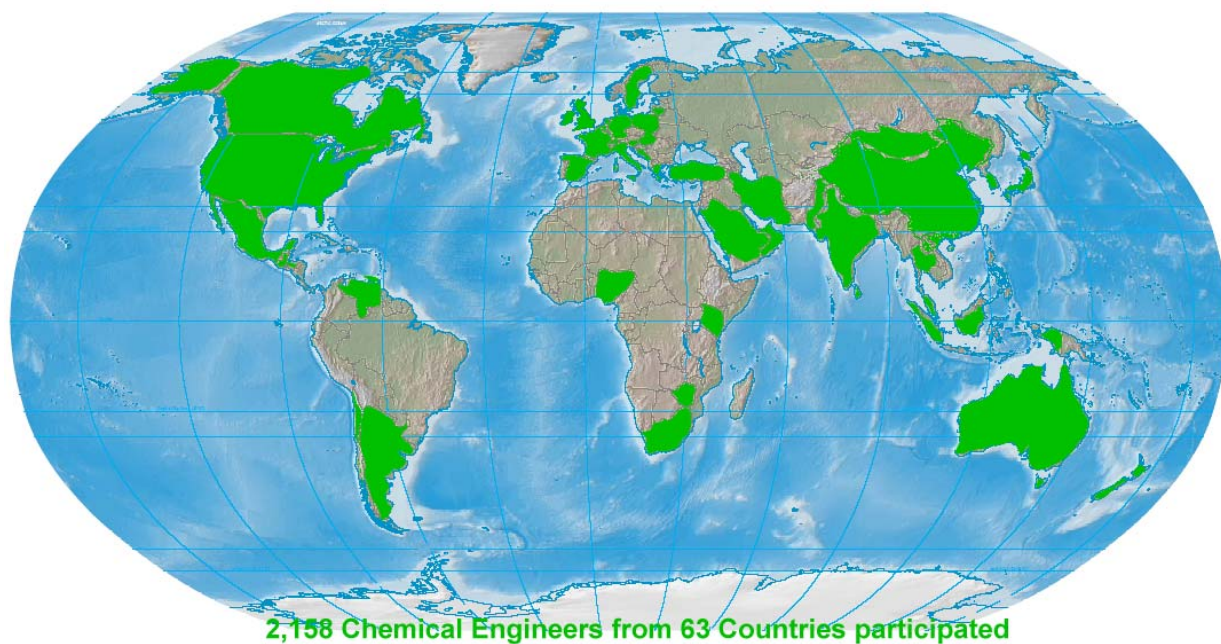


World Chemical Engineering Council WCEC

Short Report

How Does Chemical Engineering Education Meet

the Requirements of Employment ?



September 2004

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How does Chemical Engineering Education Meet the Requirements of Employment?

Short Report

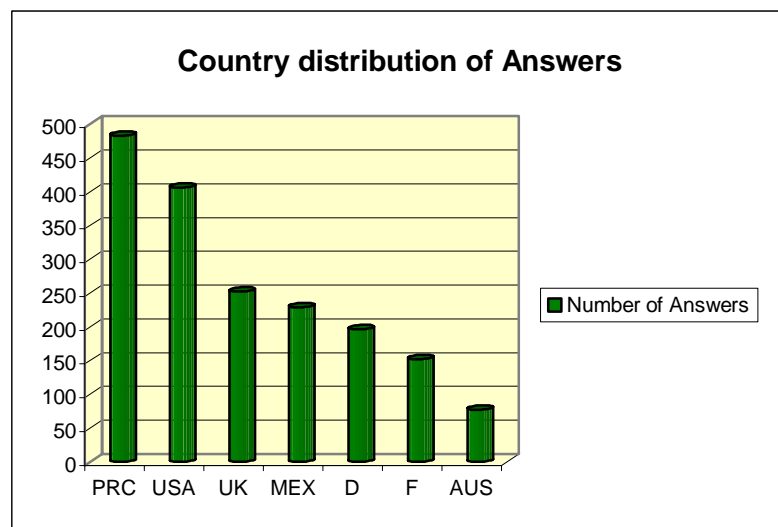
General Background

The education of chemical engineers faces with strong pressure to re-orient itself worldwide. The requirements made of graduates by the classical industries (the chemical, pharmaceutical and petrochemical industries) are changing in proportion to the extent to which chemical engineers are being employed outside their traditional employment sectors. An increasing number of chemical engineers are finding employment outside the classical industries. Furthermore the globalisation of the employment market has confronted young chemical engineers with new challenges.

This background provokes the question to what extent present-day chemical engineering education meets the requirement of employment. For this reason, this year the WCEC World Chemical Engineering Council has conducted the first worldwide survey among young chemical engineers in the first five years of their professional employment. The aim was to make a comparative assessment worldwide and for various countries of how well young chemical engineers feel their education has prepared them for the requirements of their professional lives.

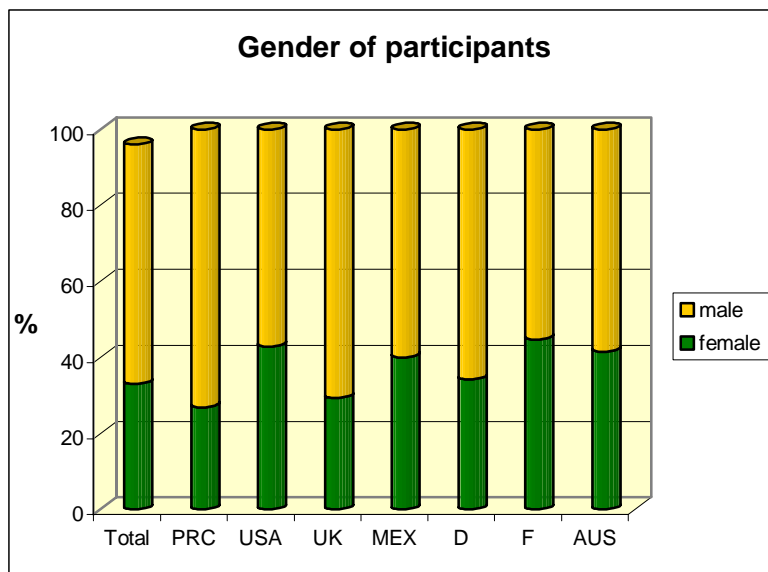
Statistical Basis

2,158 young chemical engineers from 63 countries took part in the survey. The seven countries most frequently represented and for which a country-specific statistical evaluation was, therefore, meaningful are given in the following figure.



Of those taking part in the survey 54.4% gave their highest academic degree as BSc, 35.4% MSc (this includes a large number of the British responses from those graduates with an M.Eng. degree, which is their first degree) and 10.2% PhD.

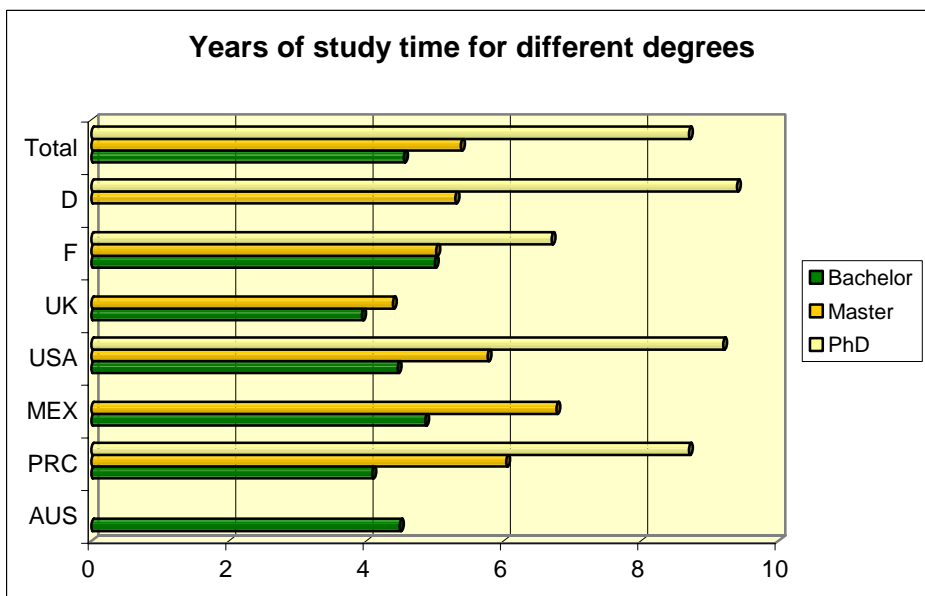
Distribution by sex is compiled in the following figure.



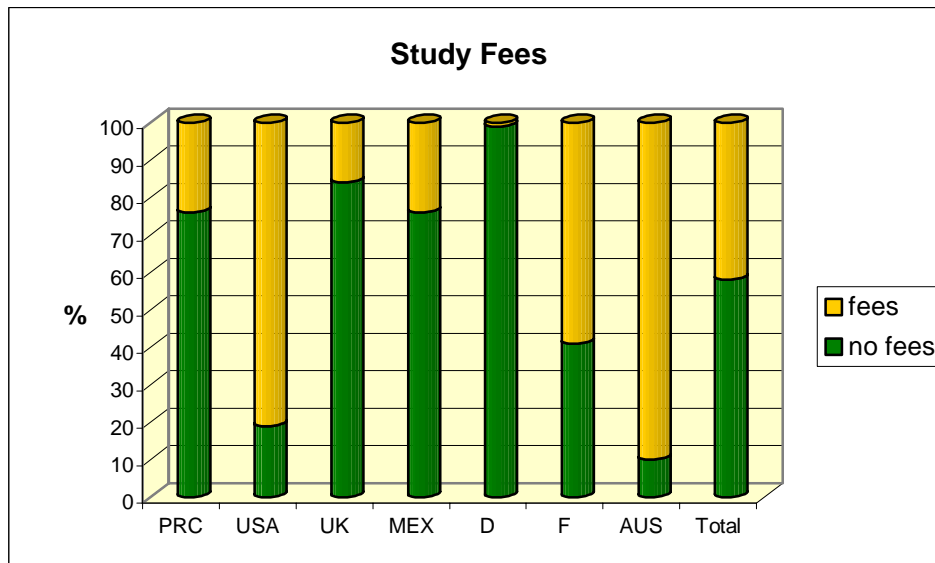
(Data Basis: Total: 2,159, PRC: 483, USA: 406, UK: 252, Mex: 229, D: 196, F: 152, AUS: 77)

Selected Results

The average number of years taken to obtain the highest degree is given in the following figure. (again includes the British M.Eng. degrees)



In all participating countries except Germany there are both non-fee-paying study courses at state universities and fee-paying courses. The relation of free to fee-paying courses varies considerably, however, from country to country.



(Prerequisite: Annual fee > 1,000 US \$)

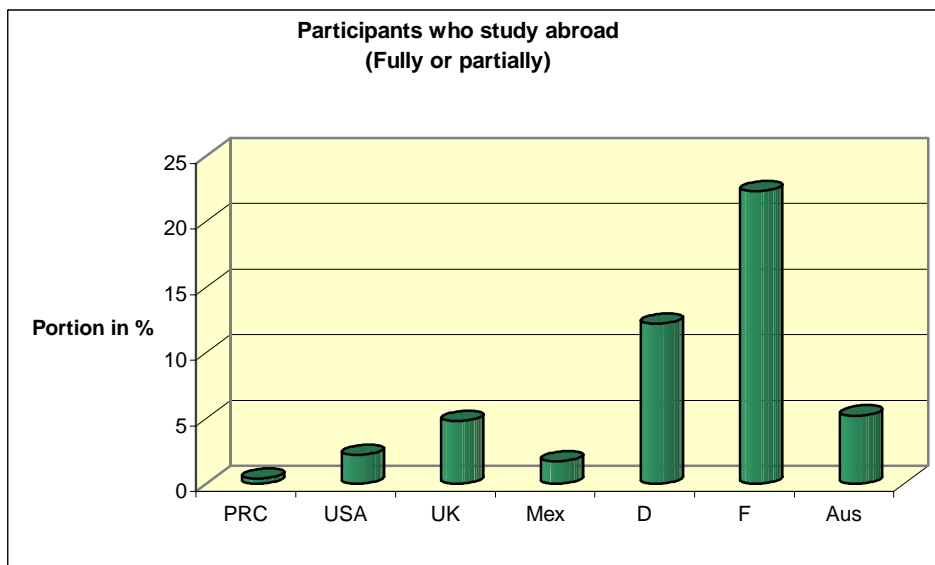
(Data Basis: Total: 2,158, PRC: 483, USA: 406, UK: 252, Mex: 229, D: 196, F: 152, AUS: 77)

Chemical Engineering is still an attractive study course on the employment market worldwide. Almost all graduates (90.6%) found their first post in less than 6 months after completing their studies. 31% of all surveyed took up their first post directly on obtaining their final qualification. The time taken to find a first post is practically independent of the academic degree obtained, however it is significantly sex-dependent. Women require an average of 0.8 months less to embark on their careers than men. 35.1% of the women, but only 26.1% of the men, took up their first professional activity immediately after completing their studies.

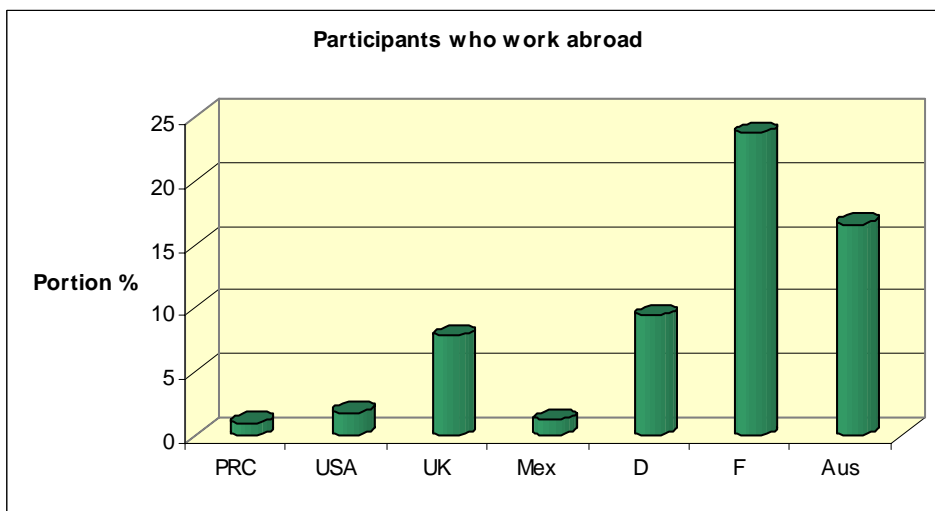
40.6% of all those covered by the survey had already been employed for over two years, while 59.4% were still in the first two years of employment. The number of previous employers ranges from 1 to 6. 98.6% of those questioned had had less than 5 employers; 56.7% were still with their first employer. The mean duration of 1.3 years per employer relates to this, however it varies considerably from country to country.

Studying and Working Abroad

Most of the participants still have studied and found a job in their Home Countries. But there are interesting differences between the countries investigated in detail. The following two figures show the portion of participants that have not studied fully or partially within their Home Countries and participants who work abroad. It is quite obvious that there is a strong correlation between studying abroad and finding a job outside the Home Country. Countries with a big Home market like China or the US offer lot of chances for young people to enter a professional career in industry. Hence there is not a perceived need to leave the country for study or employment.



(Data Basis: PRC: 2 of 482, USA: 9 of 406, UK: 12 of 252, Mex: 4 of 229, D: 24 of 196, F: 34 of 152, Aus: 4 of 77)

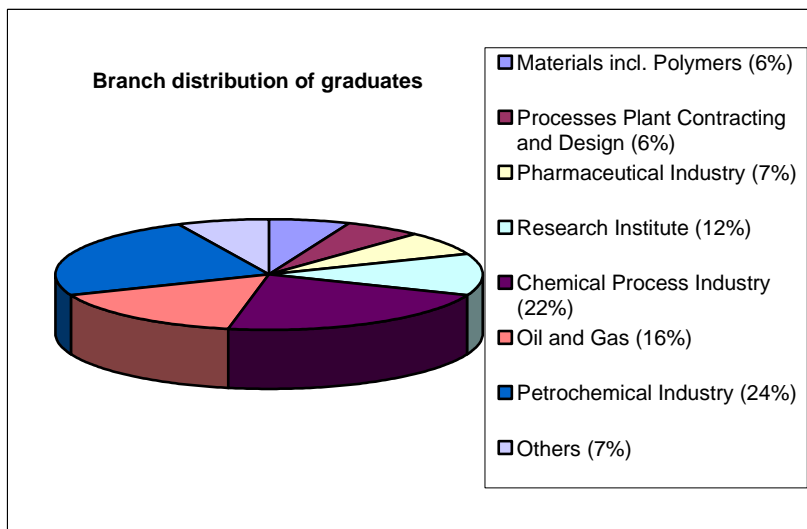


(Data Basis: PRC: 4 of 417, USA: 6 of 340, UK: 16 of 204, Mex: 2 of 168, D: 13 of 138, F: 27 of 113, Aus: 10 of 60)

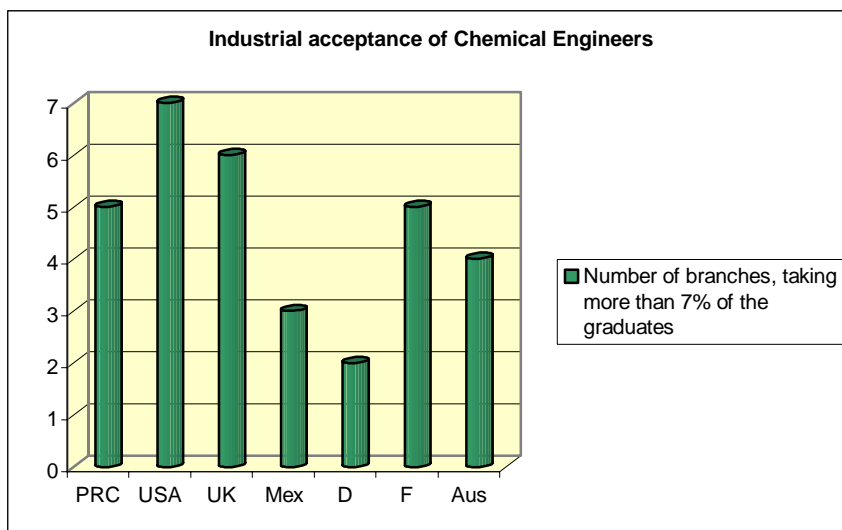
Chemical Engineering sector Distribution and Industrial Acceptance of Chemical Engineers

One particularly interesting finding is the distribution of young chemical engineers among various sectors of the profession since it reflects the trend for an increasing number of graduates to find employment outside the traditional areas, such as the chemical, pharmaceutical and oil industries. A total of 23 sectors were nominated, but the outcome from the survey increased this number to 27. Worldwide, 7 sectors each employed more than 5% of the graduates (see following figure.)

This acceptance by industry varies greatly by country. With regard to the range of employment for chemical engineers, the leading countries are USA, UK, F and PRC. The results do not permit conclusions to be drawn as to whether this is a consequence of the breadth of education or the receptiveness of the individual sectors within the Industry.



(Data Basis: Materials and Polymers: 125, Process Plant Contracting and Design: 133, Pharmaceutical Industry: 153, Research Institute: 257, Chemical Process Industry: 473, Oil and Gas: 345, Petrochemical Industry: 522)



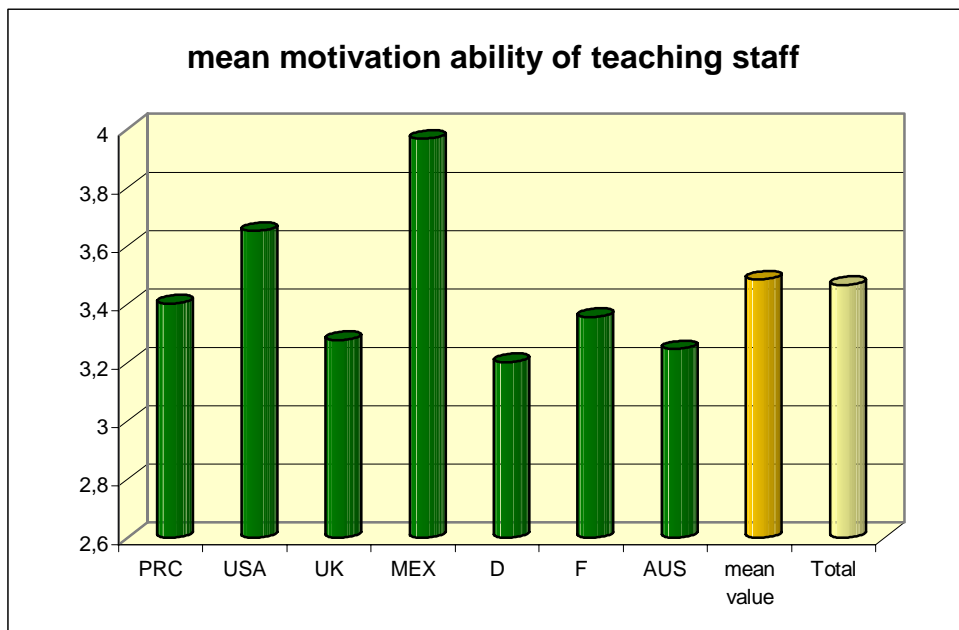
(Data Basis: Total: 2,158, PRC: 483, USA: 406, UK: 252, Mex: 229, D: 196, F: 152, AUS: 77)

Quality of Education

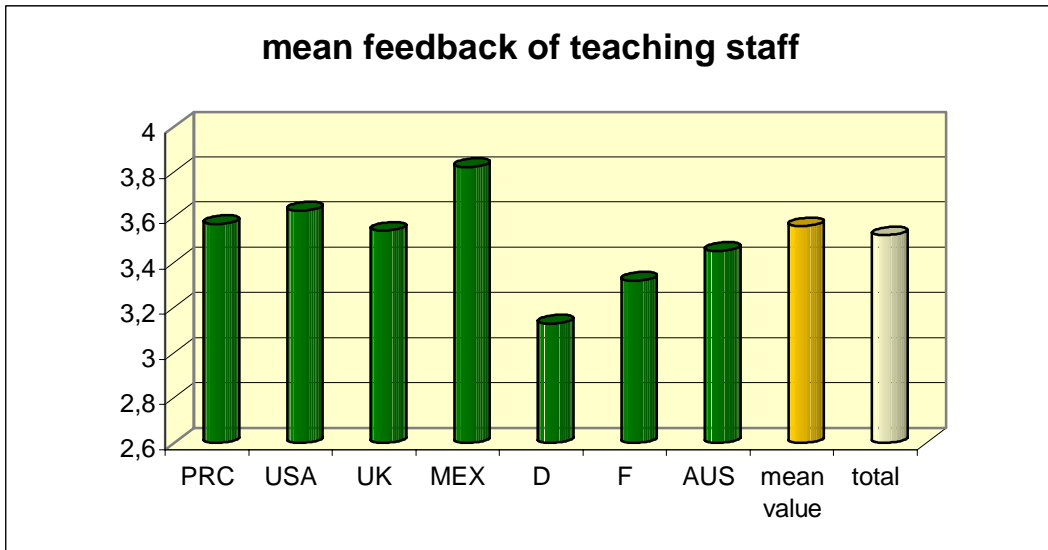
With regard to the quality of education, five criteria, ranging from 1 (very low) to 5 (very high), were assessed. The criteria were:

The teaching staff motivated me
The teaching staff normally gave me helpful feedback
My lecturers were excellent and inspiring
The assessment methods employed required an in-depth understanding of the course content
The study programme was efficiently organized

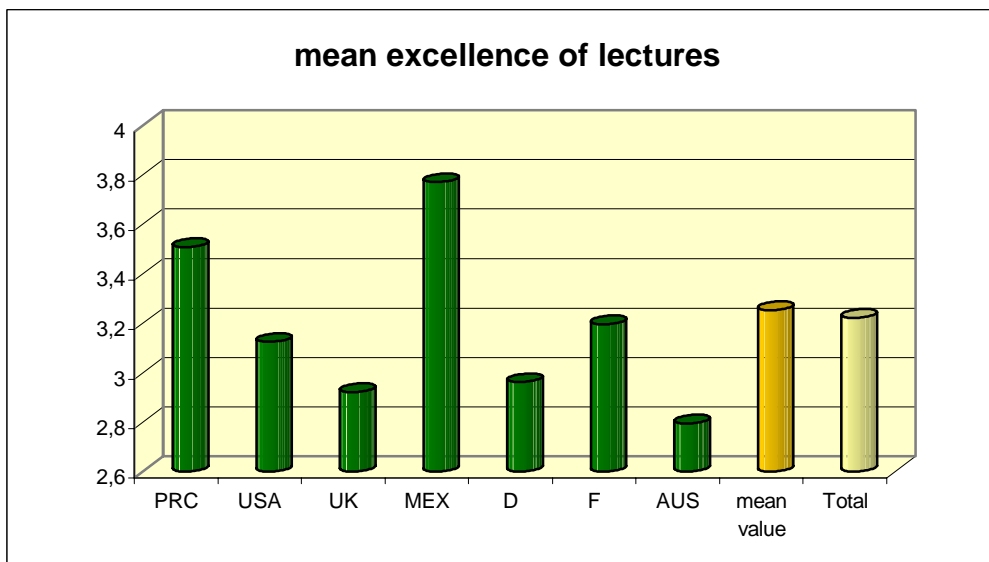
The following tables record the mean rating scores for these criteria relating to quality of education.



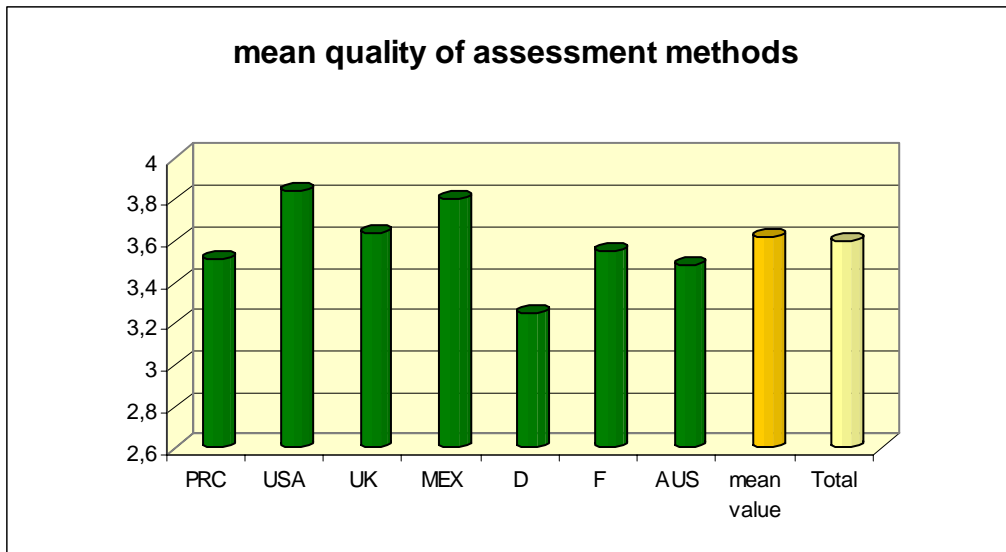
(Data Basis: PRC: 472 of 483, USA: 394 of 406, UK: 245 of 252, Mex: 212 of 229, D: 159 of 196, F: 143 of 152, AUS: 73 of 77, Total: 2,031 of 2,158)



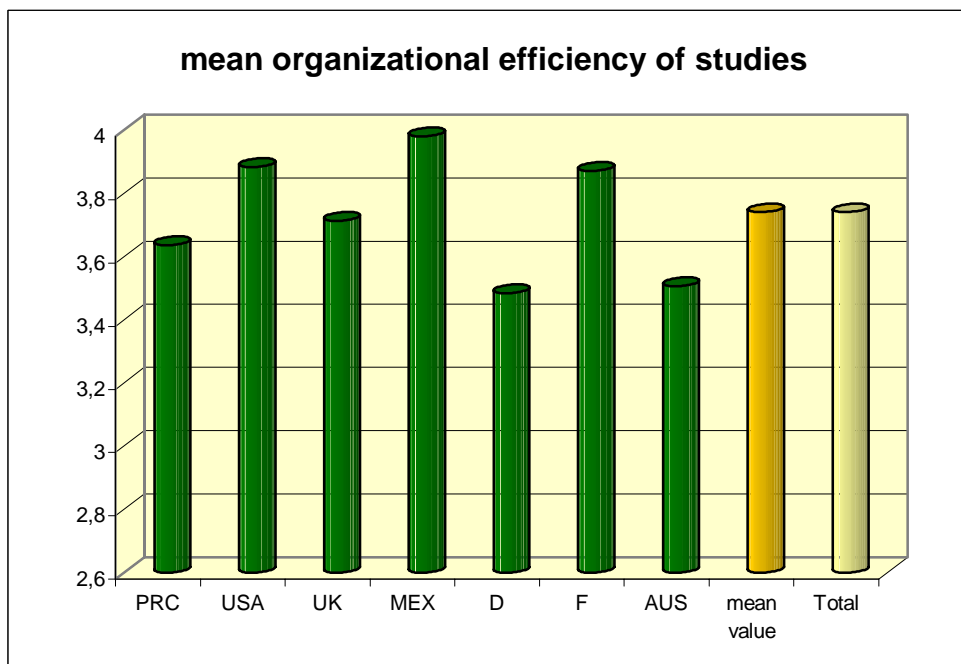
(Data Basis: PRC: 469 of 483, USA: 394 of 406, UK: 245 of 252, Mex: 213 of 229, D: 159 of 196, F: 143 of 152, Aus: 73 of 77)



(Data Basis: PRC: 469 of 483, USA: 392 of 406, UK: 245 of 252, Mex: 210 of 229, D: 159 of 196, F: 143 of 152, Aus: 73 of 77)



(Data Basis: PRC: 469 of 483, USA: 393 of 406, UK: 244 of 252, Mex: 210 of 229, D: 158 of 196, F: 139 of 152, Aus: 74 of 77)



(Data Basis: PRC: 469 of 483, USA: 393 of 406, UK: 245 of 252, Mex: 211 of 229, D: 159 of 196, F: 140 of 152, Aus: 73 of 77)

The following table shows the quality criteria that universities best fulfil worldwide.

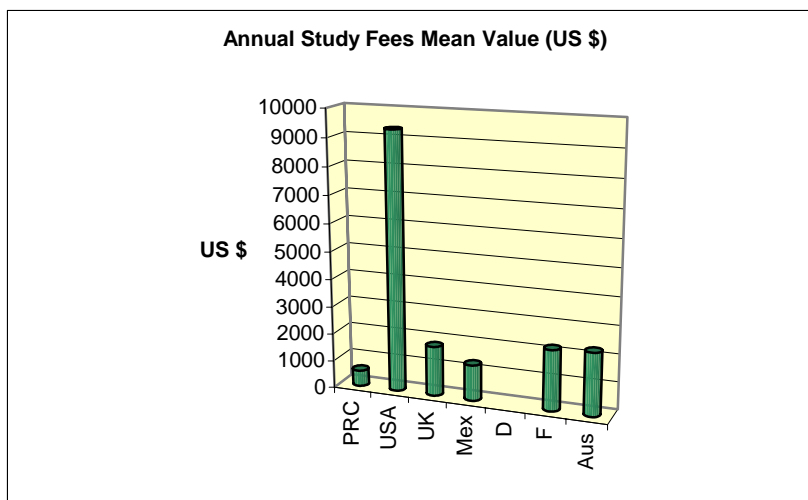
The study programme was efficiently organized	3.71
The assessment methods employed required an in-depth understanding of the course content	3.60
The teaching staff normally gave me helpful feedback	3.53
The teaching staff motivated me	3.47
My lecturers were excellent and inspiring	3.24

Women rate almost all quality criteria somewhat lower than men. This applies most to the helpful feedback criterion. This may be connected with the well-known psychological fact that women generally have a more strongly developed need for communication than men. Only with respect to examinations do slightly more women than men feel that a high standard is set.

Concerning the rating of the quality of education in the seven countries analysed in detail, Mexico and the USA clearly come first. With the exception of Australia, there are indications of a connection between quality of education and the levy of university fees.

Country	Total points for quality of education	Percentage Fee Payers
MEX	19,34	10%
USA	18,14	81 %
PRC	17,64	24 %
F	17,29	59 %
UK	17,09	16 %
AUS	16,48	90 %
D	16,03	0 %

The amount of university fees differs also significantly from country to country. The following figure shows, that the fees in the USA are significantly higher than in the other countries.



(Data Basis: PRC: 115 of 483, USA: 329 of 406, UK: 40 of 252, Mex 24 of 229, F 89 of 152, Aus 69 of 77)

Generic Attributes

Based on total data, the next two tables show the relevance of the various skills/abilities from 1 (very low) to 5 (very high), first graded with regard to quality of education then by relevance to work.

Generic Skills/Abilities	education	work	Data Basis*
Ability to apply knowledge of basic science and chem. engineering fundamentals	4.063	3.754	2,029
Ability to analyse information	4.053	4.323	2,015
Ability to gather information	3.966	4.232	2,015
Self learning ability	3.937	4.232	2,001
Ability to solve problems	3.884	4.222	2,009
Ability to work effectively as a member of a team	3.850	4.364	2,018
Importance of a broad and general education	3.803	3.958	2,026
Critical thinking	3.578	3.978	2,010
Appreciation of the potential of research	3.576	3.242	1,998
Ability to identify and formulate problems	3.564	3.972	2,003
Appreciation of an interdisciplinary approach	3.524	4.028	2,021
Ability to communicate effectively	3.482	4.279	2,009
Expectation of the need for lifelong learning	3.433	3.950	1,989
Ability to use a systematic approach to process and product design	3.367	3.614	2,004
Competence in information technology	3.339	3.596	2,010
Understanding of ethical and professional responsibilities	3.208	3.924	1,997
Ability to be a leader	3.155	3.834	2,015
Understanding of cultural diversity	2.812	3.332	2,016
Management skills	2.726	3.696	2,000
Understanding of principles of sustainable development	2.671	3.196	1,988
Understanding of fundamental principles of financial analysis	2.604	3.141	2,004
Foreign languages	2.488	2.887	1,989
Knowledge of methods for project management	2.401	3.365	1,997
Business oriented thinking / Business approach	2.275	3.332	1,997
Knowledge of methods for total quality management	2.186	3.063	1,992
Knowledge of marketing principles	1.998	2.730	1,995

*(Data Basis for "Education"; Total Number of Data Points 2,158) graded by relevance during education

Generic Skills/Abilities	education	work	Data Basis*
Ability to work effectively as a member of a team	3.850	4.364	1,990
Ability to analyse information	4.053	4.323	1,986
Ability to communicate effectively	3.482	4.279	1,979
Ability to gather information	3.966	4.232	1,987
Self learning ability	3.937	4.232	1,974
Ability to solve problems	3.884	4.222	1,983
Appreciation of an interdisciplinary approach	3.524	4.028	1,980
Critical thinking	3.578	3.978	1984
Ability to identify and formulate problems	3.564	3.972	1,979
Importance of a broad and general education	3.803	3.958	1,989
Expectation of the need for lifelong learning	3.433	3.950	1,965
Understanding of ethical and professional responsibilities	3.208	3.924	1,972
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Competence in information technology	3.339	3.596	1,980
Knowledge of methods for project management	2.401	3.365	1,974
Understanding of cultural diversity	2.812	3.332	1,980
Business oriented thinking / Business approach	2.275	3.332	1,971
Appreciation of the potential of research	3.576	3.242	1,961
Understanding of principles of sustainable development	2.671	3.196	1,959
Understanding of fundamental principles of financial analysis	2.604	3.141	1,978
Knowledge of methods for total quality management	2.186	3.063	1,965
Foreign languages	2.488	2.887	1,964
Knowledge of marketing principles	1.998	2.730	1,969

*(Data Basis for "Work"; Total Number of Data Points 2,158)

graded by relevance to work

Generally education has evident shortcomings. With the exception of only two attributes, the difference in relevance of education minus work is always negative. **This means that almost all attributes are required to a greater extent at work than they are developed during education.** The two attributes which are rated as more important more during education than for employment are

**Appreciation of the potential of research and
Ability to apply knowledge of basic science.**

These are, in fact, the traditional priorities of a classical university education. For work, their relevance ranks 21st and 14th respectively. A glance at the five most important attributes for employment shows that three of them also rank among the top five for education.

The 5 most important Generic Skills/Abilities at work	rank for education
Ability to work effectively as a member of a team	6
Ability to analyse information	2
Ability to communicate effectively	12
Ability to gather information	5
Self learning ability	4

Teamwork moves from 6th place for education to 1st place for work. The ability to communicate effectively takes 12th place for education and 3rd place for work. The ranking differences between these two attributes which are particularly important for employment should not, in principle, be criticized since education must by definition attach particular importance to the achievement of the individual; thus communication with other students may be considered by some to be less important than required for the future.

The 5 generic attributes, which are least, fostered at university compared with the demands of employment, are collected in the following table.

The 5 Generic Skills/Abilities, which are least fostered at university compared with the demands of employment	deviation	rank at work
Ability to communicate effectively	-0.797	3
Knowledge of methods for total quality management	-0.877	24
Knowledge of methods for project management	-0.964	18
Management skills	-0.970	15
Business oriented thinking / Business approach	-1.057	20

If these data are viewed as a whole, the differences in degree of relevance to education and work of almost all these attributes are more or less valid for all academic degrees. As far as the 7 countries evaluated in detail are concerned, however, the picture is more complex.

Number of abilities with positive values of education-work

Country	Bachelor	Master	PhD
PRC	3	2	0
USA	3	3	1
UK	2	3	-
MEX	3	5	-
D	-	3	3
F	3	2	4
AUS	2	-	-
mean value	2.67	3	2
total	2	2	1

(Data Basis: PRC: Bachelor: 273, Master: 153, PhD: 4
 USA: Bachelor: 307, Master: 60, PhD: 35
 UK: Bachelor: 103, Master: 146, PhD: 2
 Mex: Bachelor: 152, Master: 44, PhD: 3
 D: Bachelor: 7, Master: 64, PhD: 71
 F: Bachelor: 11, Master: 95, PhD: 15
 Aus: Bachelor: 70, Master: 1, PhD: 4)

On average those with a Master's degree consider themselves best prepared, those with a PhD, by contrast, least prepared for the demands of work. In all countries the generic attributes perceived to be required for employment yield greater scores than the same attributes when considered in terms of development during education. The average shortfall in degree of relevance of these attributes for employment versus education is presented in the following table.

Average shortfall in degree of relevance of generic abilities
 education – work

Country	Bachelor	Master	PhD
PRC	-0.11	-0.33	-0.51
USA	-0.47	-0.51	-0.64
UK	-0.6	-0.47	-
MEX	-0.51	-0.26	-
D	-	-0.86	-0.99
F	-0.47	-0.51	-0.45
AUS	-0.63	-	-
mean value	-0.47	-0.49	-0.65
total	-0.43	-0.48	-0.73

Those with a PhD generally feel least equipped for the requirements of employment. The research orientation of this academic qualification is evidently less in demand than in the past. The graduates who feel least prepared for the demands of work are the Germans. Ratings by country of the successful acquisition of generic attributes at university are given in the following table; the mean value of all participants in the individual countries was selected as the indicator.

Country	Deviation educ-work
PRC	- 0.22
USA	- 0.49
UK	- 0.52
MEX	- 0.45
F	- 0.5
AUS	- 0.63
D	- 0.93

This rating should not be seen to be an indicator of the performance of university education because it also covers the perceived requirements of employment. Thus it may well be that the demands made by employment in the emerging countries, China and Mexico, are less than those in the highly industrialized countries. Of the highly industrialized countries the USA has the lowest difference.

Affirmative answers to the final question

Are you pleased to have studied Chemical Engineering?

are given as percentages in the following table.

Country	total	Bach.	Master	PhD	Female	Male	Fee Payers	non Fee Payers
PRC	66.3 %	65.6 %	64.7 %	80.5 %	56.9 %	69.7 %	67.4 %	73.6 %
MEX	89.1 %	89.5 %	95.5 %	-	80.4 %	94.9 %	93.2 %	87.1 %
UK	92.5 %	91.3 %	93.8 %	-	91.9 %	92.7 %	96.2 %	91.8 %
USA	94.1 %	94.1 %	100.0 %	94.3 %	91.4 %	96.1 %	94.7 %	88.6 %
D	76.5 %	-	90.6 %	97.2 %	40.3 %	95.4 %		72.5 %
F	87.5 %	90.9 %	85.3 %	93.3 %	86.8 %	88.1 %	87.2 %	83.4 %
AUS	94.8 %	97.1 %	-	-	90.6 %	97.8 %	95.3 %	83.3 %
mean value	85.8 %	88.1 %	88.3 %	91.3 %	76.9 %	90.7 %	89.0 %	82.9 %
total	85.1 %	87.6 %	85.1 %	91.7 %	81.5 %	87.6 %	89.2 %	83.3 %

The degree of satisfaction with the study choice made is 85.1% worldwide; this varies relatively strongly from country to country. The least satisfied are the Chinese chemical engineers. Worldwide, PhDs show a greater degree of satisfaction than those with lesser university qualifications.

Overall, women are clearly more dissatisfied with their study choice than men. This difference is most pronounced in Germany.

The worldwide data and those from the 7 countries studied in depth are indicating the trend that satisfaction with the course of study chosen depends on payment of fees. Those who have paid are slightly more satisfied with the choice of their study.