Based on the above, it is clear that the impact factors are quite uneven in different areas. Furthermore, it is interesting to note that the *Journal of Fluid Mechanics* and *Mathematical Programming,* two journals that are notoriously difficult for accepting papers, have rather low impact factors compared to *Nature* and *Science*, which are also very selective. These observations would suggest the need for some type of normalization; *e.g.,* 30 citations of an article in the *Journal of Fluid Mechanics* could be considered a success, while 30 in *Nature* would correspond to an average paper in that journal.

CONCLUDING REMARKS

This article has demonstrated, using the experience at Carnegie Mellon with statistics on the numbers of citations, that there are a number of important potential pitfalls in compiling that type of information due to the great complexity in gathering and interpreting the information. Our experience with *Science Watch* and the NRC Report suggest that there is a pressing need for organizations that perform department rankings to carefully and rationally define measures of citations in order to avoid errors, misinterpretations, and biases against certain research areas. While we do not attempt to offer specific remedies, it would seem that the following five general policies merit consideration:

1. *Develop an identification number for authors to avoid problems with misspellings and duplicate names.*
2. *Expand the domain of search to all areas to avoid penalizing authors who publish outside of their discipline.*
3. *Consider normalizing citations according to the impact score, to reduce discrepancies between different research areas.*
4. *Ensure that the number of citations over a given time period cover publications before and during that time period.*
5. *Consult with departments to verify the statistics before publishing them, to allow for possible corrections of mistakes.*

In order to implement these policies, close collaboration with ISI and agencies performing the rankings is required. It is also hoped that this article will temper the enthusiasm of those who apply sophisticated analysis tools to questionable data, and thereby are likely to draw incorrect conclusions.

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ChE letter to the editor

Dear Editor

Alves, et al.,[1] are to be congratulated on their elegant experiment on the drainage of liquids from vertical tubes of diameter 19 and 32 mm. But their paper should have stipulated that the diameter of tube used should be no less than about 15 mm. The reason is that the simple equation for the bubble velocity

$$U = 0.345(gD)^{0.5} \quad (1)$$

does not apply for smaller tubes because of surface tension effects. The relevant dimensionless group for such effects is the Eötvos number, which is given by

$$Eo = gD^2 \Delta\rho / \sigma \quad (2)$$

where D = tube internal diameter, $\Delta\rho$ = density difference between heavy and light phases, and σ = surface or interfacial tension.

At values of Eo less than about 50 in the case of low-viscosity liquids, the velocity U is below the value predicted from Eq. (1). Moreover, if Eo is below a critical value of 3.37, corresponding to a tube diameter of about 5 mm for air/water, the bubble will not rise at all.[2] Some years ago we measured drainage rates from vertical tubes of between 6 and 10 mm diameter, with the bubble nose (meniscus) being controlled at a constant position.[3] This technique enabled the surface tension in gas-liquid and liquid-liquid systems to be measured continuously.

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