Where Ideas Fail Best

by

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At a recent national education summit, IBM announced that it wants into our schools. IBM's concern merges with what we have all heard and what many of us have experienced directly: Our schools are producing students who have difficulty reading, writing, and performing long division. IBM's plan to become more actively involved in the educational system—and the support that the idea has received from state and federal politicians—makes it obvious that to some people the solution to our educational problems is easy: They should return to the basics. Let them promote fundamental skills in grammar, math, and science. Let them produce students to help our businesses and industries survive and compete in the postindustrial global village.

The climate of dissatisfaction with our elementary and secondary schools has spilled over to include our institutions of higher education. An increasingly large segment of the public is demanding more accountability from our public universities. Quite understandably, these people want to know what our taxpayer-supported faculties are doing with their time—and what they see often confuses and irritates them. In the current climate of disappointment with our educational system, the public cannot understand why our faculty members are not spending all of their time in the classroom.

This demand for accountability strikes at the heart of the question we discuss today: Should public universities maintain their historical commitment to basic research, or should they focus exclusively on basic education? To a discontented public wanting to know the return on its tax dollars, the answer is clear: If university faculty members want to study the ability of

apes to recognize themselves in mirrors, let the chimpanzees pay for it—we’re paying to have our youth educated. The incredulity is contagious and persuasive, capable of snowballing into the idea that corporations such as IBM might be given considerable influence over the conduct and content of our elementary and high schools. Indeed, when one considers short-term economics alone, it is difficult to argue with this view. After all, to produce effective citizens, our universities must teach a core set of basic facts and skills. If universities are going to produce graduates who can find a job, secure a living, and become a creative force in our cultures, then students must be given a firm foundation in basic skills.

All of that is true, but it is certainly not the whole truth. We believe that the present accountability movement, though well-intentioned, risks seriously jeopardizing the historically dual mission of our universities. For in addition to preparing students for jobs, universities have another, equally vital mission to conduct basic research.

In this essay, we explore two reasons why universities should maintain and strengthen their commitment to scientific research. First, although most university students will not become researchers, the moral code inherent in science and research can provide a crucial lesson for students preparing to enter a host of different fields. The second reason is that if we accept the idea that innovation and discovery are necessary for our country, then we should carefully protect the research mission of our universities. Unlike research teams in the private sector, universities maintain a climate in which a myriad of ideas can germinate, most of which whither and fail; it is a climate, moreover, where research is often explicitly designed to demonstrate that certain ideas are wrong. Despite the valuable and growing connections between research and the private sector, we believe that the university’s climate is best-suited for the risky and creative research necessary for fundamental discoveries.

The Moral Lessons of Research

Our first claim is that exposing students to research faculty members and their research programs is a better way of teaching basic skills and critical thinking than teaching them only by lecture. The reason for this is embedded in an instructive double-standard inherent in scientific undertakings.

On the one hand, the very idea of scientific research is that all beliefs are open to challenge; that no knowledge is secure; that no claim (no matter how intuitively appealing) can be allowed to stand on its own. The practice of science shows us that we need reasons and evidence to support our ideas, and it simultaneously teaches us that reality will not always be kind to those ideas. This is science at its best. It is the model that scientists strive to attain, and it is what we try hardest to impress upon our students. On the
other hand, this model of scientific research presupposes certain moral or ethical standards. For example, certain practices are simply unacceptable in science. We do not fabricate results of experiments, we collect them. We do not invent the numbers that run together to comprise the results of our statistical tests, we report them. So, unlike the openness we preach when it comes to the content of our science, when it comes to its practice, as a community we preach intolerance. Professional scientific societies in virtually all disciplines have a code of ethics designed to cope with fraud, plagiarism, and unethical behavior. By and large, these standards are not open to discussion or debate.

Some academics doubt this view of science. For example, deconstructionists have managed to convince many academics that the rational model of science is impossible. They start with the observations that, first, no human inquiry is totally objective, and second, that all human efforts are political in nature.2 From these two contentions, radical deconstructionists have concluded that science itself is not possible. After all, they maintain, if scientists are political animals, if their work is colored by a complex combination of these political agendas and their a priori beliefs, and if the very experiments they choose to conduct reflect biases in the ways in which they see the world, then surely science cannot be an objective quest for truth.

Fortunately, it doesn't have to be. The startling conclusions reached by the deconstructionists are simply wrong. It is as if they were to argue that because the engineering standards behind an airplane's design are actually implemented by mere humans—plagued by fatigue, hunger, irritability, concerns about their children—that the aircraft itself cannot fly. It is as if the entire enterprise of science is evaluated by the weaknesses of the individuals who comprise it. But, of course, the airplane does fly. Wilbur and Orville Wright struggled to launch a craft into the sky, but failed, precisely because of their human limitations—their lack of knowledge, their incorrect beliefs about the physics of flight, and so on. In 1901, after three years of effort and several disappointing months of failed tests at Kitty Hawk, Wilbur Wright declares in exasperation that humans would not fly within their lifetimes, and maybe "not within a thousand years!"3 But just two years

2This view of the inherent political nature of human outlook is captured in the 1982 MGM motion picture, The Year of Living Dangerously. During a Javanese shadow puppet play, character Billy Kwan (Linda Hunt), speaking to Guy Hamilton (Mel Gibson), recites part of the play: "All is clouded by desire, Ashina, as a fire by smoke, as a mirror by dust. Through these it blinds the soul."

3John E. Walsh, One Day at Kitty Hawk (New York, 1975), p. 79. Although this is the quotation that Orville reported to his biographer (Fred Kelly), a more detailed historical analysis has argued that Wilbur actually stated that although man would sometime fly, it would not be within their lifetime. In a rare after-dinner speech, Wilbur is reported to have
later, on an overcast December morning, for twelve glorious seconds a hu-
man leaps from earth to sky aboard a heavier-than-air-machine and suddenly
everything has changed.

Scientific research can be viewed in exactly this manner: it is a human
endeavor transcending the limitations and narrow interests of those who en-
gage in it. Ideas arise and win converts who fervently defend them against
challenges. New fields emerge and early attempts to explain and predict
meet with limited success. Eventually, despite the best efforts of human
nature to sabotage the project, the aircraft rises with a regularity and ease
that astound us.

So there is a curious double-standard in scientific research. It claims
that all ideas can and should be challenged, except one: There can be no fab-
rication of the observations and experiments upon which our facts and theo-
ries are based. This double-standard reveals much about the role research
plays in a university setting. Exposing students to scientific research by
those who actually conduct it offers an opportunity to provide a moral edu-
cation for young citizens. The practice of scientific research forces students
to see that knowledge is not given, it is earned. That knowledge must be
held up to constant scrutiny. Yet at the same time it shows how this in-
quiry can and should occur according to a code of ethics that embraces some
of the oldest virtues known to our species.

Ironically, some critics of modern universities see this climate of open
and free inquiry as a key symptom of how our universities are no longer
accountable to the public who pays for them. They complain that universi-
ties across the country are straying from their mission to educate our chil-
dren and are instead teaching them that "knowledge is relative" and that "any
point of view is acceptable."

But science professes otherwise. Scientific research emphasizes impor-
tant values that are embedded in its very foundations: honesty, organiza-
tion, attention to detail, perseverance in the face of adversity. Physicist and No-
bel laureate Richard Feynman points out that this lesson is

what we all hope you have learned in studying science in school. . . . It's a
kind of scientific integrity, a principle of scientific thought that corre-
sponds to a kind of utter honesty—a kind of leaning over backwards. For
example, if you're doing an experiment, you should report everything that
you think might make it invalid—not only what you think is right about it.

. . .

said: "I confess that, in 1901, I said to my brother Orville that man would not fly for fifty
years"; see Fred Howard, Wilbur and Orville: A Biography of the Wright Brothers (New

4Richard P. Feynman, "Cargo Cult Science," in Surely You're Joking, Mr. Feynman!, ed.
In this sense, then, scientific research reveals a clear division of labor between the content of our beliefs and the methods by which we arrive at them. Most importantly, this line in the sand is not arbitrary. After all, to remove the core assumption that researchers act honestly and with integrity would be to pull out the lynchpin of the method's success. Does this mean that we think practicing scientists always act according to these high ideals? Certainly not. But because the standards are generally in place, the fatigued and overworked flight mechanics still keep the planes aloft. In this sense, the moral voice inherent in scientific research offers a common middle ground between the sincerely felt frustrations of a public and private sector who cannot understand why so many college graduates possess such poor thinking skills, and those who believe that university faculty members already shoulder too heavy a teaching load.

But do we really need our university faculties actively involved in the research? Why should the researcher and the teacher be the same person? Should we simply hire interesting lecturers who can dispassionately impart the fundamental facts of various disciplines? In other words, why not leave the real business of research to the private sector and let our faculties devote their energies to teaching?

Certainly it is possible. We don't expect the faculty members of our elementary and high schools to be involved in research, and yet we entrust them to provide our children with the skills and knowledge they will need in later life. Not all degree-granting institutions of higher education have research faculties; many small colleges and universities downplay research and instead reward excellence in teaching.

But great institutions of higher learning accept the challenge of doing both, creating a climate that fuses education and research. Undergraduates are gradually brought along from the rote learning of introductory courses to the complexities of advanced seminars in specialized areas. And it is here that exposure to the educator-researcher is so critical. Knowledge becomes more subtle, less certain, but the methods of scientific inquiry offer a powerful lesson for students as they leave the universities for nonresearch jobs. With integrity, perseverance, and brutal honesty, few problems can remain forever out of reach.

We have seen this process dozens of times. Students who have a chance—even for a single semester—to actively participate in the ongoing research program of a faculty member leave forever altered and enriched. It is a humbling experience to watch elegantly crafted ideas savagely attacked by reality, to see one's deepest convictions challenged by observation and experimentation. These are virtues that simply cannot be learned sitting at a desk studiously taking notes. The Swiss epistemologist Jean Piaget observed, "Everything one teaches a child prevents him from inventing or dis-
covering." We maintain that the same is true of educating university students. But research is more than innately virtuous. The humility and openness to new ideas that can be harnessed allow students to realize that even though we live in a complicated world, surrounded by conflicting opinions and information, in the long run, moral codes of conduct can lead us through: honesty, integrity, and perseverance in the face of adversity. In some sense it is precisely this indeterminacy that science teaches that can help expose the soft underbelly of unrealistic solutions to complex problems. We believe that even those students who will never become scientists should be required to be more involved in research—certainly not less.

In this way, a university degree can be reconceptualized not as certifications of mastery of a given subject, but as certification of a willingness to learn and to think critically. Though the mastery of the basics must remain, we ought to produce undergraduate and graduate students who have been trained to accept the challenge of learning, the openness to generate ideas, and when necessary, watch them fail. In fact, if we listen carefully to the cry from the leaders of the business community, such as IBM's chief executive Louis J. Gerstner, the problem is not that our students are lacking specific technical skills: "It is not in the interest of business leaders to turn public schools into vocational schools. We can teach [students] how to be marketing people. We can teach them how to manage balance sheets. What is killing us is having to teach them to read and to compute and to communicate and to think." Scientific research, at its best, offers precisely these lessons.

The University's Role in Discovery

So far, we have focused on how research benefits students. But our second major claim is that universities should maintain their dual research and teaching mission because universities provide a unique climate for discovery. The pace and complexity of scientific research have now reached the point where a pair of relatively self-taught, independent researchers working in their bicycle shop can no longer contribute to fundamental discovery and technological change in the manner they could have a hundred years ago. This leaves only the university and the private sector as viable engines of


6Solutions to societal problems that are based on a superficial and selective use of scientific data have a powerful influence over society, perhaps more so than science itself: "Pseudo-science is a despot ... possessing its own priests and slaves, before which everything else bows down with love and superstition hitherto inconceivable, before which science itself trembles and cringes shamefully". Fyodor Dostoevsky, *Devils*, trans. Michael R. Katz (Oxford, 1992), p. 265.

discovery and innovation. So how do we choose between the two—and should we?

One reasonable objection against using tax dollars to pay for university faculty to conduct research is that the truly necessary research can be conducted in the private sector. But can the private sector meet this challenge alone? Does it contain the right mixture of fundamental curiosity, breadth of inquiry, and mentorship to be the sole innovators and the driving force of discovery?

Whether we like it or not, change is the currency of the modern world. It is brought about by new discoveries and theories that find themselves in consumers' hands practically overnight. But corporations—naturally—are interested in profits and so their research interests are almost exclusively focused on how knowledge can be transformed into products, not how fundamental knowledge can be generated in the first place.

In striking contrast, universities teach the fundamental understanding of how nature operates, and they expose students to the great questions still besetting us. Indeed, they provide an environment in which new facts and questions are discovered and raised in the first place. It is this unbreakable circle of education, discovery, and questioning that allows great universities to distinguish themselves as catalysts of discovery and innovation.

This is not to say that universities are the only institutions actively involved in research. Government agencies, the military, and the private sector all have powerful research teams that contribute substantially to the increasing pace of innovation. But the university remains the only institution uniquely equipped to teach about, and question, this broader change, as well as explore its consequences. The historian James Burke observed that

As the pace [of discovery] quickens, and the diffusion of innovative ideas in the technological community is made easier by technological advance itself, the rate of change accelerates... But the amount of innovation increases also at an "invisible" level—that at which a high degree of specialist knowledge is necessary to understand what is happening. Unfortunately, it is at this level that many of the advances most critically important to our future occur: developments in the field of genetic engineering, radioactive fuels, drugs, urban planning, and so on.8

This, then, is exactly the knowledge that universities must both possess and be active in advancing if they are to truly provide students with the knowledge necessary to understand and foster change. It is precisely at this cutting edge of discovery—where the direction forward is still unclear—that universities must continue to face the challenge of letting researchers inquire for

the sake of inquiry alone. It is here, at universities, where ideas fail best, where the unexpected negative result of an experiment or an observation suddenly ignites a brilliant new path of research.⁹ And it is here that the universities must serve as a balance against the strictly economic interests of research conducted and supported by the private sector.

The business community is far less equipped than universities to let ideas fail. Driven by demands for wider profit margins and lower production costs, the private sector is typically interested in applying existing knowledge in a fairly narrow avenue of development. Though this process does lead to innovation and change, the societal effects of fundamental changes and discoveries are rarely questioned, nor are broad inquiries into fundamental questions encouraged or supported. Indeed, the top-down constraint of the private sector's research and development engines offers little room for the broad scope of inquiry that leads to truly new discovery and revolutions in the ways in which we think about the world. Wilbur and Orville Wright may have been able to invent the airplane in their bicycle shop, but it was not profit that drove them on; it was self-motivation and a spirit of inquiry.

It is precisely this inquiry for inquiry's sake that lies at the heart of some of humanity's greatest scientific discoveries. Newton likened himself to a "boy playing on a sea-shore" pausing occasionally to find a smoother pebble "whilst the great ocean of truth lay all undiscovered before me."¹⁰ Reflecting on the creation of wireless communication, Bertrand Russell observed that the men who made it possible—Faraday, Maxwell, and Hertz—were none of them the least interested in furthering this remarkable enrichment of human life, they were men solely interested in trying to understand physical processes, and it can hardly be said that the existence of industrialism helped them even indirectly.¹¹

While Russell may be wrong in ignoring the direct and indirect influences that economic and political forces have upon academic researchers, it remains true that forces that drive the private sector are far less conducive to such freedom of inquiry. Managerial level concerns about market share, product design, production schedules, material cost, and quality control conspire to force private sector research into particular, narrow directions. While such an approach is appropriate for the corporate world, it is clearly not likely to lead to the kind of basic discoveries upon which these eco-

⁹Fyodor Dostoevsky saw this clearly when he had one of his characters exclaim, "You will not attain to one single truth until you have produced at least fourteen false theories, and perhaps a hundred and fourteen...": Crime and Punishment, trans. Jessie Coulson (Oxford, 1991), p. 193.


nomic innovations so critically depend in the first place. Indeed, the history of discovery is littered with the results of researchers not bound by economic pressures. As Bertrand Russell observes:

Unless some people love knowledge for its own sake, quite independently of its possible uses, the new discoveries will only concern the working out of ideas inherited from disinterested investigators. Mendelism is now studied by hosts of agriculturists and stock breeders, but Mendel was a monk who spent his leisure enjoying his pea blossoms. A million years of practical agriculturalists would never have discovered Mendelism.12

It would be wrong to take from this the idea that university researchers operate in a world divorced of economic and political forces, or that all academic research is conducted solely for love of science. But it would be equally wrong—and we believe ultimately tragic—to ignore the fundamental differences that separate the research missions of universities and the private sector.

Not everyone sees these differences as relevant. In exploring currents among the educated public concerning its attitudes toward research, James Burke notes that one of the key themes is the growing feeling that "we should assess scientific and technological research strictly according to its worth for society, and curtail all other forms of research. . ."13 But as he points out, "In selecting which areas of research to encourage and which to curtail, to what extent are we depriving ourselves of serendipity, which . . . is the heart of the process of change?" When asked by a Victorian woman about the practical utility of his discovery of electromagnetic induction, Michael Faraday is reported to have quipped, "Madam, what is the use of a newborn baby?"14

Perhaps no one illustrates the relations among education, discovery, and change better than Galileo, the father of modern experimental science.15

12Ibid., p. 291. Indeed, the significance of Gregor Mendel's 1866 paper in which he reported the results of his findings, was not understood until the mechanisms of inheritance proposed by Mendel were independently rediscovered in 1900 by three different research teams of botanists working in Europe: A. H. Sturtevant, A History of Genetics (New York, 1965); L. C. Dunn, A Short History of Genetics (New York, 1965).

13Burke, Connections, p. 293.


15Albert Einstein, in his foreword to Stillman Drake's translation of Galileo's Dialogue, observed: "It has often been maintained that Galileo became the father of modern science by replacing the speculative, deductive method with the empirical, experimental method. I believe, however, that this interpretation would not stand close scrutiny. There is no empirical method without speculative concepts and systems; and there is no speculative thinking whose concepts do not reveal, on closer inspection, the empirical material from which they stem." Indeed, as Einstein points out, "The experimental methods at Galileo's disposal were
Galileo struggled his entire life to change the religious and academic entrenchment against scientific observation and experimentation.\textsuperscript{16} He left his first post at the University of Pisa because his ideas about scientific observation, experimentation, and mathematical analysis were seen as forces of change and were not welcomed by the political and religious authorities. Galileo found scientific freedom at the University of Padua, where he conducted his famous experiments concerning the nature of dynamical motion and at the same time delivered his findings to the students.\textsuperscript{17} These lectures and the resulting book, \textit{Dialogues Concerning Two New Sciences},\textsuperscript{18} set forth some of the most enduring laws of nature that our species has discovered—indeed, we still teach these same approximations to our undergraduates today. How can we weigh this moment in history when some of the underlying mysteries of the universe were first organized as a series of four axioms, bolstered by rigorous observation, scientific experiments, and mathematical formulations? Protected (if only briefly) in an atmosphere in which teacher and student alike could be immersed in a culture of open inquiry—where the failure of ideas was not feared but welcomed—the method of experimentation germinated, and the course of human history changed forever.

This is not to say that Galileo's discoveries were isolated or unrelated to the wider society. Even he was quick to recognize the practical military importance of the telescope he devised, and he offered its use to both to the Catholic Church and the opposing Protestant democracy in separate letters specifically tailored to their different religious convictions.\textsuperscript{19} But although he recognized the relation between science and society, Galileo was not content to have political and societal interests dictate the course and content of scientific research and teaching. As he noted, "In questions of science, the authority of a thousand is not worth the humble reasoning of a single indi-
And it was here, in the setting of a university, that Galileo was able to engage in his most creative reasoning and here where his greatest discoveries were made. Likewise, we believe that great universities can and must continue to play a central role in fundamental research: a place where discoveries (both large and small) are for the first time seen, held, examined, put to the test, and then proclaimed to the world—not because they are what we hoped or wished to find, but rather because they are true.

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