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Influential Engineers: Where Do They Come From and Where Do They Go?

The objective of this study is to examine the intercontinental movement of highly cited researchers (HCRs) in the field of engineering. We use the data on HCRs available from the Thomson Scientific database (<http://www.highlycited.com/>), covering a 20-year period (1981–1999), combined with information collected from the internet and the researchers themselves, to examine the movement in engineering around the world of the HCRs from birth to their present affiliation. We establish that there is a steady movement of engineers from Europe and the rest of the world to the U.S.

Movement Is Common

Intercontinental movement of scientists is a very common practice. Among scientists, 41.4% have completed at least one of their degrees, or are working, in a continent different from the one where they were born.

Table I provides information on the numbers of highly cited (HC) engineers according to their present affiliation. U.S. institutions dominate the list, in terms of HCRs in engineering (68.2%).

Next we examined the geographical breakdown of the numbers of HCRs, taking into consideration the

country of their birth, the country where the researchers' first degrees were obtained, and the country where Ph.D. degrees were obtained.

We first looked at the countries where the HCRs obtained their Ph.D. degrees (Table II).

U.S. universities still have a clear advantage over European, Asian, and universities in the rest of the world, but the advantage is slightly decreasing when the comparison is made with respect to current affiliation of the HCRs.

In engineering, one in three HCRs who completed their doctorates in Europe are now affiliated with a U.S. institution, a pattern that was also observed in the field of mathematics (see [1]). The opposite is very rare. Asia has a much higher retention rate than Europe, as has Canada (5) and Australia (3).

We also found that there is no movement at all between Europe and Asia. It seems as though many scientists from Asia and Europe who had an exceptional career that allowed them to become HCRs, either did their Ph.D. in Asia and Europe and then moved to the U.S., or they obtained a Ph.D. degree in the U.S., and then returned to their country of origin (this happened mainly with Canada and Australia).

This finding, if supported by further evidence, may suggest that Europe and Asia need to strengthen their scientific collaboration in this important field of scientific endeavor.

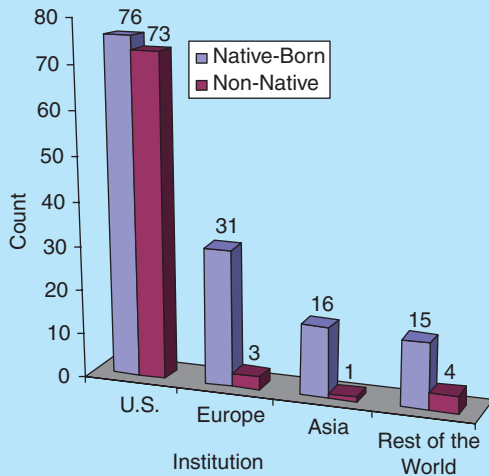


Fig. 1. Counts of HCRs for U.S., European, and non-U.S. and European institutions.

Table I
Frequencies and Percentages of HCRs in Engineering According to their Current Affiliation

Present affiliation	Number of HCRs	Percentage of HCRs
U.S.	163	68.2%
EU	39	16.3%
Asia	17	7.1%
Rest of the world	20	8.4%
TOTAL	239	100%

Table II
Frequencies and Percentages of HCRs in Engineering According to the Country where their Ph.D. Studies were Completed

Ph.D. Degree of the HCRs	Number of HCRs	Percentage of HCRs
U.S.	152	63.6%
EU	52	21.8%
Asia	17	7.1%
Rest of the world	10	4.2%
Missing	8	3.3%
TOTAL	239	100%

Looking at the countries where the highly cited engineers earned their first degree reveals more interesting facts (Table III).

Out of 239 HCRs, 41.8% (100) had completed their B.Sc. degree studies in the U.S., 23.4% earned their B.Sc. degrees in Europe, and 28.9% had B.Sc. degrees from institutions in countries outside the U.S.

Table III
Frequencies and Percentages of HCRs in Engineering According to the Country where the First Degree was Completed

Location of B.Sc. Degree of the HCRs	Number of HCRs	Percentage of HCRs
U.S.	100	41.8%
EU	56	23.4%
Asia	43	18%
Rest of the world	26	10.9%
Missing	14	5.9%
TOTAL	239	100%

Table IV
Frequencies and Percentages of HCRs According to their Country of Birth

Birthplace of HCRs	Number of HCRs	Percentage of HCRs
U.S.	78	32.6%
EU	65	27.2%
Asia	52	21.8%
Rest of the world	24	10%
Missing	20	8.4%
TOTAL	239	100%

and Europe. In engineering, the phenomenon of movement of HCRs between B.Sc. and Ph.D. studies is not as strong as in the field of mathematics, where researchers having completed their B.Sc. studies in the EU exceeded those in the U.S. (33.2% and 32.7%, respectively).

From a total of 155 HCRs affiliated with U.S. institutions (where information on both their affiliation and their B.Sc. studies was available), 27 (17.4%) and 21 (13.5%), respectively, acquired their first degree in Asia and in the EU. This corresponds to the 62.8% of the HC engineers who completed their B.Sc. degree in Asia, and to the 37.5% who completed their B.Sc. in the EU. Hence, Asia is by far the continent losing more of its engineering potential through a brain drain towards the U.S. From the nine HC Chinese engineers who obtained a B.Sc. degree in China, only one is currently working in China.

Birthplaces of HCRs

Table IV looks at the birthplaces of the HCRs. Once again, by cross-tabulations between affiliation and country of birth, we found that Asian HC engineers contribute the most to the transfer towards U.S. institutions (66%), followed by EU HC engineers with 46.2%. The EU tends to retain its HC scientists more efficiently when compared with Asia.

We find also that the movement from Europe to the U.S. (20.1%) heavily outnumbers the opposite movement (5.9%). Only about half of the researchers working in the U.S. are native-born (51%). For the rest of the world the vast majority of researchers are native-born citizens (see Fig. 1).

We also conducted a more detailed investigation, looking at the specific current institutional affiliations of HC engineers. We found that out of the top twenty institutions in engineering, ranked from the point of view of HCRs, sixteen are in the U.S., while only two are in Europe (CERN and EPFL), and two are in Canada (University of Waterloo and University of Toronto). No Asian Institution appears in the top 20 list, despite their strong tradition in engineering.

Also, no U.K. university appears in the top 20 engineering list with respect to HCRs. This finding supports the concerns voiced by industry in the U.K. about that country's engineering programs.

There are 6 Institutions in California in the top 20 list, five of which belong to the University of California system. This finding needs further examination in order to see if there is a connection to the existence of the Silicon Valley in California. Stanford and UC Berkeley, in addition to a high number of HCRs in engineering, show a very high overall number of HCRs. This confirms the diversity of these two institutions in nurturing top researchers across scientific disciplines. For the other institutions appearing in the list, it is apparent that their main emphasis is in engineering.

Observing the percentages of native and non-native HCRs in each one of the top institutions, we found that for the majority of the U.S. institutions, their HCRs originate from countries outside the United States. For instance, at Stanford, six out of eleven HCRs come from countries outside the U.S., and at M.I.T., four out of nine. There are also more extreme cases. For instance at the University of California Los Angeles, all HCRs (four) were born outside the U.S.

Highly Cited U.S. Engineers Were Nurtured Elsewhere

The findings in this article indicate that a significant proportion of highly cited engineers working in the U.S. were scientifically "nurtured" elsewhere.

While further research is needed in order to continue advancing the understanding of the movement of scientists, this study can be seen as a first step towards a better understanding of the mechanisms behind the deemed U.S. global superiority in science and in higher education.

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Reference

[1] J. Panaretos and C. Malesios, "Influential mathematicians: Birth, education and affiliation," *Notices Amer. Math. Soc.*, vol. 59, no. 2, pp. 274–286, Feb. 2012.

OPINION (continued from page 11)

temporal clearing itself in which everything and everyone presences and absences. Each of us only partakes of the time-clearing (quivering, resonant, mindful soul) for as long as we're alive, each in his or her own individual way. This partaking is the deepest, most primitive "we" (first person plural) we share. All further, more or less tenuous we's presuppose this first, primitive we-ness of sharing the time-clearing.

A further inversion, long preceding the Modern Age: the soul does not depart the body when I die, but rather, my body leaves the time-clearing (mindful soul).

Author Information

Dr. Michael Eldred is an Australian philosopher, mathematician and translator currently living in Cologne, Germany. He is the author of several books, including *Social Ontology: Recasting Political Philosophy Through a Phenomenology of Whoness* (2008), *The Digital Cast of Being: Metaphysics, Mathematics, Cartesianism, Cybernetics, Capitalism, Communication* (2009), and co-author of *Digital Whoness: Identity, Privacy and Freedom in the Cyberworld* (2013).