

Students in the sciences need to learn entrepreneurial skills

Douglas Arion's article about entrepreneurship education for physicists (PHYSICS TODAY, August, 2013, page 42) is exactly on point: All working physicists today need entrepreneurial skills, especially if they hope to do anything new. However, offering special degrees to a few is not enough; rather, the basic practices of finance, marketing, negotiation, and bureaucratic survival should be taught to all science majors. We spend much of our lives and most of our creative energies working on those challenges, not physics. Even Arion's "stage-gate" model of innovation (see the article's figure 2) has "gates" manned by gatekeepers and toll takers. Getting past them is as essential to success as excellence in any of the R&D stages.

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■ **The career path** into management for physicists and engineers, as Douglas Arion wrote in his August 2013 article, has been proposed many times, as if it would lead to some kind of promised land. More often than not, it would lead instead to unhappiness for a person who values science above all and relishes participating in it.

Typically, physicists, and many engineers too, are drawn to their disciplines by the idea of an exciting life of scientific discovery rather than by the money. Therefore, it is not unusual for researchers to see a promotion into management as a step downward.

I was particularly disappointed in Arion's long list of administrative duties. Granted, such duties cannot be ignored, but my experience suggests that

administration should be minimized. Early on as an independent principal investigator, I discerned that over-administration at best leads to excessive expense and at worst stifles progress.

Much has to do with motivations. My own R&D service and consulting company, Innovative Mechanics, is not an entrepreneurial company as served up in Arion's article. Instead, I established it to have a way to do frontier research without being encumbered by management from above. I suggest that entrepreneurially inclined people start out in a business major and take significant technological courses in math, physics, biology, and so on at the sophomore or higher level. It sure beats making reluctant entrepreneurs of people who could become good scientists.

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■ **Arion replies:** My thanks to Marc Levenson and Andres Peekna for taking interest in entrepreneurship education for physics. Permit me to restate a major theme in my article: Entrepreneurship education is not about startups, but rather about giving science students the skills, knowledge, and attitudes to be successful in their careers, whatever those might be.

Levenson's comment about the need to provide those skills to all students is spot-on, and we in the entrepreneurship education community hope that this vision indeed comes to be. The upcoming American Physical Society conference "Reinventing the Physicist: Innovation and Entrepreneurship Education for the 21st Century" in June 2014 is a step in that direction (see <http://www.aps.org/programs/education/conferences/innovation.cfm>). My article highlighted a few of the approaches that institutions are using to provide entrepreneurial skills training to physics students. Special degrees are only one option; the article also lists some of the other means by which the content can be brought to students. Methods of implementation are available to suit the particular circumstances, environment, student demographics, and desired outcomes of each institution and department.

Peekna apparently missed the main point of the article. Entrepreneurship education is not at all about channeling people into management, creating startups, or separating management careers and technical careers. It is about helping science students be successful in any position they may obtain, whether in academia, industry, or government. "Administrative duties," as he puts them, are unavoidable, and entrepreneurship education will make them easier to handle while also preparing students to deal with and excel in the real world. A business major with a sampling of science courses will not prepare students well for a technical career; a science major with entrepreneurship content will. Having entrepreneurial skills and being a scientist are not mutually exclusive but mutually supportive.

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Role of black carbon in the Arctic's new normal

In "The Arctic shifts to a new normal" (PHYSICS TODAY, October 2013, page 35), Martin Jeffries, James Overland, and Don Perovich state, without citing a reference, that "the warming might be further enhanced by the rise in atmospheric concentrations of carbon aerosols. . . . Black carbon deposition might be reducing the albedo and thus accelerating the melting of sea ice and of snow and ice on land."

Actually, the atmospheric concentrations of black carbon have been declining, as shown at all three of the atmospheric observatories making continuous measurements on the coast of the Arctic Ocean: Alert, Canada; Barrow, Alaska; and Ny Ålesund, Svalbard, Norway.¹ Alert has the longest record; the wintertime peaks there for 2006–8 were one-third of their average for 1989–91. The decline of Arctic black carbon has been attributed to the dissolution of the Soviet Union, which resulted in the closing of emission sources in Russia and Eastern Europe and depop-

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