30. Bartee, J.F., K.F. Bloss, and C. Georgakis, paper presented at the AIChE Annual Meeting, San Francisco, CA (1989)
31. Bartusiak, R.D., C. Georgakis, and M.J. Reilly, paper presented at the American Control Conferences, Atlanta, GA (1988)
32. Boye, J.A., and W.L. Brogran, *Int. J. Control,* **44**(5), 1209 (1986)
33. Chawla, V.K., and P.B. Deshpande, *Hydrocarbon Processing,* **68**, 59, October (1989)
34. Chien, I.L., D.A. Mellichamp, and D.E. Seborg, American Control Conference, San Francisco, CA (1983)
35. Corripio, A.B., *Chem. Eng. Ed.,* **8**, Fall (1974)
36. Cutler, C.R., and S. Finlayson, ACC, Atlanta, GA, June (1988)
37. Daoutidis, P., and C. Kravaris, *AIChE J.,* **35**, 1602 (1989)
38. Economou, C.G., and M. Morari, *I&EC Proc. Des. Dev.,* **25**, 411 (1986)
39. Economou, C.G., M. Morari, and B.O. Palsson, *I&EC Proc. Des. Dev.,* **25**, 403 (1986)
40. Garcia, C.E., and M. Morari, *I&EC Proc. Des. Dev.,* **24**, 472 (1985a)
41. Garcia, C.E., and M. Morari, *I&EC Proc. Des. Dev.,* **24**, 484 (1985b)
42. Gokhale, N.D., N.V. Shukla, P.B. Deshpande, and P.R. Krishnaswamy, *Hydrocarbon Processing,* April (1991)
43. Hallager, L., and S.B. Jorgensen, IFAC Workshop Adaptive Sys. Con., San Francisco, CA (1983)
44. Jensen, N., D.G. Fisher, and S.L. Shah, *AIChE J.,* **32**, 959 (1986)
45. Kravaris, C., and C.B. Chung, *AIChE J.,* **33**, 592 (1987)
46. Krishnaswamy, P.R., N.V. Shukla, P.B. Deshpande, and M.N. Amrouni, *Chem. Eng. Sci.,* **30**, 4 (1991)
47. Kulkarni, B.D., S.S. Tambe, N.V. Shukla, and P.B. Deshpande, *Chem. Eng. Sci.,* **46**, 4 (1991)
48. Lau, H., J. Alvarez, and K.F. Jensen, *AIChE J.,* **31**, 427 (1985)
49. Lee, P.L., and G.R. Sullivan, presented at IFAC Workshop on Model Based Process Control, Atlanta, GA, June (1988a)
50. Lee, P.L., and G.R. Sullivan, *Computers & Chem. Eng.,* **12**, 573 (1988b)
51. Luecke, R.H., and H.Y. Lin, *Chem. Eng. Ed.,* **20**, Spring (1986)
52. Luyben, W.L., *I&EC Proc. Des. Dev.,* **25**, 654 (1986)
53. Luyben, W.L., *AIChE J.,* **16**, 2; *Computers & Chem Eng.,* **12**, 573 (1970)
54. Mijares, G., J.D. Cole, N.W. Naugle, H.A. Preisig, and C.D. Holland, *AIChE J.,* **32**, 1439 (1986)
55. Moore, C.F. *Chem. Eng. Ed.,* **7**, Fall (1973)
56. Parrish, J.R., and C.B. Brosilow, *AIChE J.,* **34**, 633 (1988)
57. Prasad, P.R., V.K. Chawla, and P.B. Deshpande, *I&EC Res.,* **29**, 1 (1990)
58. Seborg, D.E., T.F. Edgar, and S.L. Shah, *AIChE J.,* **32**, 881 (1986)
59. Seborg, D.W., IFAC Preprints, Munich, West Germany, July 27-31 (1987)
60. Wright, R., and C. Kravaris, paper presented at the American Control Conference, Pittsburgh, PA (1989)
61. Wittenmark, B., and K.J. Astrom, *Automatica,* **20**, 595 (1984)
62. Yu, C.C., and W.L. Luyben, *I&EC Proc. Des. Dev.,* **25**, 498 (1986)

CAI Software in Process Control

63. Arulalan, G.R., Sanjay Kumar, and P.B. Deshpande, "CAI in Advanced Process Control," *CACHE News,* **26**, Fall (1988)
64. Edgar, T.F., "Software for Undergraduate and Graduate Process Control," *CACHE News,* **26**, Spring (1990)
65. Frederick, D.K., and M. Rimvall, Eds., "ELCS: The Extended List of Control Software," U.S. Edition No. 4, CACHE Corporation, Austin, TX, December (1987)
66. Seborg, D.E. T.F. Edgar, and D.A. Mellichamp, *Process Dynamics and Control,* John Wiley & Sons, Inc., 701 (1989) (Listing of Control Software) ❐

ChE ***letter to the editor***

THE ACADEMIC ELITE IN CHE

Dear Editor:

A ranking of the most highly regarded doctoral programs in chemical engineering was presented in the November 1983 edition of *Changing Times.*[1] This ranking was based on a study published by the National Academy of Sciences.[2] For the ranking reported by *Changing Times* two key measures of reputation from the National Academy study were combined: 1) "faculty quality" assessed how chemical engineering professors around the country rated their peers in the same discipline, and 2) "program quality" assessed how well the faculty thought each program educated research scholars and scientists. *Changing Times* combined these two measures and derived a ranking of the top ten percent of the programs in chemical engineering. If one goes by the assumptions of the *Changing Times* article, the eight schools with the highest combined scores represented the "academic elite" in chemical engineering—the "best" programs in the country.

Given the subjective nature of the evaluation process which produced the National Academy ratings, I decided to examine the composition of the faculties of the top eight schools. I suspected that these departments would be substantially linked to one another through the hiring of one another's graduates, hence enhancing one another's reputations. I also expected that among the academic elite there would be a high degree of academic "inbreeding"—the hiring of graduates from one's own program.[3]

I used the *American Chemical Society Directory of Graduate Research 1989* to examine the full-time faculties of the eight highest-ranked chemical engineering departments. An item of primary interest was where the full-time faculty members at these institutions had received their doctoral degrees. It soon became obvious that there were numerous interrelationships among the departments in terms of where the faculty had received their doctoral degrees.

The following table lists the top-ranked departments and indicates the percentages of full-time faculty who received their doctoral degrees from one of the "elite" departments on the list (which includes those who received their degrees from the same departments where they are currently on the faculty).

Rank	Program	N	Percentage Elite[1]	Percentage Own[2]	Number Produced[3]
1	Minnesota	32	50.0	0.0	13
2	Wisconsin	20	65.0	15.0	13
3	Cal-Berkeley	21	71.4	19.0	17
3	Caltech	8	75.0	0.0	6
4	Stanford	8	62.5	12.5	7
5	Delaware	19	52.6	5.3	6
6	M.I.T.	33	69.7	42.4	31
7	Illinois, Urbana	12	75.0	0.0	4
	TOTALS	153			97

[1] Percentage of faculty who received PhD*s* from one of the eight top-ranked programs.
[2] Percentage of faculty who received PhD.*s* from the program in which they are now employed.
[3] Number of PhD recipients from the programs who were on the faculty of one of the top-ranked programs in 1989.

As can be seen in the table, in all of the top-ranked departments a substantial proportion of the faculty received PhD*s* from one of the "academic elite." The California Institute of Technology and the University of Illinois had the highest percentages of degree holders from the top-ranked departments (75.0%), and the University of Minnesota had the lowest (50.0%). At most of the schools, anywhere from one-half to three-quarters of the faculty graduated from one of the prestigious programs.

The table also addresses academic inbreeding among the top-ranked chemical engineering programs. Berelson[4] and Caplow and McGee[5] have demonstrated that a high degree of inbreeding among elite schools is not accidental. According to both studies, if elite programs are to maintain their prestige, they cannot hire a large number of PhD*s* from lower-ranked departments, and this would include PhD*s* from upwardly mobile "middlemen" programs where elite credentials have yet to be established. In his study of sociology departments, Gross[6] found that the higher the prestige of a department, the greater the proportion of "home-grown" graduate faculty. With some modifications, Shichor's study[7] confirmed Gross' findings. Shichor found the relationship between departmental inbreeding and the prestige of a department to be curvilinear, with the highest and lowest ranking departments having the highest rates of inbreeding while mid-level departments were found to have the lowest rates.

As can be seen from the table, in 1989 the school with the largest percentage of its own graduates on its full-time chemical engineering faculty was Massachusetts Institute of Technology (42.4%). The University of Minnesota, California Institute of Technology, and the University of Illinois had not hired any of their own graduates.

The table also presents the number of PhD*s* produced from each department who were full-time faculty members of one of the elite departments in 1989. MIT had thirty-one of its graduates in faculty positions at the elite departments, and Berkeley was next with seventeen. Illinois had the least with four.

I think that graduate departments in chemical engineering (or in any discipline) must rely to a large extent upon their reputations in order to attract highly qualified faculty and graduate students to participate in their programs. The eight chemical engineering graduate programs that were top-ranked in the 1981 National Academy study are undoubtedly strong programs. I certainly do not wish to argue that they are not. However, the data suggest that a number of subjective factors influence the procedure by which academic departments are ranked. Primarily, I contend that a rather small group of institutions (eight in this instance) tend, consciously or unconsciously, to enhance one another's reputations by hiring one another's graduates.

The *Changing Times* article used two measures of reputation in order to establish its list of the "best" graduate departments: how professors rated their peers in the same discipline, and how well the faculty thought each program educated research scholars and scientists. These criteria are vitally linked; when elite faculty are asked to rate their peers at other schools, they are (to a large extent) rating their former professors or students. There are a total of 153 full-time faculty in the chemical engineering elite, and 97 of them (63.4%) graduated from one of these distinguished programs. Clearly, it is in their best interest to rank their alma maters highly.

The remarkable stability in the ranking of elite programs over the last few decades suggests that not only do elite faculty rate their own programs highly, but so also do large numbers of faculty from less prestigious programs. Several factors may explain this phenomenon. On the one hand, the data suggest that the consistently high rankings of elite programs are due to the large number of graduates that those very same programs put into the discipline each year. While they place some graduates in other elite schools, most descend into mid-level schools or less renowned institutions where they continue to subjectively rank their alma maters as the very best. The high number of elite school graduates at all levels also seems to enable them to play a disproportionate role in shaping opinion within the discipline.

There is another way of explaining the relative stability in the ranking of elite programs over time. Obviously, there are not enough faculty from elite schools at middle and lower level programs for them to maintain the high ranking of their alma maters without some support from their non-elite colleagues. Tradition may be a partial explanation for the non-elite's acceptance of their inferior status. Elite schools have been accorded high esteem for decades, and these traditions typically have gone unchallenged.

A more likely explanation, however, is that the non-elite, in a classic example of Marxian *false consciousness,*[8] have adopted their elite peers' assessment that the latters' programs and faculties are superior. Buttressed by only a few subjective government surveys and contact with a handful of individuals from elite programs, the non-elite have not only accepted but also even promoted the notion that elite graduate programs are deserving of high esteem, whereas others, including their own, are not.

Ultimately, I think it should be asked: Are the eight highest-ranked programs indeed the best PhD programs in chemical engineering, or do they comprise an "academic elite" with a large number of faculty members in the discipline and an obvious interest in perpetuating the present ranking system? I believe that data suggest that the latter is true.

Two final comments seem in order. First, I contend that because of their subjectivity, current ranking systems are a detriment to the discipline. They may impede professional mobility, reward status over achievement, and result in programs of lesser renown being bypassed, even though they may merit as high or higher recognition than do those of the elite. Second, I believe that current, subjective ranking systems incorporate serious distortions and misrepresentations. Because they have the potential to do as much harm as good, I recommend that as they are presently constituted, subjective systems of departmental ranking should be routinely ignored.

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1. *Changing Times,* p. 64-67, November (1983)
2. Jones, L.V., G. Lindzey, and P.E. Coggeshall, *An Assessment of Research-Doctorate Programs in the United States: Engineering,* National Academy Press, Washington, DC (1982)
3. Bair, J.H., W.E. Thompson, and J.V. Hickey, *Curr. Anthropol.,* **27**, 410 (1986)
4. Berelson, B., *Graduate Education in the United States,* McGraw-Hill, New York (1960)
5. Caplow, T., and R.J. McGee, *The Academic Marketplace,* Anchor-Doubleday, New York (1965)
6. Gross, G.R., *Am. Sociologist,* **5**, 25-29 (1970)
7. Schichor, D., *Am. Sociologist,* **5**, 157-160 (1970)
8. Marx, K., and F. Engel, *The German Ideology,* International Publishers, New York (1967) ❒

ChE *book review*

CHEMICAL AND ENGINEERING THERMODYNAMICS
Second Edition

by Stanley I. Sandler; John Wiley & Sons, New York; 622 pages and 5-1/4" diskette, $59.95 (1989)

Reviewed by
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This is the second edition of a text for undergraduate chemical engineers. As the author's preface points out, the objectives of both editions are the same: 1) to develop a course relevant to other parts of the curriculum, such as separations, reactors, and design, and 2) to present sufficient detail in a way that leads to good understanding and proficiency of application.

Distinctive treatments of the first edition included introduction of the mass, first, and second law balance equations in the same way (this may demystify entropy for some students). Also, treatment of the variety of phase equilibrium situations among solids, liquids, and vapors is more complete and more categorized than in other texts.

The major change from the first edition is the inclusion of BASIC programs for calculating 1) thermodynamic properties and VLE for pure and for multicomponent systems from a cubic EOS, 2) low-pressure VLE from activity coefficients from group contributions, and 3) equilibrium constants and stan-

Continued on page 195.