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ShanghaiRanking's Global Ranking of Academic Disciplines 2016: engineering

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Introduction

The first multi-indicator ranking of world universities, Academic Ranking of World Universities, was published by the Institute of Higher Education of Shanghai Jiao Tong University in June 2003. Although the initial purpose of Academic Ranking of World Universities was to establish the global standing of top Chinese universities, it has attracted worldwide attention from governments, universities, media and the public in general. Professor Simon Marginson of UCL Institute of Education recently wrote in the *European Journal of Education* (2014, 49(1): 45) 'Since the first Shanghai Academic Ranking of World Universities in 2003 global rankings have transformed higher education', noting that '(s)ince the emergence of global rankings, universities have been unable to avoid national and international comparisons, and this has caused changes in the way universities function'.

While institutional rankings represent a principle object of global university rankings, it is evident that there are also reasons for subject or discipline related rankings. Firstly, without diminishing the importance of the organising framework represented by the university, academic disciplines provide substance and context in which academic activities are carried out. Secondly, academic disciplines are important in determining the intellectual and scholarly identity of academics. Thirdly, and particularly relevant in the context of rankings, is that there is hardly an institution which can claim to perform equally well in all academic disciplines. Considering the impact of global university rankings on higher education across the world, there is an increasing need for subject or discipline related rankings. The recent publication of Global Ranking of Academic Disciplines for engineering subjects (http://www.shanghairanking.com/) is the latest contribution of ShanghaiRanking.

Methodologies

Selection of universities

To be included in a subject ranking, universities must have a minimum number of research publications. For engineering subjects in 2016, the scholarly output requirement is 200 papers over the past five years.

Scope of subjects in engineering

Seven subjects in the field of engineering were ranked, including chemical engineering, civil engineering, electrical and electronic engineering, energy science and engineering, environmental science and engineering, materials science and engineering, and mechanical engineering. Their corresponding ASJC (All Science Journal Classifications) categories and codes in the Scopus database are shown in Table 1.

Table 1. Academic disciplines ranked in 2016 and their corresponding Scopus categories

Academic Disciplines	Corresponding ASJC Codes and Categories
Chemical Engineering	1500: Chemical Engineering (all sub-categories)
Civil Engineering	2205: Civil and Structural Engineering 2215: Building and Construction
Electrical & Electronic Engineering	2208: Electrical and Electronic Engineering
Energy Science & Engineering	2100: Energy (all sub-categories)
Environmental Science & Engineering	2300: Environmental Science (all sub-categories)
Materials Science & Engineering	2500: Materials Science (all sub-categories)
Mechanical Engineering	2203: Automotive Engineering 2209: Industrial and Manufacturing Engineering 2210: Mechanical Engineering

Indicators and weights

A new weighting system is adopted (Table 2). Instead of allocating a total weight of 1, the new methodology for the engineering subjects ranking allocates a weight of 100 each for publications (PUB), top 25 per cent most cited papers (TOP25), top one per cent most cited papers (TOP1), international co-authorship (IC), most cited researchers (MCR), and staff wining important international awards (AWARD), and allocates a weight of 200 each for field weighted citation impact (FWCI) and academic corporate collaboration (CC). For each indicator, institutions are calculated as a percentage of the top scored institution and then multiplied by the allocated weight. A final score is arrived at by adding scores for all indicators, and the final scores are ranked in descending order. Detailed definitions of the indicators are provided in Table 3.

Table 2. Indicators and weights for subject ranking in engineering

Indicator	Weight	Indicator descriptions
PUB	100	The number of papers authored by an institution and indexed in Scopus in each engineering subject
TOP25	100	The number of world top 25 per cent most cited papers in each engineering subject
TOP1	100	The number of world top one per cent most cited papers in each engineering subject
FWCI	200	The number of citations received by an institution's publications as compared with the average number of citations received by all other similar publications in each engineering subject in the Scopus database
IC	100	The extent to which an institution's publications have international co-authorship
CC	200	The percentage of an institution's publication with academic and corporate or industrial co-authors
MCR	100	Most cited researchers in each engineering subject
AWARD	100	Refers to the total number of the staff at an institution winning an important international academic award in an engineering subject. The Von Hippel Award by the Materials Research Society in the United States is selected for the Materials Science and Engineering ranking and the Tyler Prize by the University of Southern California in the United States is selected for the Environmental Science and Engineering ranking

Table 3. Detailed definition of indicators for subject ranking in engineering

Indicators	Definition
PUB	PUB measures research productivity. It is the number of papers authored by an institution and indexed in Scopus in a specific subject for the latest five calendar years (2010-2014). A paper is assigned to one of the seven engineering subject fields according to the classification of the Journal Categories (ASJC codes) in the Scopus database. The publication types include articles and reviews, as well as conference papers.
TOP25	TOP25 measures high quality research outcomes. TOP25 is the number of world top 25 per cent most cited papers an institution has for the latest five calendar years (2010-2014). The publication types include articles, reviews and conference papers. The top 25 per cent cited papers are selected from publications in the same year, of the same type, and within the same sub-category and then aggregated.
TOP1	TOP1 measures top quality research outcomes. TOP1 is defined as the number of world top one per cent most cited papers an institution has for the latest five calendar years (2010-2014). The publication types include articles, reviews and conference papers. The top one per cent cited papers are selected from publications in the same year, of the same type, and within the same sub-category and then aggregated.
FWCI	FWCI is the Field-Weighted Citation Impact indicator that measures an institution's research quality as compared with the world average. The indicator shows how the number of citations received by an institution's publications compares with the average number of citations received by all other similar publications in the Scopus database. A FWCI of one indicates that the institution's publications have been cited exactly the same as the global average for similar publications. A FWCI of greater than one shows a stronger performance of an institution's publications compared to similar publications around the world. Similar publications are those in the Scopus database that have the same publication year, publication type and discipline.
IC	IC measures the extent to which an institution's publications have international co-authorship. The publication types cover articles, reviews and conference papers. The data is collected for the latest five calendar years (2010-2014). The indicator is scaled by total research publications in the subject so that large institutions with high research productivity do not have an unfair advantage in the ranking process.
CC	CC is Academic-Corporate Collaboration, which measures the degree of collaboration between academic and corporate affiliations. It represents the percentage of an institution's publication with academic and corporate or industrial co-authors. The publication types for this indicator cover articles, reviews and conference papers. The data is collected for the latest five calendar years (2010-2014).
MCR	MCR measures an institution's number of researchers with globally academic influences. MCR are selected by three steps: first, the total number of citations received by a researcher in Scopus from the publications where he/she is the corresponding or first author is calculated; second, those researchers with the greatest number of citations in each sub-category are carefully scanned, confirmed and then aggregated into different subjects; third, in each subject, up to 300 top researchers are identified and published.
AWARD	AWARD measures the academic achievements and recognitions researchers at an institution have obtained. It refers to the total number of staff at an institution winning an important international academic award in a particular subject field. 'Staff' is defined as those who work at an institution at the time of winning the prize. The significant awards are those satisfying the following two criteria. First, the award needs to have more than a 0.67 (2/3) reputation score according to the IREG List of International Academic Awards. An IREG score of 0.67 indicates that the award has a high reputation in a particular field as compared with the reputation of the Nobel Prize. The second criterion is that the awards should have no more than 80 per cent domestic winners. 'Domestic winners' are defined as those whose affiliation and awarding organisation are in the same country. Different weights are set according to the time periods in which awards are won. The weight is 100 per cent for winners after 2011, 80 per cent for winners in 2001-2010, 60 per cent for winners in 1991-2000, 40 per cent for winners in 1981-1990, and finally 20 per cent for winners in 1971-1980. If a winner is affiliated with more than one institution, each institution is assigned the reciprocal of the number of institutions. If the award is awarded to more than one winner in one year, each winner is assigned the reciprocal of the number of winners.

Data sources

Only internationally comparable third-party data are used. No data is collected from individual institutions. Clean-up of data is always performed whenever necessary. Main third party data sources are provided in Table 4.

Table 4. Data sources for indicators of subject ranking in engineering

Scopus	http://www.info.scopus.com
SciVal	http://www.info.scival.com
Von Hippel Award	http://www.mrs.org/vonhippel/
Tyler Prize	http://tylerprize.usc.edu/

Results and analysis

Statistics by region

Although the Americas dominate the list of the top 20 (Table 5), as they often do in a variety of rankings, Europe and Asia/Pacific perform almost equally well as the Americas in the list of the top 100 (Table 6).

Table 5. Statistics of top 20 institutions by region

Region	CheE	CivE	EleE	EnrE	EnvE	MatE	MecE	Total
Americas	8	8	11	7	13	12	12	71
Asia/Pacific	7	6	6	8	1	3	4	35
Europe	5	6	3	5	6	5	4	34
Africas	—	—	—	—	—	—	—	—

Note: CheE for Chemical Engineering, CivE for Civil Engineering, EleE for Electrical & Electronic Engineering, EnrE for Energy Science & Engineering, EnvE for Environmental Science & Engineering, MatE for Materials Science & Engineering, and MecE for Mechanical Engineering.

Table 6. Statistics of top 100 institutions by region

Region	CheE	CivE	EleE	EnrE	EnvE	MatE	MecE	Total
Americas	32	32	49	30	45	42	42	272
Europe	37	33	27	32	41	29	33	232
Asia/Pacific	31	35	24	38	14	29	25	196
Africas	—	—	—	—	—	—	—	—

Note: CheE for Chemical Engineering, CivE for Civil Engineering, EleE for Electrical & Electronic Engineering, EnrE for Energy Science & Engineering, EnvE for Environmental Science & Engineering, MatE for Materials Science & Engineering, and MecE for Mechanical Engineering.

Statistics by country

As indicated in Tables 7 and 8, the United States dominates the list of both the top 20 and the top 100 in all of the seven subjects. China, Switzerland, Singapore, the United Kingdom, and South Korea perform reasonably well in the majority of the subjects.

Table 7. Statistics of top 20 institutions by country

Country/Region	CheE	CivE	EleE	EnrE	EnvE	MatE	MecE	Total
United States	8	7	11	7	12	12	12	69
China	3	2	2	4	0	1	2	14
Switzerland	2	2	2	2	1	1	2	12
Singapore	1	1	2	2	0	2	1	9
United Kingdom	0	1	0	1	1	3	2	8
Netherlands	2	1	0	0	2	1	0	6
South Korea	2	1	1	1	0	0	1	6
Denmark	1	1	1	2	1	0	0	6
China-Hong Kong	0	2	1	0	0	0	0	3
Canada	0	1	0	0	1	0	0	2
Australia	0	0	0	1	1	0	0	2
Japan	1	0	0	0	0	0	0	1
Sweden	0	0	0	0	1	0	0	1
Italy	0	1	0	0	0	0	0	1

Note: CheE for Chemical Engineering, CivE for Civil Engineering, EleE for Electrical & Electronic Engineering, EnrE for Energy Science & Engineering, EnvE for Environmental Science & Engineering, MatE for Materials Science & Engineering, and MecE for Mechanical Engineering.

Statistics by institutions

As shown in Table 9, top universities from the United States, such as the University of California at Berkeley, Massachusetts Institute of Technology and Stanford University, are seen in the top 20 list in almost all of the subjects. Swiss Federal Institute of Technology Lausanne and Swiss Federal Institute of Technology Zurich also have most of their engineering subjects in the top 20 list. Singaporean universities, such as the National University of Singapore, and Chinese universities, such as Tsinghua University, are performing very well. Universities in Denmark, the United Kingdom, South Korea and the Netherlands are also performing well.

Table 8. Statistics of top 100 institutions by country

Country/Region	CheE	CivE	EleE	EnrE	EnvE	MatE	MecE	Total
United States	31	26	45	25	39	41	36	243
United Kingdom	10	11	6	8	17	7	10	69
China	11	9	7	17	2	7	6	59
South Korea	6	5	5	5	1	8	7	37
Japan	7	3	4	4	0	6	6	30
Australia	3	8	1	4	9	4	1	30
Canada	1	6	4	5	6	1	6	29
Netherlands	8	2	2	4	5	4	2	27
Germany	6	1	4	4	1	5	6	27
Sweden	3	2	3	2	4	1	4	19
Switzerland	2	2	2	2	4	2	2	16
Denmark	2	2	2	3	3	1	2	15
Italy	0	4	4	3	0	1	2	14
Singapore	2	2	2	2	1	2	2	13
France	2	1	0	2	3	3	2	13
Belgium	2	3	1	1	2	2	1	12
China-Hong Kong	0	4	1	4	0	0	1	10
China-Taiwan	0	1	3	1	0	1	1	7
Finland	1	1	1	0	1	1	1	6
Saudi Arabia	2	0	0	1	0	1	1	5
Spain	1	0	1	1	0	0	0	3
New Zealand	0	2	0	0	1	0	0	3
Norway	0	1	0	1	1	0	0	3
Austria	0	0	1	0	0	1	1	3
Greece	0	1	0	1	0	0	0	2
Portugal	0	2	0	0	0	0	0	2
Malaysia	0	1	0	0	0	0	0	1
Israel	0	0	1	0	0	0	0	1
Ireland	0	0	0	0	0	1	0	1

Note: CheE for Chemical Engineering, CivE for Civil Engineering, EleE for Electrical & Electronic Engineering, EnrE for Energy Science & Engineering, EnvE for Environmental Science & Engineering, MatE for Materials Science & Engineering, and MecE for Mechanical Engineering.

Table 9. Statistics of institutions by total number of top subjects

Institution	Country/Region	Subjects in Top 20	Subjects in Top 100
University of California, Berkeley	United States	7	7
Massachusetts Institute of Technology (MIT)	United States	6	7
Stanford University	United States	6	7
Swiss Federal Institute of Technology Lausanne	Switzerland	6	7
Swiss Federal Institute of Technology Zurich	Switzerland	6	7
Tsinghua University	China	6	7
Georgia Institute of Technology	United States	5	7
National University of Singapore	Singapore	5	6
University of Illinois at Urbana-Champaign	United States	5	6
Nanyang Technological University	Singapore	4	7
Technical University of Denmark	Denmark	4	7
Imperial College London	United Kingdom	4	7
The University of Texas at Austin	United States	4	7
University of California, Los Angeles	United States	4	7
University of Michigan-Ann Arbor	United States	4	7
Harvard University	United States	4	5
Korea Advanced Institute of Science and Technology	South Korea	3	6
Seoul National University	South Korea	3	6
Northwestern University	United States	3	5
University of California, Santa Barbara	United States	3	5
Pennsylvania State University - University Park	United States	2	7
Princeton University	United States	2	7
University of Cambridge	United Kingdom	2	7
Eindhoven University of Technology	Netherlands	2	6
Shanghai Jiao Tong University	China	2	6
University of California, San Diego	United States	2	6
University of Oxford	United Kingdom	2	6
Rice University	United States	2	5
Zhejiang University	China	2	5
Aalborg University	Denmark	2	4
City University of Hong Kong	China-Hong Kong	2	4
Utrecht University	Netherlands	2	3

Concluding remarks

Any ranking system is controversial, and no ranking system is absolutely objective. Nevertheless, university rankings have become popular in almost all major countries in the world. Whether universities and other stakeholders agree with the various ranking systems, rankings are clearly here to stay. The key issue then becomes how to improve ranking systems, and how to use ranking results properly. Ranking methodologies should always be read carefully before looking at any ranking lists, and ranking results should be used with caution.

ShanghaiRanking endeavored to rank research universities across the world by their academic or research performance, based on internationally comparable third-party data that is publically available. Nevertheless, there are still many methodological and technical limitations. ShanghaiRanking will continue to improve its ranking methodologies and provide more diversified ranking products. After the recent release of its Global Ranking of Academic Disciplines for engineering subjects, ShanghaiRanking plans to publish its Global Ranking of Academic Disciplines for subjects in social sciences and natural sciences in the near future.

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