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Adjunct educators in a profit-driven arena

To the Issues and Events story about contract lecturers (PHYSICS TODAY, November 2018, page 22), I would like to add a significant concern that we have seen arise with instructors and adjuncts over about the past two decades. During that time the numbers of private and public community colleges and universities have skyrocketed while funding has declined. Those facts, combined with the profit motive and less stringent admissions practices at the freshman level, have led to many displeased academics, particularly in the hard sciences.

Nowadays a significant number of students entering these institutions are not well prepared to succeed in hard-science courses. In search of profits, institutions of learning have loosened entrance requirements. As a result, some admitted students have no motivation to continue in science but either need to take these courses for a career in other fields or are bent on receiving high grades without doing the necessary work.

As test and exam dates draw near, some students realize that they cannot make the high grades, and they complain to the dean or department chair, who rarely offers the teacher an opportunity to make a defense. If the teacher is present, then the students are less likely to embellish their performance or tell lies or denigrate the teachers. Student complaints often get lodged without rebuttal or evidence and become part of the teacher's record. And even if the complaints are true, institutions should have a protocol established for instructors to be able to improve their performance or correct the record. That rarely happens. Now instructors, realizing that they could be fired, may jack up grades in the hope of calming the complaints. One has to think twice to fail a student who might file a complaint.

Often the result is that the complaining students receive better grades than their work deserves and teachers—even research leaders with broad teaching experience—may lose their positions. Their loss leads to a decline in academic standards. In the past decade or so, maybe as a result of this, many failures of high-tech manufacturing products, services, and air travel, some of which have been life threatening, have been in the news.

Colleges and universities must change their policies regarding admissions standards and quality of education, particularly in the hard sciences. Having school administrators require that an instructor be present when a complaint is lodged will minimize students' opportunity to present only their side of the situation, and supporting the professors once they are hired should also help maintain ethical standards. Administrators could also encourage the complainers to first try to settle with their teachers before they lodge an administrative grievance.

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Notes on superconducting hydrides

In their article "The quest for room-temperature superconductivity in hydrides" (PHYSICS TODAY, May 2019, page 52), Warren Pickett and Mikhail Eremets commented that "in the late 1960s William McMillan of Bell Labs extended the [Bardeen-Cooper-Schrieffer] analysis to moderately strong coupling," which is measured by the electron–phonon coupling constant, λ. According to Pickett and Eremets, the McMillan "equation for T_c was extrapolated beyond its regime of validity to fortify claims that 30 K would be the upper limit for electron–phonon coupling."

The above comment may not be entirely fair if its subject is the analysis McMillan made in a 1968 article,[1] in which he doesn't mention 30 K as a possible maximum value of T_c but does list 9.2, 22, 28, and 40 K as possible maximums. None of those temperatures are the upper limit of electron–phonon coupling in general. Rather, they are upper limits of T_c in classes of materials represented by lead, niobium, and niobium–tin and vanadium–silicon alloys, and they have not exceeded the regime of validity of the McMillan equation. In particular, McMillan does not exclude higher T_c in other classes, provided that λ does not exceed 2 in his equation.

Specifically, McMillan realizes that T_c from his equation declines when, on average, the phonon frequency becomes either too large or too small and searching for maximum T_c leads to $\lambda = 2$. Since in 1968 it was believed that $T_c = 7.2$ K and $\lambda = 1.3$ in Pb, McMillan concludes that T_c may reach 9.2 K in a Pb alloy when $\lambda = 2.8$. In that case, T_c was found numerically and therefore was not subject to the $\lambda < 2$ limit. Had, say, McMillan found $T_c = 203$ K with $\lambda = 1.3$ from a material in his day, he likely would have concluded that T_c could be higher still in a similar material with $\lambda = 2.8$.

In recent work,[2] we extended the McMillan equation for $0.6 < \lambda < 2.67$. We found that the original McMillan equation is indeed highly accurate if $\lambda < 2$. We also predicted that T_c can reach ~44 K in a beryllium–lead alloy, when the Be to Pb ratio is 0.58 to 0.42 ($\lambda = 1$ and Debye temperature is 871 K). Our result may be useful to experimenters because it not only shows that T_c may be high in a class of alloys, but it also gives the exact composition of the alloy, hopefully without extreme pressure.

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The article by Warren Pickett and Mikhail Eremets on room-temperature superconductivity in hydrides had me thinking about the role of specific heat in superconductivity research.

Heike Kamerlingh Onnes and Gilles Holst reported in 1914 that "with respect to the specific heat, nothing peculiar happens" at mercury's superconducting transition,[1] which Kamerlingh Onnes had discovered three years earlier. Twenty years later, after technical advances in cryogenics and thermometry, Kamerlingh Onnes's former student, Willem Keesom, and J. A. Kok discovered a specific heat jump at the critical temperature T_c, without latent heat.[1] It was misinterpreted as a sudden drop in Debye temperature, which assumes phonons are the predominant contributor to specific heat, even though the free electronic model for electronic specific heat ($C_e = \gamma T$) had been proposed before then. It took almost another 20 years for the superconducting-state electronic specific heat (C_{es}) to be identified, but still erroneously concluded as having a T^3 dependence. Eventually, experimental data covering a wider (T_c/T) range confirmed the exponential-temperature dependence of its electronic origin.[2]

In their 1957 article, John Bardeen, Leon Cooper, and J. Robert Schrieffer opened with the statement, "The main facts which a theory of superconductivity must explain are (1) a second-order phase transition at the critical temperature, T_c, (2) an electronic specific heat varying as $\exp(-T_0/T)$ near $T = 0$ K and other evidence for an energy gap."[3] The rest is now history.

In my opinion, superconducting hydrides may provide opportunities for studying C_{es} in detail over an exceptionally broad (T_c/T) range. Intuitively, the near-room-temperature transition would make it impossible to delineate the electronic and the lattice contributions from total specific heat ($C = C_e + C_\ell$) being obtained calorimetrically. That appears to be a valid concern for cuprate superconductors with T_c near or above 90 K. In contrast, for metallic hydrogen with an exceedingly high Debye temperature[4] of approximately 3500 K, the lattice specific heat C_ℓ at 280 K can be estimated to be approximately 1 J/mol K. The same amount of normal-state $C_e = \gamma T$ would also prevail at 280 K if the coefficient $\gamma = 3.6$ mJ/mol K^2, which is comparable to that of many conventional superconductors.

The difficulty rests with the high-pressure aspect in calorimetric measurements. A standard pressure-cell approach was successfully employed on superconducting uranium some 50 years ago,[5] but only at 10 kbar. Researchers are designing and developing diamond anvil cells, but they face challenges regarding pressure limits and heat leak. However, as we look back, after 1911 it took more than 40 years of improving cryogenics and low-temperature calorimetry to finally reveal exponential-temperature dependence of C_{es}, which was important to the Bardeen-Cooper-Schrieffer theory. We now need to overcome another technical hurdle—in pressure instead of temperature.

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▶ **Pickett and Eremets reply:** X. H. Zheng and J. X. Zheng focus on McMillan's classic 1968 paper to address the decades-studied but unresolved question of maximum T_c. The last short section of his paper was on issues of maximum T_c. Though he carefully stated that his equation for T_c "was derived for $\lambda \leq 1$," he nevertheless extrapolated