The European Chemical Engineering Skills Pipeline

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The Need for Chemical Engineers

Chemical Engineering skills are core to the success of the process industries which enable so many everyday products expected by consumers – transportation fuels, plastic goods, personal products, medicines, foodstuffs etc. - to be manufactured. They also have a vital role at the heart of many of the world's greatest challenges: developing a sustainable future and tackling the pandemic to name just two. Chemical Engineers are employed by many industrial sectors as well as in regulatory authorities, arms of government, the charitable sector, and education. The salary premium for Chemical Engineers is high[1] demonstrating that they are held in high regard.

This article aims to explore whether the ecosystem for developing Chemical Engineers in Europe is optimal and consistent to ensure that demand is satisfied. The European Federation of Chemical Engineers represents more than 100,000 chemical engineers in Europe giving it a particular interest in the pipeline of Chemical Engineers across Europe. It was formed in 1953 to promote scientific collaboration and support the work of chemical engineers in 30 European countries.

Over the years student recruitment has depended on economic cycles and the performance of the relevant industrial sectors. Currently student recruitment is buoyant in many countries but age profiles within the academic community are quite diverse across Europe. By bringing together some statistics of age profiles and student to staff ratios this article aims to build a picture of good practice. This will help national Member Societies in EFCE member countries and Universities to argue for more academic recruitment to maintain a strong discipline basis for Chemical Engineering in each country, if it is out of line with best practice.

[1] interestingengineering.com/chemical-engineering-salaries-worldwide

Consistent data is difficult to get. There is some information on Eurostat but the definitions and processes used were very out of line with how the Chemical Engineering community sees itself.

The article first outlines the methodology used, presents the results, and then discusses them in the context of the assumptions made and the different conditions in countries across Europe. Data was not available for all countries with EFCE member organisations but comparisons can be made across the majority of countries. Finally some conclusions are drawn about the consistency across Europe and what might be done to address inconsistencies.

Methodology

Member Societies were asked to give five numbers about teaching for Chemical Engineering degrees in Universities (including Universities of Applied Science where appropriate) in their country:

1. Numbers of teaching staff (Full Time Equivalent) in Chemical Engineering Departments (or in some cases broader Schools or Faculties) – including academic staff, assistants, and teaching fellows but not postgraduates and postdocs who teach unless it is a major part of their responsibilities. The aim was to get the number who really have responsibility for teaching and assessment of Chemical Engineering studies.
2. Average age of the Chemical Engineering teaching staff (as defined in 1)
3. Total number of students within Chemical Engineering Departments in all years (all students i.e. including Bachelor, Masters and PhD but not post experience short courses) for the most recent year available.
4. The number of graduating Chemical Engineers with degrees (only Bachelor and Masters level) for the most recent year that was available.

The way Chemical Engineering education is organized differs between countries. Chemical Engineering can embrace Chemical Technology, Process Chemistry, Process Biotechnology etc. but some do not include the same elements as others. The approach used here was to allow countries to define for themselves how they would draw the envelope around Chemical Engineering. Societies were asked to include those courses that graduate what they recognize broadly as Chemical Engineers and not those that include only a small element of Chemical Engineering. This means that definitions may vary across the member countries and organisations and may depend on the strategic needs of the country as to where Chemical Engineers are mostly deployed.

Data was collected for eighteen countries: Croatia, Czech Republic, Denmark, France, Germany, Greece, Italy, Lithuania, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom and Ukraine. It was surprisingly difficult to collect the data as most Societies do not collect this information and so in some cases it was necessary to contact staff within the education systems.

It was not possible to obtain figures for Bulgaria, Estonia, Finland, Hungary, Latvia, Russia, Serbia, Turkey, and Norway and only partial figures were available for Ireland and were not sufficient to be comparable.

Germany is a particularly complex case but the numbers are large given the significance of the German chemical industry. In data collected by German agencies Chemical Engineering is not disaggregated from Mechanical Engineering. A dedicated survey was undertaken through a partnership between EFCE, ProcessNet and the DECHEMA Fachgemeinschaft Biotechnology with the purpose of capturing a first impression of the situation in Germany and this data is included here.

Results

Table 1 shows the data that were obtained. It is data mostly for 2018 with some more recent and the degree of accuracy is variable. However we are looking for significant trends so the data can be considered accurate as an Engineering approximation to allow drawing some conclusions.

The raw data obtained (shown in Table 1) gives numbers of teaching staff (Full Time Equivalent) for whom teaching is a major part of their responsibilities; their average age; the total number of students within Chemical Engineering Departments in all years; and the number of graduating Chemical Engineers with Bachelors or Masters degrees.

From this were calculated the student/staff ratio, the number of Chemical Engineering Graduates per 100,000 population and the number of graduates per 1000 in the national Chemical industry workforce as reported to CEFIC. These are shown in the subsequent tables (Tables 2-5) presented in rank order for each particular indicator. Table 6 gives the number of people employed in the Chemical industry as reported to CEFIC for the year 2018.

Discussion

It is possible to make some comparisons on the basis of these indicators although comparisons between countries need to be made with care. The total numbers of staff and students for each country needs to be considered with respect to the breadth of courses considered, the industrial base of the country, the duration of the courses and the extent of recruitment of Chemical Engineers to employment beyond the traditional industries of chemicals, pharmaceuticals, oil and gas. While bearing these issues in mind and recognising that there is no ideal profile, we can look at some overall trends.

Tables 2 (age) and 3 (student/staff ratio) give an indication of the investment in Chemical Engineering education by the countries over recent decades. Lead times for seeing the effects of new staff investment are long since academics with substantive responsibility are often appointed in their early 30s. For those countries where the average age is high it means that over the last 20 years or so there has been less investment in young staff leading to an aging staff profile.

Of course averages can hide unusual age distributions but mostly staff are appointed rarely and in a steady fashion except where a new institution or Department is started.

Denmark, Slovenia, Sweden, U.K and Lithuania are at the lower end. The case of the UK is interesting since there is now no retirement age so staff can continue in post for much longer so we could expect a higher average. It indicates that there has been a continual renewal leading to a low average. UK Universities have complete freedom in recruitment. This is not the case in some other countries where national competitions are organised, staff are appointed as public servants employed by the state, and Ministries can control the number of posts that are opened. This is the case in Spain and Italy and others although there is increasing pressure for more institutional freedom in recruitment. Ukraine reported the oldest average and colleagues there confirmed that there has been little recruitment in recent years. Italy has had recruitment freezes in the last decade. The financial situation in Greece has affected recruitment in Universities across all disciplines and Chemical Engineering is no exception.

The student/staff ratio varies very considerably from around 17:1 to 6:1 (the figure for Ukraine is a clear outlier based possibly on a rather different organisation of the studies). Some of this may reflect how teaching staff are defined but the range is striking. This is affected by the stage in the curriculum at which Chemical Engineering academics included here begin to teach. In some cases they teach little in the early years of the study programme. In Greece there is very strong demand for places to study Chemical Engineering but the number of institutions is low. The Netherlands figure seems surprisingly high perhaps reflecting structural change in Engineering education in recent years with merging of Institutes. It seems that across Europe there are broadly two traditions: one with a ratio of around 16 and the other around 8. It is likely this reflects a different organisation of studies and of the staff that teach them.

It is interesting to see how the numbers compare with the size of the population as shown in Table 3 (graduates per 100,000). Comparisons must be tempered with the knowledge that the size of the industrial base varies significantly. However the formation of Chemical Engineers prepares graduates for a wide range of careers such as environmental management, energy regulation, water treatment, medical applications and many others where there is chemical and physical transformation of materials. Traditional career routes are in the chemical and energy sectors. CEFIC provides figures for employment on the chemical industry and Table 4 gives the number of graduates per 1000 employed and table 5 the CEFIC figures from which Table 4 was derived. It should be noted that the CEFIC figures include the chemical and petrochemical industry but not the pharmaceutical industry or oil refining.

Countries are producing very different numbers per head of population and per 1000 in the chemical industry workforce. Portugal's industry is relatively small but is producing graduates going into a wide range of industries and careers with a significant proportion being recruited as consulting engineers.

Romania has a long tradition of producing Chemical Engineers because of the long standing size of the oil and gas sector. The UK figure is also high possibly because academic programmes and the research base have promoted the value of Chemical Engineering skills well beyond the traditional employment sectors.

Countries with relatively low numbers such as Slovakia, Croatia, Poland, Switzerland, Sweden, Czech Republic and Slovenia and could reflect whether they are indeed producing enough Chemical Engineers for the wide range of career options that are available. The figure for Switzerland is surprisingly low but, although the process industry is large, much of it is in the pharma sector and this industry does recruit heavily from Chemistry graduates. The same may be the case for Sweden.

An interesting point is that the German figures, which were obtained for several years in succession, showed a very significant variation from year to year. The total number of students studying in 2019 was 2650, in 2020 it was around 8000 and in 2021 only 4500. The German report states 'This can be explained with the delay in curriculum and potentially unfinished data preparation due to the Corona pandemic'. Some participants stated that classes could not be carried out in 2020 causing a shift to the subsequent year 2021.' 35% of the students graduated in 2019, only 25% in 2020, and in 2021 less than 10% which supports this hypothesis. In Germany it is relatively easy to delay taking the assessment for a course thereby delaying graduation. The employment market has been relatively weak encouraging students to delay graduation. The authors of the German report's analysis reported a carefully justified average to reflect a historical trend.

Conclusions

The results show a significant variation in the various indicators across European nations. The average age of staff is not so wide but it does reflect the lack of investment in new academic staff that has been reported by colleagues in Ukraine, Italy and Greece. Student to staff ratios show a very wide range and, although some could be because of different academic structures and the way the curriculum is delivered, it should provide some ammunition to seek for greater investment in new academic staff in countries particularly as there is growing demand for Chemical Engineers in a wide range of roles beyond the process industries.

The figures in proportion to the population are harder to interpret and need to be considered by the Member Societies in each individual country to explore whether the figures indicate that there could or should be increased student recruitment. The best way might be to compare with countries of a similar industrial profile. In countries where the numbers are small it could also indicate an opportunity to promote the skills of graduate Chemical Engineers more widely. The comparisons against the Chemical industry employment numbers also need interpreting carefully but again if the number is low and there are reports of shortages by the main employers the figures would provide support for the need for more graduates.

The numbers are worth considering by the main process industry employer organisations since their interest is in productivity which can be hampered by lack of skilled engineers.

It is hoped that these comparisons can help them make a stronger case for investment in new teaching staff at Universities and where appropriate for more student places. Chemical Engineering is a very portable qualification so where skills are in short supply they can be filled from other countries in Europe or beyond if the employment conditions are sufficiently attractive. The EFCE is keen to ensure that the skills base does meet the needs of the sectors that can benefit from the very powerful skill set the graduate Chemical Engineers have acquired and are valued by the traditional process industries and many new areas of employment.

Acknowledgements

The author wishes to thank the many colleagues who helped in collecting and assembling these data.

	Teaching staff	Av. age of staff	Students (B,M&D)	Student / staff ratio	Graduates (B,M)	ChE Graduates per 100000	ChE Graduates per 1000 Chem Ind workforce
Croatia	69	46	1032	15.0	179	4.2	3.0
Czech Republic	409	49.5	4296	10.5	550	5.3	4.2
Denmark	67	44	442	6.6	171	3.1	16.0
France	550	49	4360	7.9	1550	2.3	9.3
Germany	1272	50	22167	17.4	4050	4.9	8.8
Greece	62	54	1079	17.4	135	1.2	10.0
Italy	400	55	5500	13.8	1375	2.3	12.5
Lithuania	40	45.2	248	6.2	55	1.9	8.7
Netherlands	166.3	48	2900	17.4	974	5.8	17.1
Poland	533	46	4881	9.2	1114	2.9	8.7
Portugal	302	53.4	2853	9.4	565	5.3	38.7
Romania	360	46.2	3010	8.4	770	3.9	34.2
Slovakia	22.5	49	158	7.0	52	2.5	1.1
Slovenia	35	45	600	17.1	150	7.3	4.8
Spain	900	43-47	11600	12.9	2500	5.3	12.7
Sweden	135	45	1300	9.6	202	2.1	3.9
Switzerland	110	46	810	7.4	260	3.3	3.7
United Kingdom	1028	45	16030	15.6	4206	6.3	27.5
Ukraine	194	57	462	2.4	70	0.17	Not available

Table 1: Staff and student figures for Chemical Engineering

	Av. age of staff
Denmark	44
Slovenia	45
Sweden	45
United Kingdom	45
Spain	43-47
Lithuania	45.2
Croatia	46
Switzerland	46
Poland	46
Romania	46.2
Netherlands	48
Slovakia	49
Czech Republic	49.5
Germany	50
Portugal	53.4
Greece	54
Italy	55
Ukraine	57
France	N/A

Table 2

	Student/staff ratio
Greece	17.4
Netherlands	17.4
Germany	17.4
Slovenia	17.1
United Kingdom	15.6
Croatia	15
Italy	13.8
Spain	12.9
Czech Republic	10.5
Sweden	9.6
Portugal	9.4
Poland	9.2
Romania	8.4
France	7.9
Switzerland	7.4
Slovakia	7
Denmark	6.6
Lithuania	6.2
Ukraine	2.4

Table 3

	Grads per 100K population
Slovenia	7.3
United Kingdom	6.3
Netherlands	5.8
Czech Republic	5.3
Portugal	5.3
Spain	5.3
Germany	4.9
Croatia	4.2
Romania	3.9
Switzerland	3.3
Denmark	3.1
Poland	2.9
Slovakia	2.5
France	2.3
Italy	2.3
Sweden	2.1
Lithuania	1.9
Greece	1.2
Ukraine	0.17

Table 4

	Grads per 1000 Chemical Industry workforce
Portugal	38.7
Romania	34.2
United Kingdom	27.5
Netherlands	17.1
Denmark	16
Spain	12.7
Italy	12.5
Greece	10
France	9.3
Germany	8.8
Lithuania	8.7
Slovenia	4.8
Czech Republic	4.2
Sweden	3.9
Switzerland	3.7
Poland	3.5
Croatia	3
Slovakia	1.1
Ukraine	N/A

Table 5

	Numbers employed in Chemical Industry (CEFIC)
Croatia	5987
Czech Republic	129500
Denmark	10657
France	166650
Germany	462553
Greece	13500
Italy	109600
Lithuania	6300
Netherlands	57000
Poland	315000
Portugal	14604
Romania	22500
Slovakia	46143
Slovenia	31000
Spain	196800
Sweden	51300
Switzerland	70000
United Kingdom	153000
Ukraine	Not available

Table 6