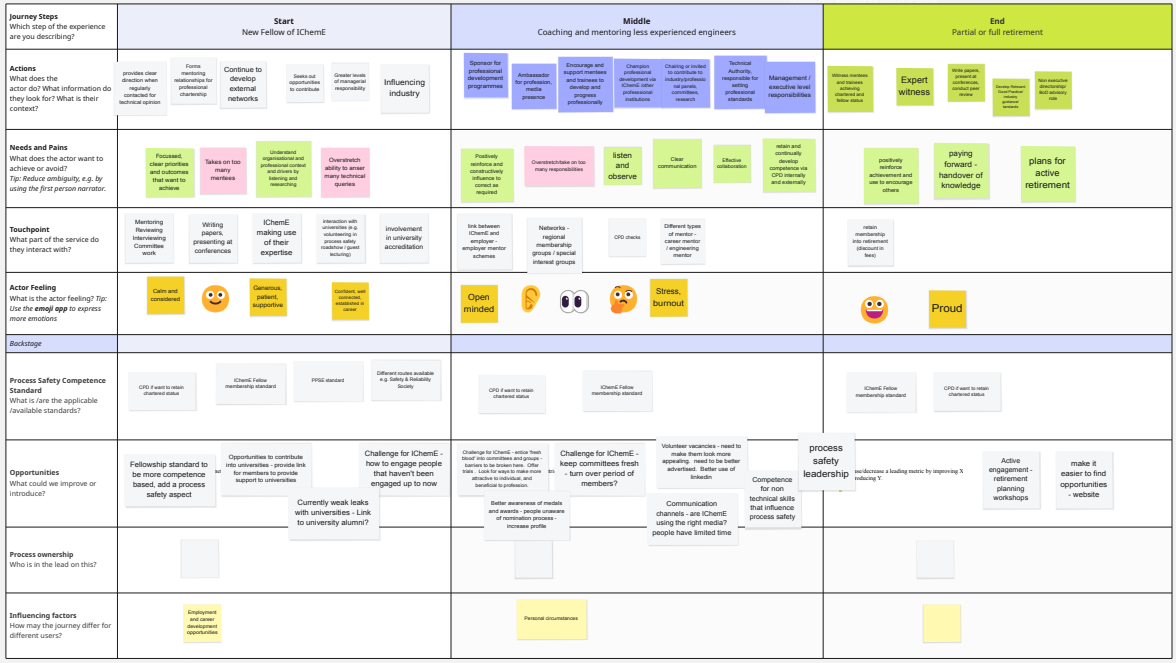
What do they struggle with most?

multiple demands on their time

What tasks do they have?

Provide chemical engineering and process safety leadership internally and externally

Develop organisational chemical engineering and process safety capability



What changes for them?

Outcome

What are they able to do now?

roles and enjoy the level at which they contribute

What can they finally stop doing?

working

What changed in my environment?

Figure C6 – Late Career Professional Journey Map

This is the journey of a

Partially Retired Chemical Engineer

A partially retired Chemical Engineer volunteering to support the profession's development and share experience that develops and maintains their process safety competence to defined standards

What are their key goals and needs?

- Give back
- Contribute to success of profession - ensuring longevity

What do they struggle with most?

- knowing when to let go
- keeping relevant
- Don't want to be unproductive

What tasks do they have?

- identify what activities I am involved in / prioritise initiatives
- provide support to younger engineers

Journey Steps Which step of the experience are you describing?	**Start** Newly partially retired	**Middle** Volunteering to support the profession's development and share experience	**End** Full retirement
Actions What does the actor do? What information do they look for? What is their context?	small amounts of work in areas of interest Identify opportunities	In control - retire when you're ready	
Needs and Pains What does the actor want to achieve or avoid? *Tip: Reduce ambiguity, e.g. by using the first person narrator.*	Free to pick and choose - flexibility more free time	making positive contribution take on too much frustrations - things not moving forwards	frustrated - 'forced' to retire
Touchpoint What part of the service do they interact with?	Volunteer opportunities throughout IChemE	Volunteer opportunities throughout IChemE Discounted IChemE membership reducing level of involvement	None / interest only through magazines
Actor Feeling What is the actor feeling? *Tip: Use the **emoji app** to express more emotions*	Enthusiastic Revitalised - next chapter Apprehensive to retain purpose	Tipping point - change from positive contributor, recognise limitations	satisfied / sense of achievement fed up - time to move on guilt over leaving
Backstage			
Process Safety Competence Standard What is /are the applicable /available standards?	CPD if want to retain chartered status	CPD if want to retain chartered status	CPD if want to retain chartered status
Opportunities What could we improve or introduce?	Working population - IChemE to find ways to keep them involved - payback loop Vocational group - networking opportunities better awareness of volunteering opportunities retirement workshops	Same as start More active opportunities to harness knowledge and experience of retiring members active engagement of long serving members to contribute back	Long service award?
Process ownership Who is in the lead on this?	self driven	self driven	self driven
Influencing factors How may the journey differ for different users?	Financial stability / personal commitments	Financial stability / personal commitments	Financial stability / personal commitments

What changes for them?

Outcome

What are they able to do now?

- consider other opportunities
- Continue with volunteering roles
- Focus on different things outside of profession

What can they finally stop doing?

- Work
- interacting with IChemE if choose to retire completely

What changed in my environment?

- 'Need' to work

Figure C7 – Partially Retired Professional Journey Map

APPENDIX D – ICHEME MEMBERSHIP SURVEY RESPONSES

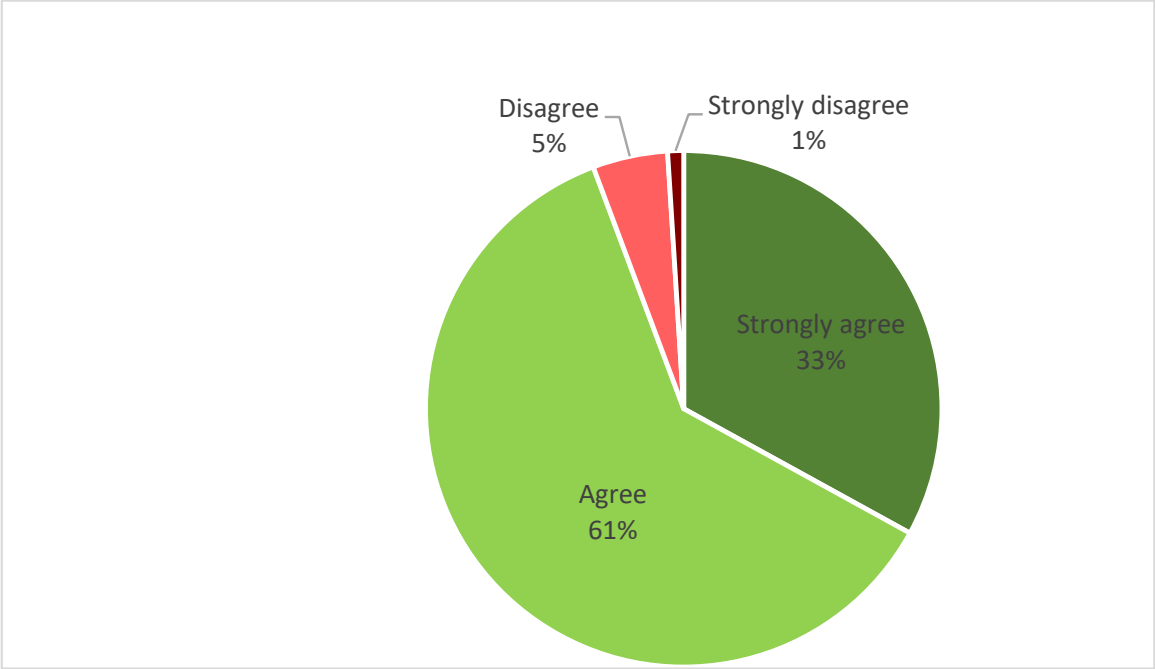


Figure D1 – Do you agree with the IAEA definition of competence used by the project?

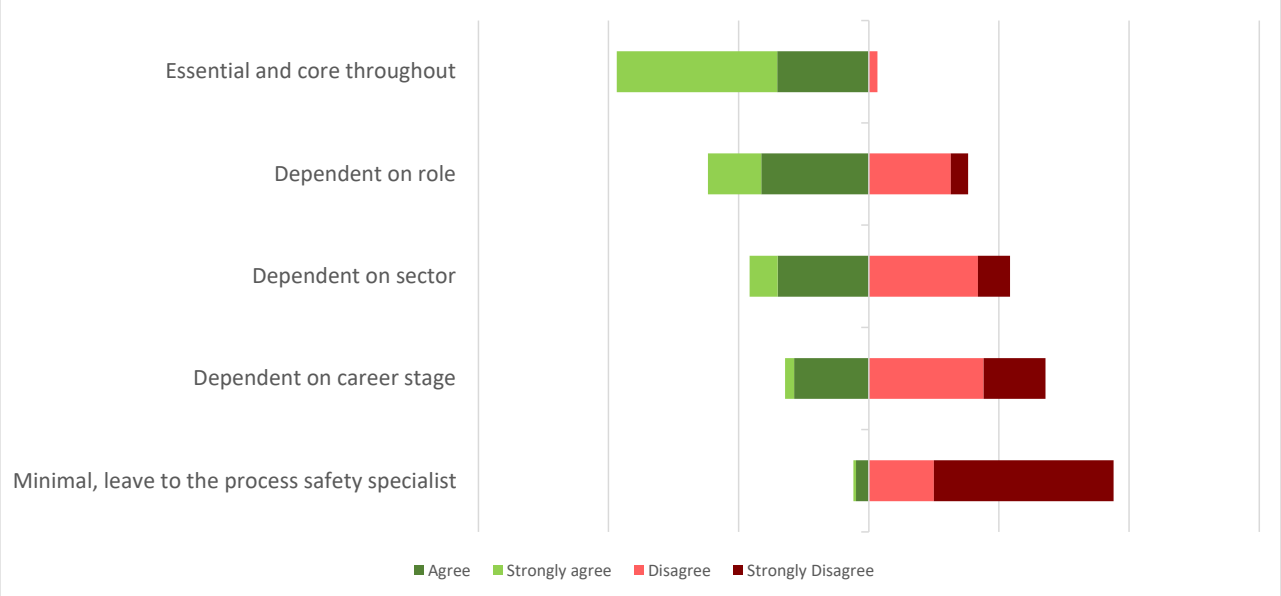


Figure D2 – How important do you think Process Safety Competence is to a Chemical Engineer?

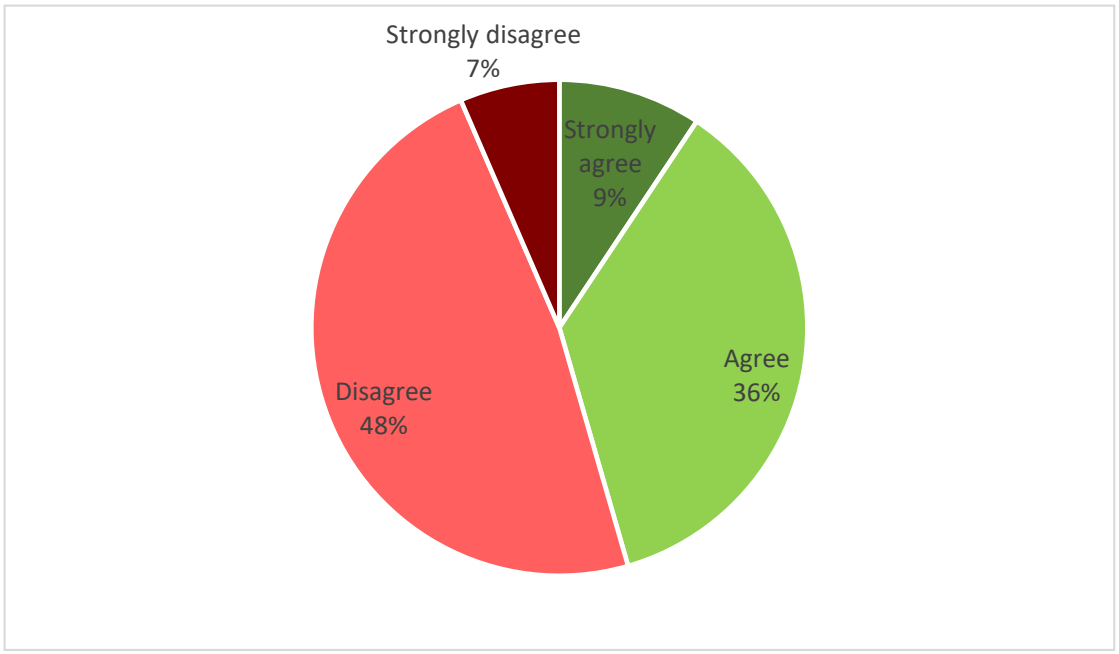


Figure D3 – Do you agree that the process safety competence standard for your career phase is clearly defined?

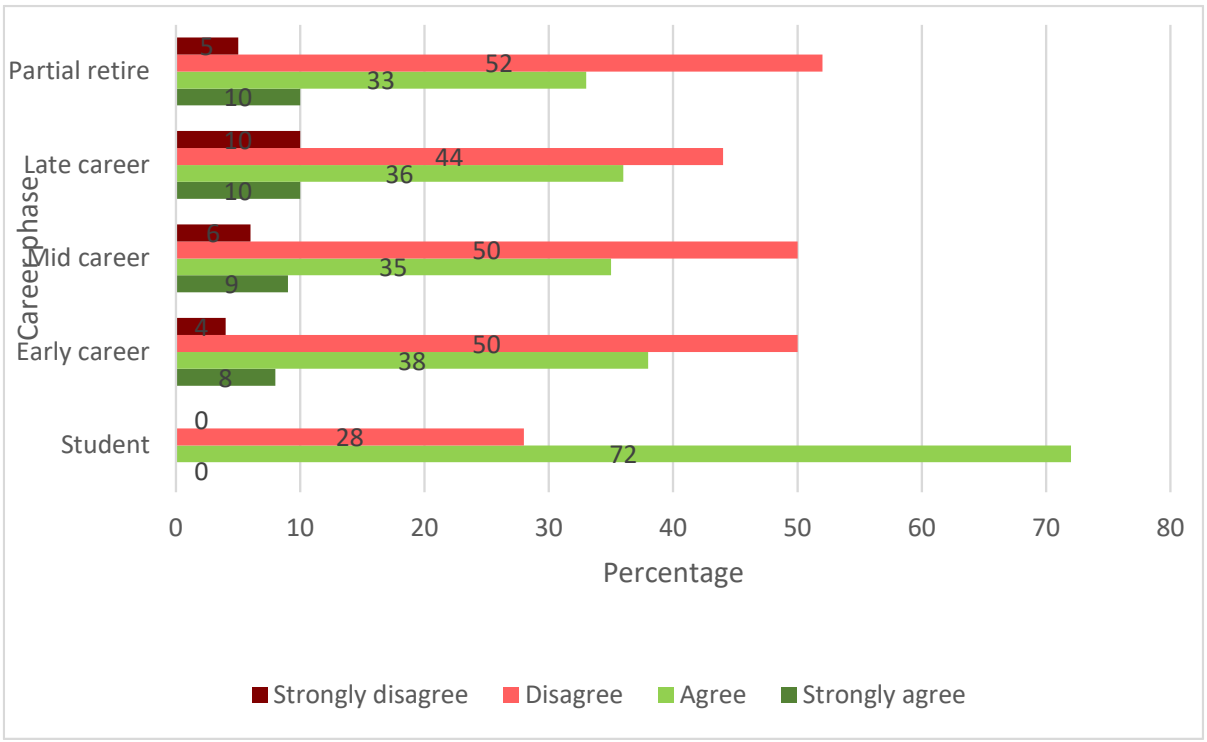


Figure D4 – Do you agree that the process safety competence standard for your career phase is clearly defined? – distributed by self identified career phase

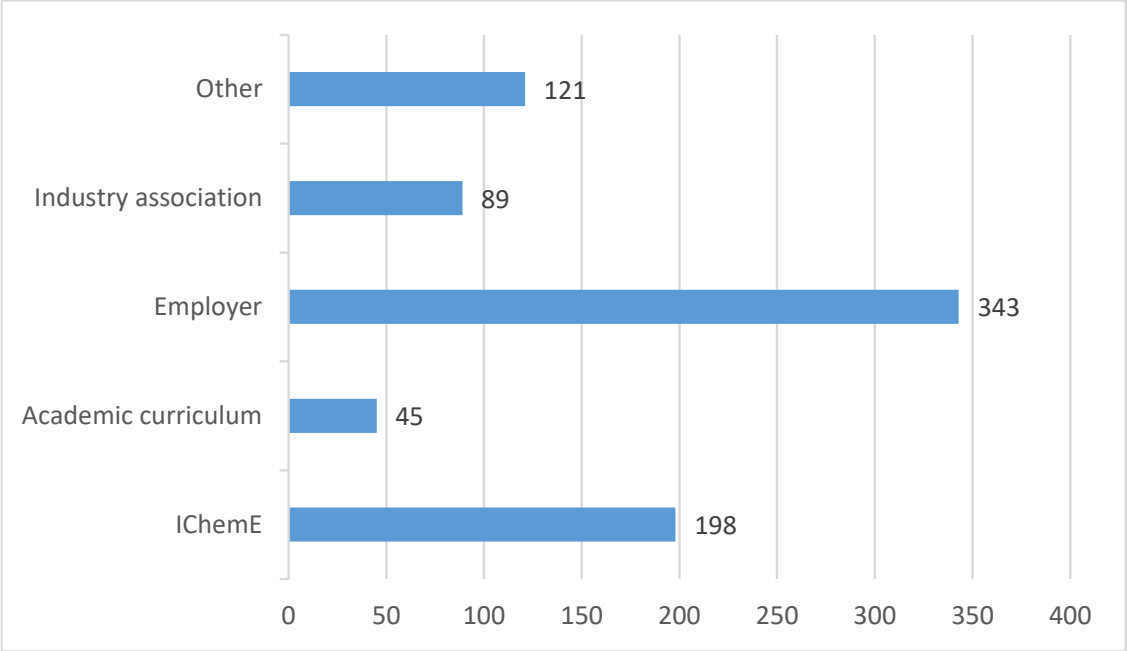


Figure D5 – Where is the process safety competence standard for your career phase defined

Figure D6 – Where is the process safety competence standard for your career phase defined – Other answers

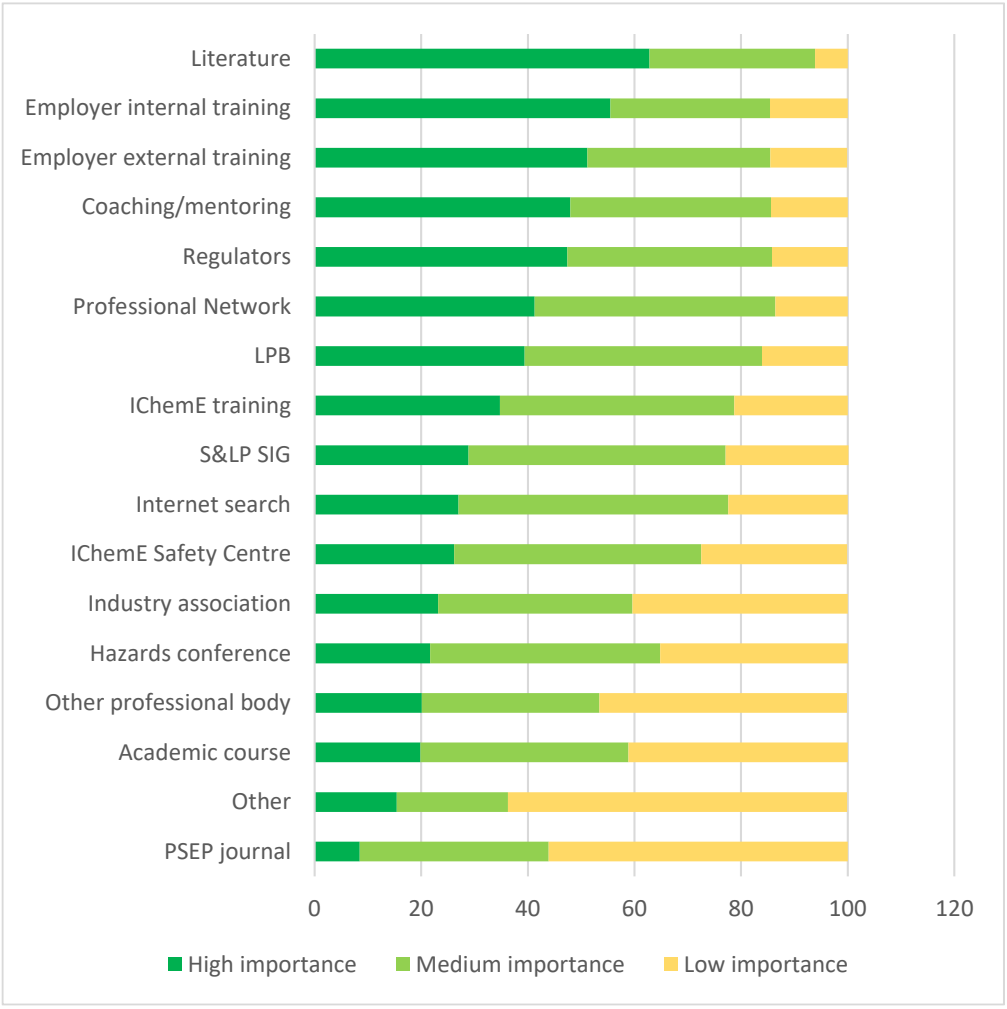


Figure D7 – Where do you source information and support to help you develop and retain process safety competence?

Figure D8 – Where do you source information and support to help you develop and retain process safety competence? – Others

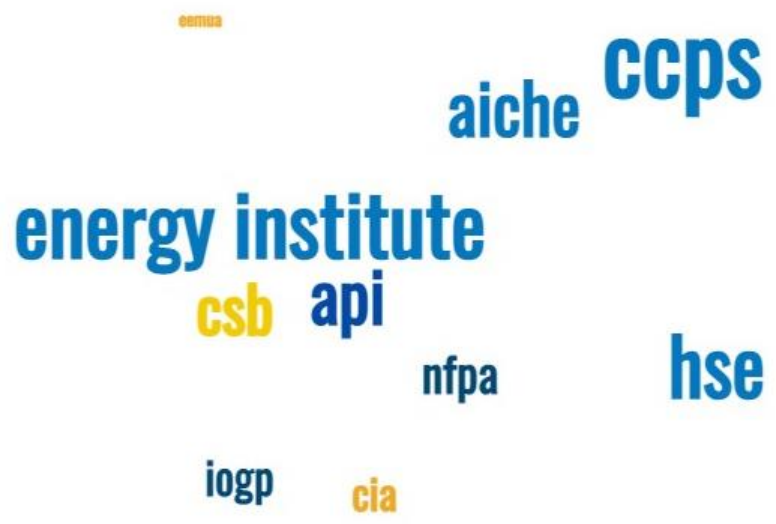


Figure D9 – Please list the other professional bodies, industry associations and information sources which are important to you for developing and retaining process safety competence

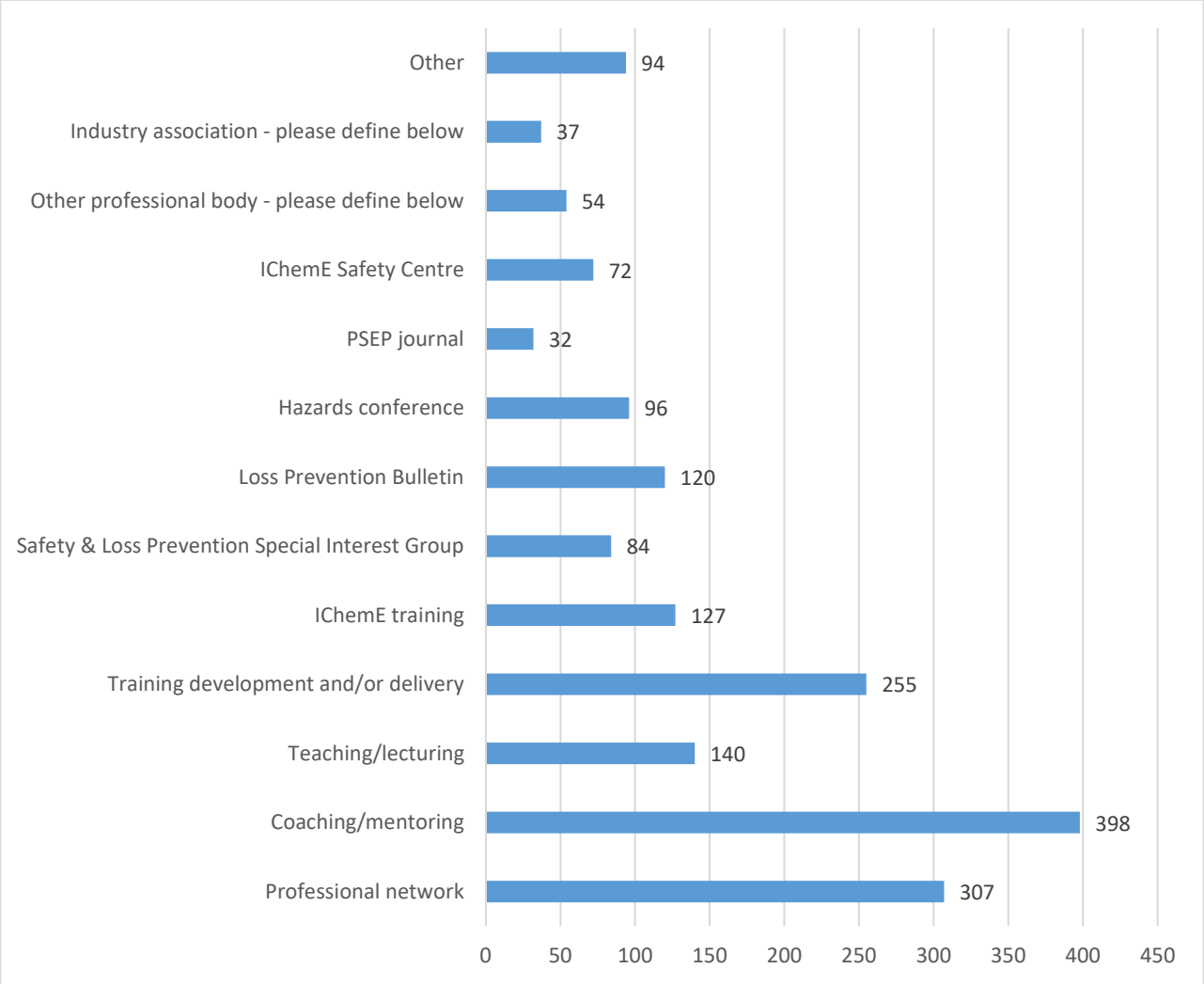


Figure D10 – How do you support other chemical engineers in developing and retaining process safety competence?

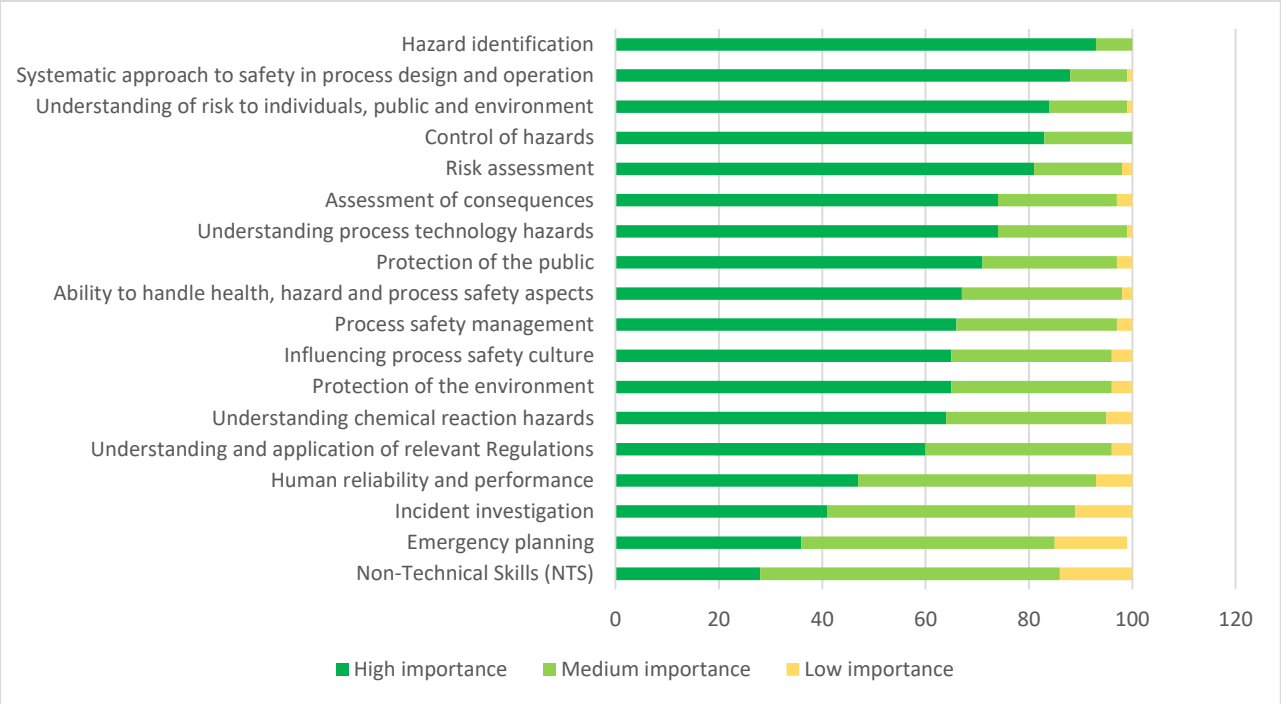


Figure D11 – What do you think are key process safety competencies for a chemical engineer?

Figure D12 – Please list any other key Process Safety Competencies for a chemical engineer

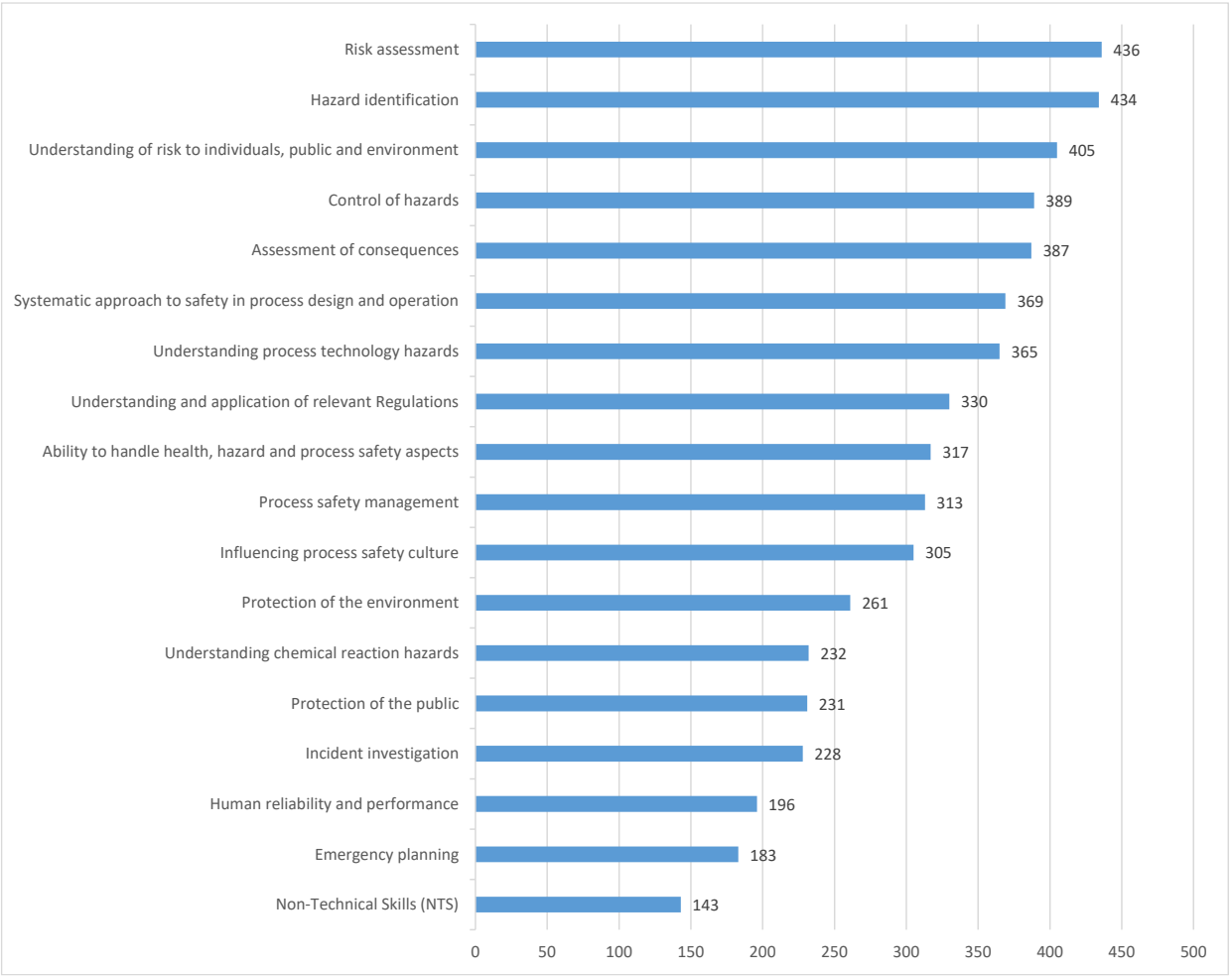


Figure D13 – Which process safety competencies have you applied within the past six months?

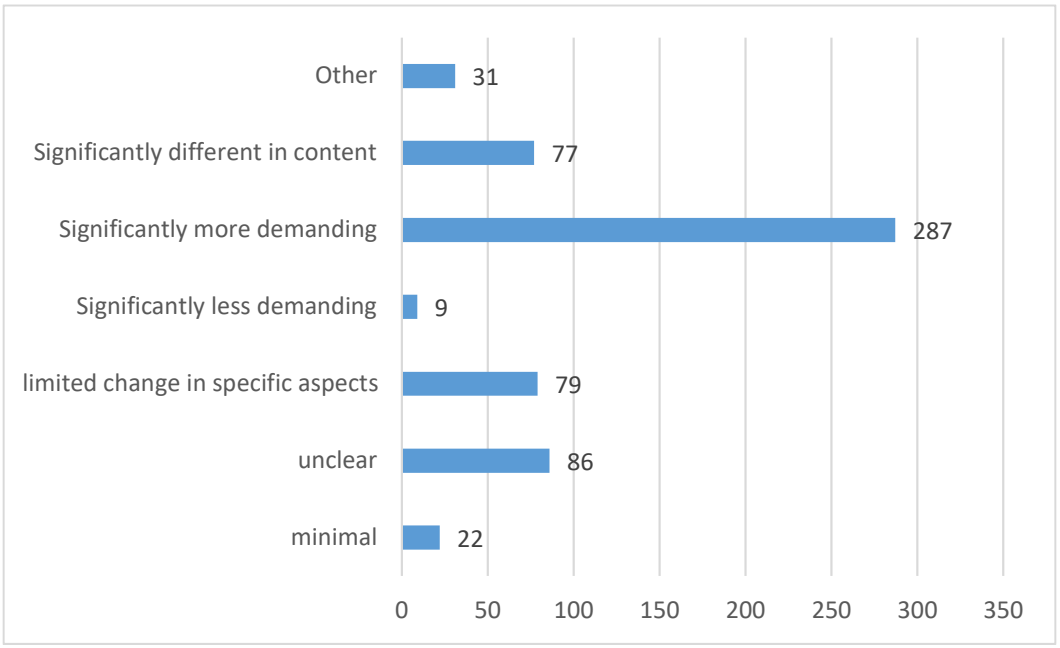


Figure D14 – To what extent do you think process safety competence requirements have changed (past) and will change (future)?

Figure D15 – If you consider that requirements have changed and/or will change, please describe how and in what areas

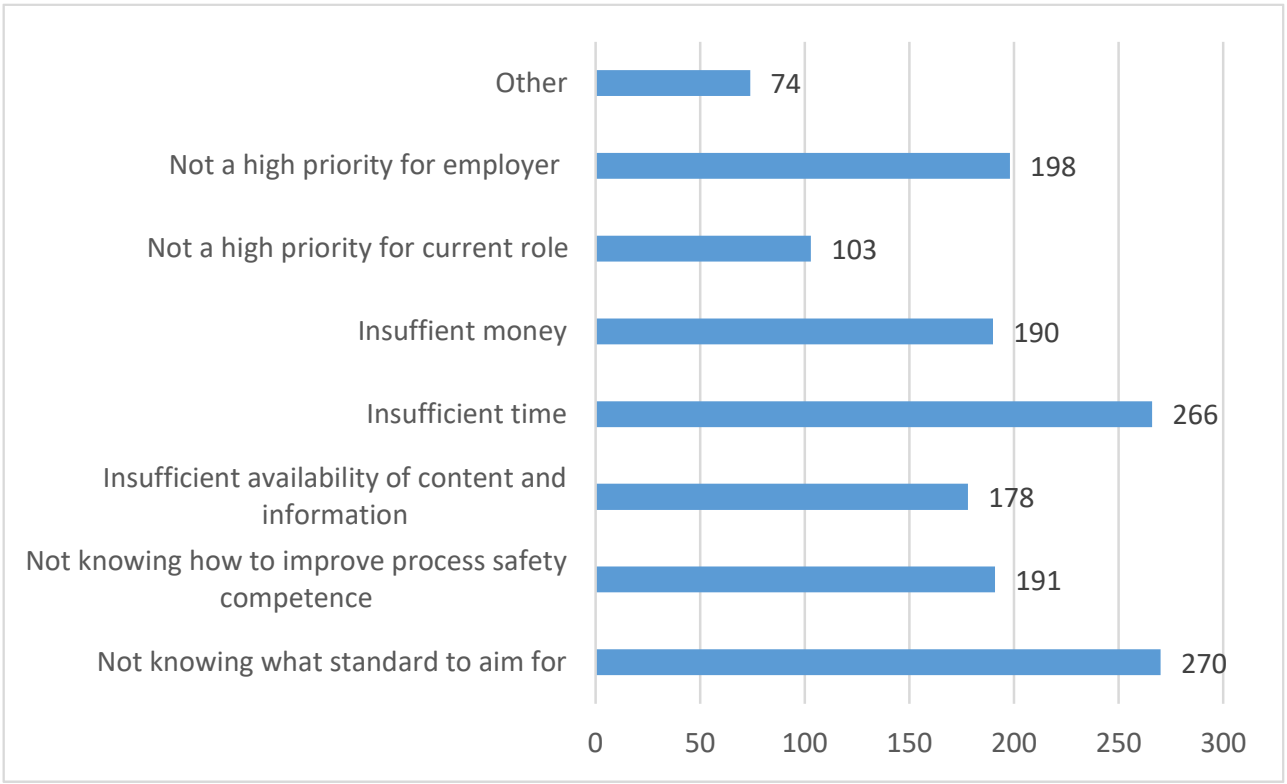


Figure D16 – What are the barriers to process safety competence?

IChemE Process
Safety Competence

Figure 21 - Embedded Object - Survey Raw Data File

APPENDIX E – NOTES FROM UNIVERSITY CHEMICAL ENGINEERING LECTURER GROUP DISCUSSION (ICHEME ACCREDITED COURSES)

Discussion Topic	Points of Note	Potential Opportunities for IChemE
Should Process Safety be integrated across the modules, or be a stand-alone module?	• Desire to embed and integrate process safety into ChemEng modules • If you asked the students they may not recognise the process safety aspects • Important to signpost safety aspects with the module content • Some universities will want to specialise, others won't	• Setting a clear standard for integration of process safety within the syllabus of accredited courses
When is the right time to start talking about process safety?	• Process safety module comes in year 3 – difficult to do earlier – need certain level of maturity for these topics • Process safety in year 2 so before industrial placement	
What are the teaching resource challenges?	• Academics need to be active in research, this is a requirement of universities - so those teaching may not have the background to teach this stuff • There is no 'standard' each university has access to different staff • Access to data /drawings /examples can be difficult	• Resource library – anonymised industry information, drawings, data sheets etc to be used. • Discussion forum for lecturers. • Provide links, to give universities access to people from industry
What is done around practical application?	• Most of the focus is HAZOP • Difficult to teach what industry wants in an non-industry context • Universities are there to educate not train for a role • Is teaching things like SIL and LOPA too much, should that be left to the career? • FE facilities have better links to industry • BASECA industry day = good example • There is no 'standard' each university has access to different equipment	• Provide links so universities can partner with industrial organisations • Provide links for work placements • Provide links for site visits • Develop links between universities and FE facilities
Is there wider value in process safety content in Chemical Engineering courses?	• Many doing a ChemEng degree don't then go into chemical engineering roles – what is the value from their perspective? • Process safety is not redundant outside of ChemEng career - the skills cut across disciplines e.g. risk evaluation in finance • Transferable skills – risk, probabilities, defence in depth – as we say systems thinking is transferable, so are process safety skills	• Showcase these transferable skills • Showcase the role of process safety across industry

APPENDIX F – CIEHF COMPETENCE FRAMEWORK COVERING ALL CAREER PHASES AND SPECIALISATION (AS SHOWN IN CHECKLIST)

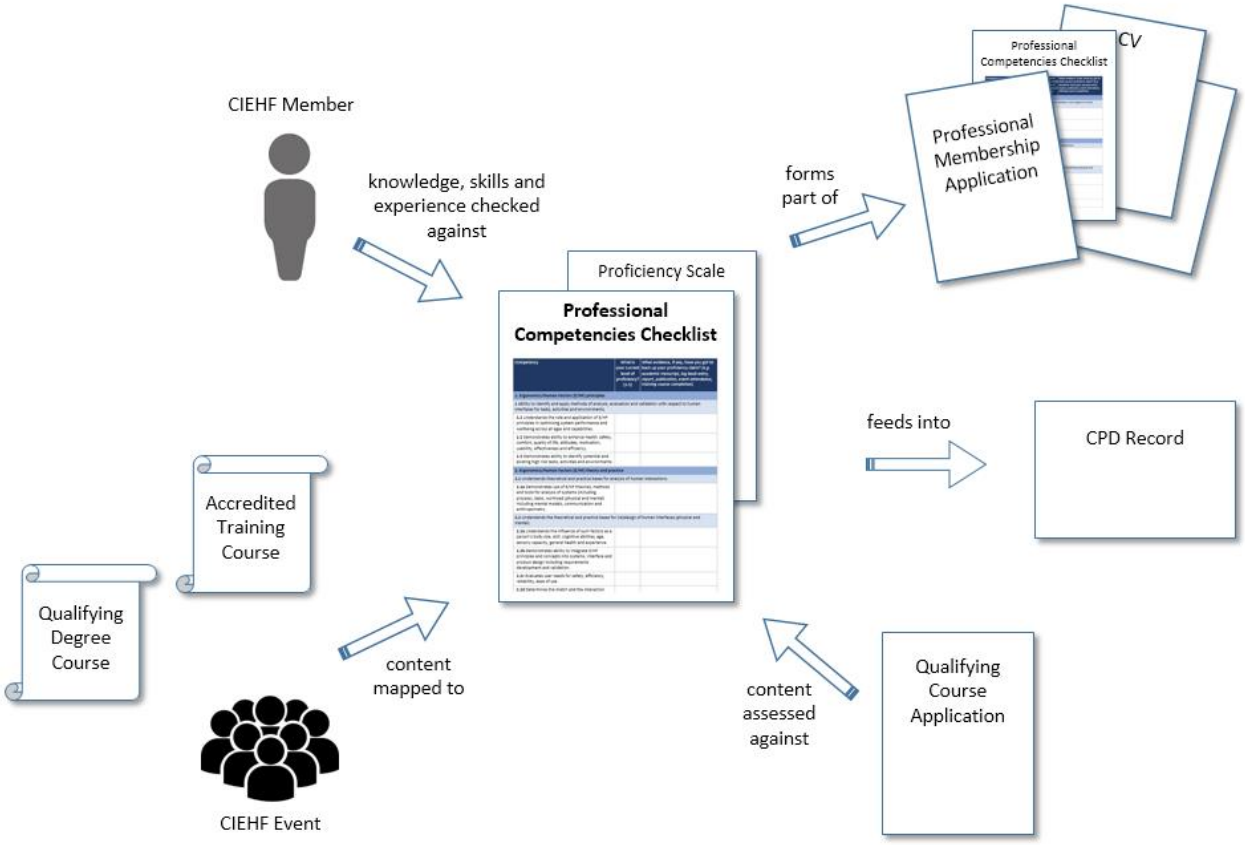
Professional Competencies Checklist

What it is and how to use it

Chartered Institute of Ergonomics & Human Factors

A checklist of professional competencies has been developed as a guide to expected competencies for qualification as an ergonomist and human factors specialist. It is already in use as an assessment tool for CIEHF accreditation of degree courses.

It can be used in conjunction with a proficiency scale to show progress in breadth and depth of skills and expertise as your career progresses.



Use of the checklist for membership applications

For professional membership (Registered Member, Technical Member and Fellow), it will form part of the application and will be used to help demonstrate breadth (through the number) and depth (through levels of proficiency) of claimed competencies.

If you are planning to upgrade to Registered Membership, it might help you to complete the checklist as soon as you can. This will allow you to see any areas where you are particularly strong which might guide your log book entries or where you might need to fill any gaps. You will need to give evidence for your proficiency claims and examples of these could be log book entries, training courses or a publication.

Use of the checklist as an aid to professional development

All members are encouraged to consider use of this checklist as an aid to their career development. This is optional but you might find it a useful tool in assessing your continuing professional

development (CPD). It may be helpful to use this list in conjunction with your employer's work planning cycle.

It could be used as an ongoing record of the breadth and depth of your competency in ergonomics and human factors based on the number of competencies you feel you have proficiency in and the level of that proficiency. Used this way, it would show you where you have gaps in your competency or where you need to increase your level of proficiency based on your membership grade, role and career aspirations. This would help to guide your CPD activities, although there would be no requirement to submit this checklist with your CPD submission.

Expected breadth of competence and levels of proficiency

CIEHF-accredited 'Qualifying' degree courses have been assessed against this checklist as providing learning for every competency listed. Those graduating from such a course should have at least an awareness of every competency. As your career progresses and experience increases, your level of proficiency will increase, as it should for any member of any grade who is committed to their continuing professional development.

There are 6 levels of proficiency as follows:

0 = Unaware 1 = Aware 2 = Novice 3 = Intermediate 4 = Advanced 5 = Expert

For a detailed explanation of this proficiency scale, please refer to table 1 at the end of this document.

It would be expected that your proficiency would increase as your career progresses and you become more competent. Which level of proficiency would be attributable to which competency will depend on your level of experience, seniority and your exact career path. No-one would be expected to become 'expert' in all competencies.

Depending on the route you have taken in your career, you might have proficiency in a variety of competencies, but as a guide:

Grade of membership being applied for	Expected length of time in practice	Expected breadth of professional competencies	Expected range of proficiency levels
Student Member	-	-	0 - 1
Graduate Member	On graduation	100%	1 - 3
Technical Member	2 years	60%	1 – 4*
Registered Member	Minimum 3 years	100%	2 – 4**
Fellow	10 years	100%	3 - 5

* Applicants must have proficiency levels 4-5 in all competencies in one section and at least proficiency level 1 across the other sections

** Applicants must have proficiency levels 3-5 in the majority of competencies and at least proficiency level 2 in all the rest

Filling the gaps

The content of each Qualifying degree course and CIEHF-accredited training course will be mapped against the competencies, as will the content of each CIEHF event. This will help you to find CPD activities that could fill the gaps in your competencies or help to raise your proficiency level.

The checklist

The checklist is split into 5 sections:

1. Ergonomics/Human Factors (E/HF) principles
2. Ergonomics/Human Factors (E/HF) theory and practice
3. Human capabilities and limitations
4. Design and development of systems
5. Professional skills and implementation

Each section is further split into individual competencies. The checklist can be used to record levels of proficiency for each competency and the supporting evidence for each proficiency claim.

Competency	What is your current level of proficiency? (1-5)	What evidence, if any, have you got to back up your proficiency claim? *(e.g. academic transcript, log book entry, report, publication, event attendance, training course completion)*
Section 1: Ergonomics/Human Factors (E/HF) principles		
1 Ability to identify and apply methods of analysis, evaluation and validation with respect to human interfaces for tasks, activities and environments.		
1.1 Understands the role and application of E/HF principles in optimising system performance and wellbeing across all ages and capabilities.		
1.2 Demonstrates ability to enhance health, safety, comfort, quality of life, attitudes, motivation, usability, effectiveness and efficiency.		
1.3 Demonstrates ability to identify potential and existing high risk tasks, activities and environments.		
Section 2: Ergonomics/Human Factors (E/HF) theory and practice		
2.1 Understands theoretical and practice bases for analysis of human interactions.		
2.1a Demonstrates use of E/HF theories, methods and tools for analysis of systems (including process), tasks, workload (physical and mental) including mental models, communication and anthropometry.		
2.2 Understands the theoretical and practice bases for (re)design of human interfaces (physical and mental).		

Competency	What is your current level of proficiency? (1-5)	What evidence, if any, have you got to back up your proficiency claim? *(e.g. academic transcript, log book entry, report, publication, event attendance, training course completion)*
2.2a Understands the influence of such factors as a person's body size, skill, cognitive abilities, age, sensory capacity, general health and experience.		
2.2b Demonstrates ability to integrate E/HF principles and concepts into systems, interface and product design including requirements development and validation.		
2.2c Evaluates user needs for safety, efficiency, reliability, ease of use.		
2.2d Determines the match and the interaction between human characteristics, abilities, capacities and motivations, and the system(s), organisation, planned or existing environment, products used, equipment, work systems, machines and tasks.		
2.2e Understands the management of E/HF risks, including priorities and mitigations; potential benefits and costs of E/HF solutions; short and long term goals relevant to defined problems.		
2.2f Can apply relevant legislation, codes of practice, standards (government and industry).		
2.2g Determines whether the interface or interaction is amenable to E/HF intervention.		
2.3 Understands the theoretical and practice bases for data collection and analysis relating to E/HF.		
2.3a Understands the type of quantitative and qualitative data required for E/HF appraisal and design; selects and validates the proposed collection/analysis methods and tools.		
2.3b Understands and can apply the basics of experimental design and statistics.		
2.3c Understands and can apply the basics of qualitative study design and analysis including knowledge elicitation, interviews, document analysis, and observation.		

Competency	What is your current level of proficiency? (1-5)	What evidence, if any, have you got to back up your proficiency claim? *(e.g. academic transcript, log book entry, report, publication, event attendance, training course completion)*
2.3d Demonstrates ability to seek and obtain relevant ethical approval for E/HF data collection and analysis.		
Section 3: Human capabilities and limitations		
3.1 Understands the theoretical and practice bases for E/HF relating to physical capabilities and limitations.		
3.1a Demonstrates a working knowledge of anatomy, functional anatomy, anthropometry, physiology, pathophysiology, and environmental sciences as they apply to E/HF practice.		
3.1b Can apply knowledge of biomechanics, anthropometry, motor control, energy, forces applied as they relate to stresses and strains produced in the human body.		
3.1c Understands the effects of the environment (including acoustic, thermal, visual, vibration) and individual sensory response (sight, hearing, touch, taste, smell) on human health and performance.		
3.2 Understands the theoretical and practice bases for E/HF relating to psychological and social capabilities and limitations.		
3.2a Understands theoretical concepts and principles of social and psychological sciences relevant to E/HF.		
3.2b Recognises psychological characteristics and responses and how these affect health, human performance, attitudes, perception, stress, human reliability and error.		
3.2c Can apply knowledge of human information processing (including situation awareness, memory, decision making).		
3.2d Demonstrates a knowledge of systems theory including socio-technical systems and culture (e.g. organisational and safety culture).		

Competency	What is your current level of proficiency? (1-5)	What evidence, if any, have you got to back up your proficiency claim? *(e.g. academic transcript, log book entry, report, publication, event attendance, training course completion)*
3.2e Understands the principles of group functioning, motivation, engagement and participation.		
3.2f Understands the principles of organisational management including individual, group (team) and organisational change techniques, including training and work structuring.		
Section 4: Design and development of systems including products, tasks, jobs, organisations and environments		
4.1 Understands the theoretical and practice bases for E/HF relating to design and development of systems.		
4.1a Understands basic engineering (technology) concepts, with a focus on design solutions and contextual operation of technologies.		
4.1b Demonstrates an understanding of the principles of E/HF and human-machine interface technology including hardware, software, internet and network based technologies and social media.		
4.1c Understands the requirements for safety systems, the concepts of risk, risk assessment and risk management.		
4.2 Utilises a systems approach to the human-aspects of the specification, design, assessment and acceptance of products, services and human factors interventions.		
4.2a Applies E/HF principles to design of systems (and services), products, job aids, controls, displays, instrumentation and other aspects of tasks and activities.		
4.2b Understands the iterative nature of design development including simulation and computer modelling.		
4.2c Considers the options for achieving a balance between human and technological, task and environment to achieve an optimal system.		

Competency	What is your current level of proficiency? (1-5)	What evidence, if any, have you got to back up your proficiency claim? *(e.g. academic transcript, log book entry, report, publication, event attendance, training course completion)*
4.2d Selects appropriate forms of E/HF solutions and recommendations based on theoretical knowledge and practice, and develops a comprehensive, integrated and prioritised approach.		
Section 5: Professional skills and implementation		
5.1 Understands role of E/HF in change strategies.		
5.1a Provides design specifications and guidelines for technological, organisational and E/HF design or redesign of the work process, the activity and the environment which match the findings of E/HF analysis.		
5.1b Develops strategies to introduce a new design to achieve a healthy and safe human interaction.		
5.1c Recognises the safety hierarchy, application of primary and secondary controls and the order of introducing controls.		
5.1d Recommends personnel selection where appropriate as part of a balanced solution to the defined problem.		
5.1e Interacts effectively with clients at all levels of personnel.		
5.2 Develops appropriate recommendations for education and training in relation to E/HF principles.		
5.2a Understands current concepts of education and training relevant to application of E/HF principles.		
5.2b Implements effective education and training programmes relevant to understanding the introduction of E/HF measures.		
5.3 Supervises the application and evaluation of an E/HF plan.		
5.3a Implements appropriate design or modifications.		

Competency	What is your current level of proficiency? (1-5)	What evidence, if any, have you got to back up your proficiency claim? *(e.g. academic transcript, log book entry, report, publication, event attendance, training course completion)*
5.3b Incorporates methods to allow continuous improvement.		
5.3c Selects appropriate criteria for evaluation.		
5.3d Produces clear, concise, accurate and meaningful records and reports.		
5.4 Shows a commitment to ethical practice and high standards of performance and acts in accordance with legal requirements.		
5.4a Behaves in a manner consistent with accepted codes and standards of professional behaviour.		
5.4b Recognises the scope of personal ability for E/HF analysis and when it is necessary to consult and collaborate with different professional experts.		
5.4c Demonstrates commitment to ongoing professional development by maintaining skill set and an awareness of wider E/HF practice.		

Table 1: Proficiency Scale

Score	***Proficiency Level***	***Description***
0	**Unaware**	You have no knowledge or understanding of this competency.
1	**Aware**	*For a particular competency:* You have knowledge or an understanding of basic techniques and concepts. *Your professional development:* Your focus is on learning more.
2	**Novice (basic)**	*For a particular competency:* You have limited experience gained in a classroom and/or as a trainee on-the-job. You are expected to need help with this competency. Your focus is on developing through on-the-job experience. You can understand and discuss terminology, concepts, principles and issues, and can use reference and resource materials related to this competency. *Your professional development:* Your CPD shows responsibility for, and awareness of, your own learning and professional development.
3	**Intermediate (skilful)**	*For a particular competency:* You can successfully complete tasks in this competency independently, though you may need help from an expert. Your focus is on applying and enhancing your knowledge or skill. You understand and can discuss the application and implications of changes to processes, policies, and procedures in this area. *Generally:* You show awareness of how even a narrowly focused task can draw upon knowledge crossing a variety of different knowledge areas. You can demonstrate the appropriate use of different techniques and methods in the application of human factors research or consultation. *Your professional development:* Your CPD demonstrates learning outside of your immediate job requirements. Your forward plan shows how you will learn new skills to complement your career path such as management, business administration, marketing, personnel management.
4	**Advanced (mastery)**	*For a particular competency:* You can perform the actions associated with this competency without assistance. You are recognised within your organisation as the go-to person regarding this competency. Your focus is on broad organisational/professional issues. You participate in senior level discussions regarding this competency. You assist in the development of reference and resource materials in this competency, and are capable of training others. *Generally:* You have responsibility for integrating and delivering programmes of work and meeting deadlines and milestones. You mark, grade and review the work of others in the context of project delivery. You bring together disparate theories and techniques or the application of novel solutions to complex problems. You demonstrate use and application of multiple tools and techniques to more complex projects that require human factors integration. You present the output of work and research undertaken. *Your professional development:* Your CPD shows awareness of knowledge and skill fade in areas not being practised due to career specialism and provides a plan to compensate. You show consideration

Score	Proficiency Level	Description
		of the development of your management and administrative skills so you have greater autonomy and authority over project delivery.
5	**Expert**	*For a particular competency:* You are known as an expert or recognised authority in this area. You can provide guidance, troubleshoot and answer questions related to this area of expertise. Your focus is strategic. You have demonstrated consistent excellence in applying this competency across multiple projects and/or organisations. You are considered the go-to person in this area within and outside your organisations. You create new applications for and/or lead the development of reference and resource materials for this competency. *Generally:* You contribute to the development and success of the discipline possibly through voluntary activities within the CIEHF. You interact with other strategic thinkers within your community of expertise. *Your professional development:* Your CPD demonstrates communication of learning, teaching or mentoring of others.

Table adapted from NIH Competencies Proficiency Scale https://hr.od.nih.gov/workingatnih/competencies/proficiencyscale.htm

APPENDIX G – PROPOSAL FOR UNDERGRADUATE CHEMICAL ENGINEERING PROCESS SAFETY CONTENT AND DELIVERY

Workforce and public safety and protection of the environment are critically important in all engineering and science disciplines. It is an accreditation requirement for all IChemE accredited undergraduate courses to include defined Process Safety topics. However, the breadth and depth of content and forms of learning utilised differ widely. It has been a clear and consistent finding that students feel strongly that the content and way it is delivered requires improvement to better prepare them for their first employed role post study. The majority of university lecturers are keen to receive more support from IChemE in process safety content and its delivery.

It is recommended that the following topics are included in all undergraduate Chemical Engineering courses and that opportunities for experiential learning, preferably with field application are provided:

- Key process hazards and underpinning science (overpressure, underpressure, toxicity, eco-toxicity, radiation, flammability limits, fire, explosion, ignition energy)
- Design Envelope (Basis of Design) and Safe Operating Envelope (Basis of Safety)
- Process safety through a facility lifecycle (Hazard Studies 1 to 6)
- Professional engineering ethics, non-technical skills, performance standards
- Hazard identification (Hazard Study 1, 2, 3 (HazOp), FMEA, What-if)
- Chemical reaction hazards
- Inherent safety
- Consequence assessment (harm criteria, types of people and environmental receptor, use of simple models to determine extent and severity, source pathway receptor model)
- Likelihood assessment (reliability, availability, maintainability, survivability, redundancy, diversity, independence, interdependence, fault and event trees)
- Hazard evaluation (barrier analysis, hierarchy of controls, design of protective measures)
- Risk assessment (with and without Risk Reduction Measures, ALARP, SFAIRP, IChemE 'Guidance on Risk')
- Different forms of protective measures: Mechanical, Instrumented Functions, Programmable
- Human and organisational factors (human performance models, PIFs /EPC, PSMS models, PDCA, performance metrics, process safety culture, control of work (PTW), management of change)
- Incident investigation and learning from incidents
- Regulatory framework
- Case studies illustrating all of the above

Many institutions will already include much of the above, some of which can be usefully incorporated in other parts of the curriculum. For those without the necessary process safety content or time /expertise to develop, it is recommended that they are provided with material from the IChemE course: 'Fundamentals of Process Safety'. This course was developed with input from members of the Safety & Loss Prevention SIG and has been delivered worldwide for 15 years with approximately 1,500 attendees. The course is delivered over 35 hours of lectures and group working and IChemE owns the IP for the course material. The content could be delivered in-house /by IChemE members with the necessary process safety and training expertise or during a vacation course.

In all cases, opportunity for experiential learning with input from process safety professionals, such as the Safety & Loss Prevention SIG Process Safety Workshops, should be encouraged and facilitated by IChemE. Use of plant facilities, such as CATCH, during term or vacation practical residential courses would aid and embed competence development, is favoured strongly by students and has proven highly successful for civil engineers.

Institutions may wish to build on the above list by including topics which require more detailed analysis such as: complex sociotechnical systems (resilience engineering), two phase overpressure events, flammability limits with 3 or more components, complex fault and event trees, fractional dead time etc.