



ON THE RANKING OF UK UNIVERSITIES FOR WORLD-LEADING QUALITY OF CHEMISTRY RESEARCH: MONEY MAKING THROUGH JOURNAL IMPACT FACTOR

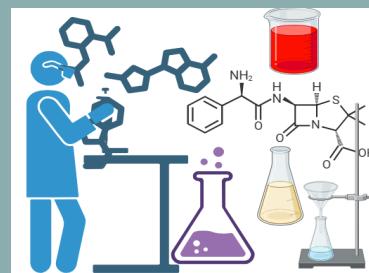
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1. The ranking of UK universities as places of chemistry education

The UK is the world's best expert in ranking universities. The resulting league tables are claimed to help people in making informed decision, predominantly prospective students on where to study, where to do research, and who to collaborate with. In recent years, university rankings have further been extended to specific subject areas such as chemistry that I am using herein as a prime example. The Complete University Guide (CUG) listed 68 universities in the UK that offer 438 undergraduate chemistry courses. In its latest [2024](#) best chemistry subject league table, it ranked 55 Universities using the following criteria: entry standard, student satisfaction, research quality, continuation, and graduate prospects. This league table on the top-end of the list was similar with the previous year's CUG ranking but showed some spectacular changes for the top [Russel Group Universities](#), with significant drop in their positions such as that for King's College (by 6 places to 30th), University College London (UCL) (by 9 places to 17th), Queen's University Belfast (by 13 places to 26th), Liverpool (27th, by 15 places), and Queen Mary University of London (QMUL) (by 16 places to 34th),

as well as few other universities including Hull (by 11 places), and Leicester (by 12 places). On the other hand, the [Guardian University Ranking](#) for chemistry as a subject scored 51 universities in its 2024 league table using entry tariff, continuation, career prospect (after 15 months) and student satisfaction (with various subsets) as with CUG, but with the exclusion of research quality and additional criteria of value adding, student to staff ratio and spend per student. The stark variation between the Guardian and CUG leagues is obvious with research-intensive universities such as King's College London (49th), and even UCL (50th) which has top ranking in chemistry at global stage, placed at the far bottom of the Guardian league table. In fact, the worst performers of universities in the UK's recent research assessment exercise [REF-2021 for chemistry subject](#) (e.g., Universities, Greenwich, Bradford, and Huddersfield) have all ranking positions better than the likes of QMUL (REF 2021, ranking of 14th), Manchester (REF 2021, 7th), King's College London (REF 2021, 5th), and the UCL (REF 2021, 3rd) in Chemistry education leagues.

REF Research Excellence Framework
2021



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CHEMISTRY

- Education
- Research
- Ranking
- REF



Chemistry: National vs Global leagues

REF 2021 – Chemistry: Ranking by GPA

3692 papers submitted to the chemistry UOA in REF 2021 along with outcome scores were scrutinised ...

The recent subject-specific and university league assessments by this national league providers therefore appear to have taken away some of the traditional advantages of research-oriented universities by giving lesser emphasis to research and more emphasis to students. Even though the teaching/learning of STEM subjects like chemistry is highly dependent on research infrastructure such as state-of-the-art instrumentation and research-based subject know-how of the teaching workforce, one can still argue that

the traditional research-intensive (or the Russel Group) universities in the UK are not necessarily places of best chemistry education in the country. Given the variation in the ranking orders by different league providers, and discrepancies between the national and some globally available leagues for chemistry as a subject (see results section), to what degree these national leagues give accurate information on quality (such as world-leading position) of chemistry education is not known.

2. The ranking of UK universities for chemistry research quality

One major ingenuity of the UK is in the research quality assessment (research excellence framework - REF) of universities that takes every ~5 years; the data of which is not only universally adopted for research league tables, but also linked to financial allocation by the government. The huge data set for the recent [REF 2021](#) in this exercise included 157 universities and covering 34 subject-based units of assessments (UOAs). The outcomes (published in May 2022) have been used for ranking institutions based on their overall research quality or individual subject areas including [chemistry](#). The REF 2021 scoring was based on three major areas: research paper **OUTPUTS**, which accounted for 60% of the overall weighting and measuring the originality, significance, and rigour of each paper; **IMPACT** which accounted for 25% of the overall outcome and measuring the reach and significance of impact case stud-

ies submitted; and the research **ENVIRONMENT** (15% of weighting) for supporting research and enabling impact (vitality and sustainability). The overall quality was presented as percent proportion of submission for the institution/subject as world-leading (4*), internationally excellent (3*), internationally recognised (2*), nationally recognised (1*) and unclassified (0*). Based on the aggregated score of these three assessment areas, the chemistry research quality (UOA 8, REF 2021) in the UK was ranked for 41 submitted universities with a total of 1502.02 FTE academic staff. The ranking order on the bases of overall GPA score has been published (e.g., by [THE](#)). The top 10 performers, as one expects in research ranking, were the Russel Group Universities in the order of: Bristol, Cambridge, UCL, Imperial College, King's College, Oxford, Manchester = Liverpool, York, and Edinburgh = St Andrews.

3. Analysis methodology

Given the bulk of the overall REF 2021 outcome was accounted by the **OUTPUTS** weighting in the form of submitted paper quality, emphasise was given to this area of assessment as a major driving force of world-leading (4*) quality measure. For the sake of completion, the direct relationship between the overall outcome (aggregated GPA) and world-leading (outstanding) **IMPACT** or world-leading research **ENVIRONMENT** were also assessed. There is no doubt that world-leading research quality can come from **OUTPUT** in less cited/impact factor journals and as such there was no guidance on linking journal impact factor (where the papers are

published) with paper quality. There has always been speculation however on the link between paper quality and the journal impact factor. For the chemistry submission, there were a total of 3692 papers submitted which in this analysis were individually scored based on their current perspective journal impact factor (where the papers published) in the literature. The average impact factor of the submission was calculated for each institution, the data of which was further used to establish the correlation between journal impact factor and world-leading **OUTPUT** or overall GPA of REF 2021 for chemistry subject.

Key to Table 1

*See the [THE](#) ranking for the calculation of overall GPA.

†Impact factor of the journals where each submitted paper to the REF 2021 exercise was published. The average impact factor per person submitted was calculated for each institution.

‡ 6.5166 with adjustment for one patent entry.

§ 9.2755 with adjustment for 2 patents entry.

4. Summary of results

4.1. The quality and quantity of outputs submitted to the Chemistry UOA

Readers should note that the paper outputs shown in the REF 2021 database were the selection of the very best of the authors' publication during the review period; not all that they published. In this connection, the number of outputs for each institution was 2.5 times the FTE academics submitted with each staff member contributing at least one and no more than five outputs. Nevertheless, the representative chemistry papers reflect the truly outstanding quality of papers published by several institutions as revealed by the proportion of papers rated as world-leading quality. The chemis-

try submission also had high proportion of eligible staff with research responsibility submitted to the REF exercise. Except for the Universities, Greenwich (60%), Huddersfield (90%) and Bradford (95%), all the other institutions in chemistry UOA returned 100% or more of the eligible staff. i.e., 92.68% of universities in chemistry UOA returned 100% or more of the eligible staff. In contrast, UOA 3 (Allied Health Professions, Dentistry, Nursing and Pharmacy) with bigger list (91 institutions) had 31.87% of universities returning 100% or above of the eligible staff.

4.2. Ranking by overall GPA

Tabulated data and ranking of outcomes for the REF 2021 assessment parameters are shown in **Table 1**, while the relevant key correlations between the assessed parameters are presented in **Figure 1**. The percentage of world-leading OUTPUTS ranged from the lowest, the University of Greenwich (2.3%), to the highest, University of Bristle (67.8%) which also had 1st ranking by overall GPA score. The calculated average impact factor for the submitted papers OUTPUTS ranged from just under 7 for the University of Greenwich to 26-29 for the Universities, Manchester, Cambridge, and Bristle. The 4* (outstanding) IMPACT ranged from 0% for Chester and Huddersfield to 100% for King's College London and Newcastle. This IMPACT assessment was not good in differentiating institutions: 6 institutions had the same score of 25% and 8 institutions scored 50%. Out of the 41 institutions in chemistry subject entry for research quality, 14 scored 0% for world-leading research culture - ENVIRONMENT. Imperial College, Manchester, Edinburgh, and St Andrews scored 100% for research ENVIRONMENT.

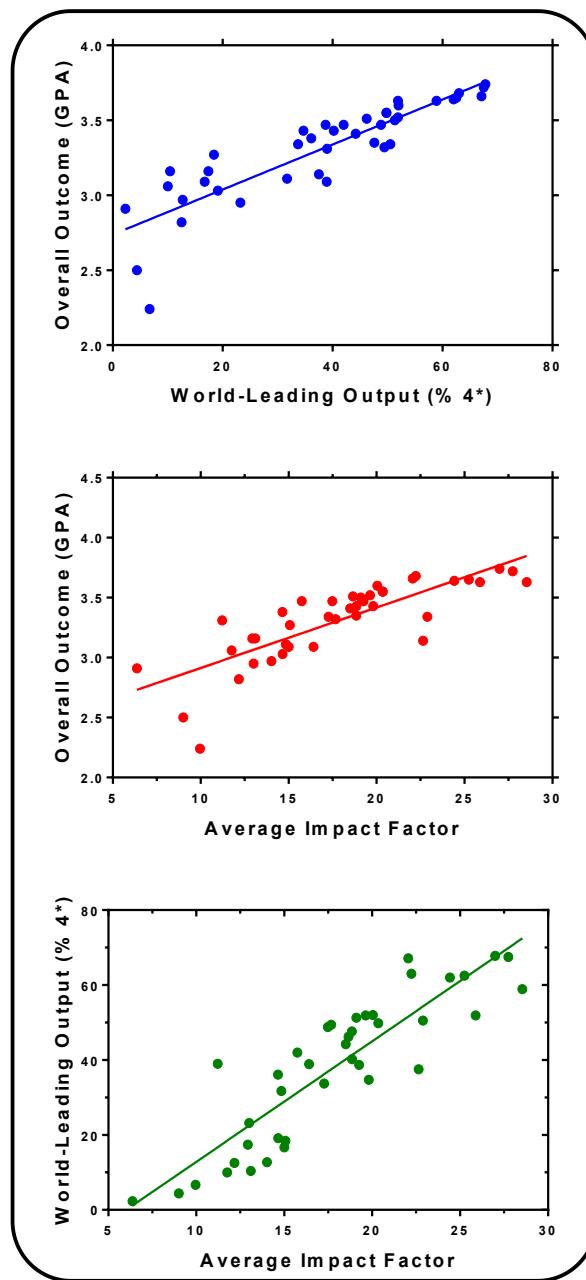


Figure 1. Key correlation graphs for REF 2021 assessment parameters in the Chemistry UOA.

UOA:
chemistry
Institutions:

41

FTE: 12 - 77.23

PAPERS: 30-
194

Average IF: ~7
-29

Eligible staff:
60% -
>100%

Correla-
tion:

GPA vs 4*

Output

GPA vs IF

IF vs 4* out-
put

Table 1. REF 2021 Outcomes for UK Higher Education Institutions in the Chemistry (UOA 8) subject.

Rank by Overall GPA*	Institution	Staff No. (FTE)	Overall GPA	World-Leading OUTPUT (% 4*)	Outstanding IMPACT (% 4*)	World-Leading Environment (% 4*)	Average Impact Factor
1	Univ. of Bristol	64.2	3.74	67.8	80	87.5	26.9903
2	Univ. of Cambridge	77.23	3.72	67.5	83.3	87.5	27.7422
3	UCL	64.8	3.68	63	70	87.5	22.2300
4	Imperial College London	63.34	3.66	67.1	50	100	22.0453
5	King's College London	19	3.65	62.5	100	25	25.2416
6	Univ. of Oxford	83	3.64	62	64.3	87.5	24.4240
7	Univ. of Manchester	76.2	3.63	58.9	50	100	28.5324
7	Univ. of Liverpool	43	3.63	51.9	87.5	75	25.8765
9	Univ. of York	56.8	3.6	52	70	57.5	20.0392
10	Univ. of Edinburgh & Univ. of St Andrews	48	3.55	49.8	42.9	100	20.3495
10	Univ. of St Andrews & Univ. of Edinburgh	40.28	3.55	49.8	42.9	100	20.3495
12	Univ. of Bath	41.6	3.52	51.9	50	62.5	19.6270
13	Univ. of Warwick	46.8	3.51	46.2	50	75	18.6508
14	Queen Mary University of London	15.5	3.5	51.3	75	0	19.0957
15	Univ. of Southampton	44.35	3.47	38.7	62.5	75	19.2554
15	Univ. of Sheffield	34.2	3.47	48.8	66.7	37.5	17.4750
15	Newcastle Univ.	34	3.47	42	100	12.5	15.7464
18	University of Nottingham	46.7	3.43	40.2	37.5	75	18.8552
18	Cardiff University	39.35	3.43	34.7	62.5	50	19.8062
20	University of Strathclyde	34.4	3.41	44.2	50	25	18.4905
21	Durham University	44.2	3.38	36.1	50	50	14.6428
22	Univ. of Leicester	18.8	3.35	47.6	25	0	18.8465
23	Univ. of Glasgow	41	3.34	50.5	12.5	62.5	22.8840
23	Univ. of East Anglia	34.2	3.34	33.7	83.3	0	17.2674
25	Univ. of Birmingham	30.8	3.32	49.4	16.7	50	17.6709
26	Univ. of Leeds	39.95	3.31	39	25	37.5	11.2208
27	Queen's University Belfast	30.3	3.27	18.4	83.3	12.5	15.0622
28	Univ. of Aberdeen	19	3.16	10.4	50	12.4	13.0982
28	Univ. of Sussex	18.3	3.16	17.4	75	0	12.9332
30	Swansea Univ.	19.2	3.14	37.5	25	0	22.6427
31	Univ. of Kent	18	3.11	31.7	25	0	14.8344
32	University of Hull	14.5	3.09	16.7	25	0	15.0000
32	Univ. of Lincoln	14.2	3.09	38.9	25	0	16.4115
34	Univ. of Reading	15.93	3.06	10	50	0	11.7532
35	Loughborough Univ.	31	3.03	19.1	16.7	12.5	14.6491
36	Lancaster Univ.	25	2.97	12.7	16.7	0	14.0162
37	Heriot-Watt Univ.	39.69	2.95	23.2	12.5	0	12.9984
38	Univ. of Greenwich	17.2	2.91	2.3	75	0	6.3651†
39	Univ. of Bradford	19	2.82	12.5	0	0	12.1650
40	Univ. of Huddersfield	27	2.5	4.4	16.7	0	9.0028§
41	Univ. of Chester	12	2.24	6.7	0	0	9.9580

4.3. The influence of journal impact factor on world-leading ranking

In the present analysis, the world-leading research IMPACT (4*) data for the chemistry submission were widely spread showing poor predictive value to the overall outcome (aggregated REF 2021 GPA). Similarly, the 4* data for world-leading research ENVIRONMENT offers little value in predicting the overall outcome. Given bigger research-intensive universities have large number of staff submissions, there was a trend of increased overall outcome with increasing staff number, but the data offers not much value in predicting the overall outcome. In contrast, important correlations of statistical significance ($p < 0.001$) were observed (Figure 1) as follow:

- ◆ The overall outcome (GPA) appears to show a direct relationship with the proportion of world-leading paper OUTPUT (% 4*). Since OUTPUT

Hence, the impact factor of the journals where the chemistry papers published may serve as a predictor of the quality of world-leading research output (paper) as well as overall research quality in the UK REF assessment.

4.4. Implication of journal impact factor to research funding

REF 2021 was widely reported to cost around £471 million, which translates to about £3 million per university or £6,000 on average per individual submitted. It is however all about accountability of a much bigger public/government money spend on research in the UK universities - according to UKRI, the said cost was a tiny fraction (3-4%) of the total research funding to be distributed based on the REF outcomes. The data also shows to the world the extent of the truly high-

4.5. What constitute high quality paper in chemistry submission?

The impact factors of the submitted chemistry papers greatly vary. Even the very top performers do have some papers with impact factor of less than 7 but they have far higher proportion of papers in journals with impact factor of over ~10. The 194 publications submitted by the University of Cambridge in chemistry UOA, for example, constitute:

- ◆ Nature journals: 36.08%
- ◆ Journal of the American Chemical Society: 13.92%
- ◆ Proceedings of the National Academy of Sciences of USA: 10.31%
- ◆ Science: 7.22%
- ◆ Angewandte Chemie International Edition: 6.70%
- ◆ Other high impact factor journals include Cells, Advanced Materials, Science Advances and Chemical Science which was common in submissions by various institutions.

Looking into the whole list of the chemistry papers OUTPUTS for the submitted universities, one would notice the following:

- ◆ By research measure, chemistry is not a book-oriented discipline. There was no single entry of a book as a research output.

accounted 60% of the overall weighting of the REF 2021 score, the proportion of 4* rating in OUTPUT may be used as a good predictor of the overall outcome.

- ◆ The calculated average impact factor for the institutions in chemistry submission appears to show direct relationship with the overall outcome (GPA) of the research quality assessment. i.e., Impact factor may be used as a predictor of the overall GPA outcome.
- ◆ The calculated average impact factor for institutions in chemistry submission appears to show direct relationship with the world-leading quality OUTPUT in the chemistry submission. i.e., impact factor may be used as a predictor of world-leading quality OUTPUT (% 4*).



quality research undertaken in the UK universities. Since the research funding algorithm does not reward 1* and 2* activities and the benefit of 4* over 3* is weighed in the ratio of 4:1, the publication impact factor may be used as predictor of REF-based research income. i.e., The 4* activity is a money maker! By influencing OUTPUT which is the highest weighted assessment parameter in REF 2021, impact factor could influence the amount of money an institution receives through its REF activity.

- ◆ Even though granted patent and published patent applications were eligible as research OUTPUT, they were not common in the chemistry submissions. In fact, only two universities at the very bottom of world-leading OUTPUTS ranking, University of Greenwich (1 entry) and University of Huddersfield (2 entries), used patents as outputs.
- ◆ The above-mentioned relationship between impact factor and world-leading OUTPUT or overall GPA suggests "gaming" the REF system is possible. i.e., productivity via a handful (per academic) of publications in high impact factor journals as well as maintaining quality output through a fractional academic contract - FTE of as low as 0.2 contract was enough for entry to REF submission.
- ◆ Whatever criticism there may be on OUTPUT assessment, understanding the world-leading quality of paper OUTPUT is far easier than the other assessment areas: primarily IMPACT (measuring the reach and significance of research beyond academia) and ENVIRONMENT (measuring research culture).



4.6. Bibliometric indexes in chemistry research and education ranking

Ranking of academic staff, institutions and subjects based on bibliometric performance is quite common globally. The number of citations that a paper attracts on yearly basis which in turn contributes to the mean citability of the journal, or journal impact factor, is routinely used as performance measure in academia. On this basis, the best universities of the UK and the world at large were ranked by the [U.S. News 2022-23 Best Global Universities Subject Rankings](#) which also included chemistry as a subject. The ranking was made by Clarivate largely by using bibliometric matrixes from the Web of Science. The assessment parameters included academic research performance on the subject (from 2016 to 2020) such as publications and citations (up to May 29, 2022), as well as indicators for global and regional reputation in each specific subject. The weighting used in this listing included global (12.5%) and regional (12.5%) reputation, publications (15%), citation impact (15%), total citations (15%) number (10%) and percentage (5%) of publications among the 10% most cited, number of (5%) and percentage (5%) of top 1% cited papers, and international collaborations (10%). Undoubtedly, this excluded smaller or less-research intensive UK universities which did not meet the required paper threshold of 250 in chemistry and ultimately included only 39 UK institutions out of the global listing of 1337 universities. In this ranking, the top five UK chemistry research (REF 2021) league performers appeared within the top 100 of the global best university listing in chemistry. The [THE](#) also uses com-

plex performance indicators including research quality (citation impact, research strength, research excellence and research influence) for ranking universities globally and at national level, as well as breakdown by subject areas including chemistry. In its 2024 UK league table, research-intensive institutions listed at the very bottom-end of the Guardian best chemistry league table (e.g., UCL, King's College and Manchester) appeared within the top 10 in the UK and with excellent ranking globally. As stated earlier, the national leagues on chemistry subject education may not reflect the world-leading chemistry research position of the UK universities. i.e., they may offer little help to international students or as a reflection of world-leading education quality.

Hence, if we are to measure a world-leading quality of chemistry education, the REF 2021 outcome data would be inevitability of value though its weighting as a performance measure in teaching would still be a subject of further discussion. A significant exclusion from the Chemistry UOA in REF 2021 were the less research-intensive chemistry education providers. In the London area, for example, all post-92 universities in chemistry provision, except for the University of Greenwich, shunned the chemistry UOA. Whatever the REF outcome might be, however, participation in the chemistry unit of assessment gives institutions credential for being a good place of education for the subject area. In the eyes of the participating universities, everyone is a winner - the reward of funding via participation, pride for improved outcome over the previous REF exercise, and entry in the who-is-who list of the subject field.

5. Conclusion

Even though it is not widely acknowledged, the research quality assessment in the UK, as observed in the Chemistry UOA, has strong link with bibliometric performance, primarily impact factor of the journals where the papers were published. This kind of analysis can help institutions prepare for the next REF exercise, and hopefully not for gaming the REF system as the crucial money-making score (world leading paper OUTPUT) is influenced by impact factor.

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Biblio-metric indexes:
Ranking the quality of chemistry research and education

Next REF:
Preparation vs gaming REF?

