

# Thoughts On Creativity, Diversity and Innovation in Science & Education

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Often observing the national debate on the topics of diversity and affirmative action, I have the impression there is a missing part that needs to be at least understood by those who would argue in favor of actions to continue Affirmative Action policies similar to those first enunciated by the Nixon Administration. While there are powerful moral arguments made for these policies, much less often are heard others as to why diversity policies have the potential to benefit the nation and all of its citizens in many ways.

It is always a temptation to generalize one's own experiences assuming that this provides a lens for insight into such large questions. In the following, however, I will attempt to speak to the issues of my title as I have seen these play out in the milieu I know best...working at the cutting edge of innovation in theoretical physics and teaching the next generation of aspiring physicists. I offer these thoughts in the hope that others responsible for establishing procedures and policies might have an intellectual scaffold upon which to add their own valued contributions.

My personal efforts concerning serious deliberation on these questions dates back to 1993 when a African-American scientist asked me the question, "Why is Affirmative Action fair?" After two years of examining this question, I began to write some small number of essays [1, 2] in answer to this. A different small number of essays [3, 4] have been the result of my being offered the opportunity to speak on matters of innovation/creativity inside and outside of STEM (science, technological, engineering and mathematical) disciplines. These two sets of essays are reinforcing and overlapping with regard to the topic of this essay and I will draw heavily from these previous works. I wish to offer my gratitude to Atty. Jamie Lewis Keith, Vice President and General Counsel at the University of Florida, for solicting these remarks which I forward in the hope this expression of my thoughts is useful to others.

## (1.) Thoughts On The Dynamics Of Science

Science is the human process by which our species gains its most precise understanding of the place in which we live, the universe (or physical reality – the part of reality not dependent on our emotional state as far as we can measure). It is a process, a conversation among a group of humans, and in a sense, a conversation between a group of humans and the universe. This conversation has taught us to be cautious in our attitude toward what it is that we believe.

Often non-scientists appear subject to an illusion that science uncovers scientific truths for our species. This is not the work of science. Science reveals theories about the structure of the universe. Albert Einstein once said [5],

“It is difficult to attach a precise meaning to the term scientific truth.

Thus the meaning of the word truth varies according to whether we deal with a fact of experience, a mathematical proposition, or a scientific theory.”

The use of the word theory recognizes any paradigmatic explanation of facts (i.e. scientific observation) is a proposition that can be proven false. Any claim made to being a part of science must surrender ab initio to this property, and it must in principle allow (by the action and reasoning of scientists) for the claim to be proven false.

While the use of logical rationality is a hallmark of science, there is what I think of as an irrational basis for science. The mathematician Kurt Gödel (1906-1978) essentially showed the impossibility to formulate a completely axiomatic system. Simply put, making working assumptions as a basis for deriving subsequent statements is unavoidable, and these assumptions precede and ultimately lie outside the system of rational scientific analysis.

Knowledge (mathematical, scientific, and technological) is finite. It possesses a boundary beyond which we are blind. The only human facility by which we go beyond this boundary is imagination. A theoretical physicist is essentially a mathematician who has the ability to calculate something useful about our cosmos. We imagine new answers and solutions. We make them up! However, as scientists we are charged with taking this marvelous facility and seeking nature's confirmation that we are less incorrect than with our previous theories. Such paradigm shifts illustrate Einstein's comment, “Imagination is more important than knowledge.”

## (2.) Thoughts On The Matter Of Diversity

The effort of doing science particularly makes one aware that it is the individual from which basic progress is derived. Ideas come to people not to committees or groups. Mind is really only an attribute of the individual. Thus, one must eschew the concept of group entitlements. Simultaneously I argue that it is important to the vitality of the field to achieve the greatest possible diversity. In speaking of broad diversity, one must recognize that every individual – of any ethnicity, gender, etc. – will bring different perspectives, experiences, creativity, i. e. the irrational portions described previously. But when individuals from groups that face traditional biases in our society are excluded or inadequately represented, we inherently limit the diversity that is possible – and with that, we limit the potential for achievement, discovery, innovation and learning in the sciences (and likely in other fields). I argue this limits the robustness of the scientific enterprise as a whole. As a scientist, I look for observable models in the world about me in order to reach conclusions about complicated systems. Surely the interactions in a society around the issues of bias and discrimination are of great complexity.

It is almost universally accepted that diversity is of great importance in biological realms. The genetic diversity of an organism or group of organisms is almost always found to enhance long term prospects for survival. A diverse genetic pool is the reserve from which biological systems draw in order to adapt to changing environments. Diversity is often associated with enhanced levels of vigor and performance.

I argue by analogy that these same types of effects can be seen in the more complicated area of human endeavors. There may exist a rock-and-roll-effect in relation to the importance of diversity. I take this name from one of the most identifiably American contributions to world culture. It is also one of the most forceful avenues by which this country is brought to the attention of young people the world over.

This music (like that other new American contribution, jazz) is a derivative of two older forms. It was (and is) the result of a dialog between practitioners of African and European musical forms. The diversity of the conversationalists (numbers of artists taking elements from both older forms) increases the chances for a heterosis to occur. As both classical and jazz music simultaneously exist today, we don't think that we are musically poorer. Had jazz never come into existence we would have been musically poorer, but before this occurred musicians could say, "We are doing just fine. We have this wonderful art form here." That possibility is what is lost when people with diverse aesthetics don't participate in science. I argue that this "natural law of the efficacy of diversity" likely holds in all realms of human creativity.

### **(3.) Thoughts On Diversity In Education**

The other major responsibility I have had in life is as an educator who began teaching college students in 1972 and has continuously done so to the date of this essay in 2009. This has permitted me a second platform upon which to gather observations in the classroom and laboratory and formulate hypotheses on the topic of this essay. Obviously, such anecdotal evidence may be subject to dispute and I do not have pretensions of being either a social scientist nor researcher in the field of education. However, it seems likely to me there might exist scientific data that can be used to either support or dispute my contentions. I offer, however, my judgment as an educator in science whose experience informs me that broad diversity of students and faculty in the classroom and laboratory enriches the learning environment for all students.

My experiences as an educator seem to have correlations with my observations of how progress occurs in the expansion of human scientific knowledge. The identification, recognition and exploitation of multiple distinct pathways for asking questions about and solving scientific problems often precedes discovery – and sometimes – head-spinning new paradigms. These new answers and advances in science continues its evolution and avoid the fate of becoming a static state of knowledge. Learning in the classrooms and laboratories of my experience mimics these processes.

My observation is that the broadest possible manifestation of diversity is a critical force-multiplier to the learning process for all students in a science classroom or laboratory. Diversity, with its inherent differences in background, experience and intellectual aesthetics (or style), seems to lead to the broadest spectrum of questions about any posed problem. Although there may be one answer to a physics, chemistry or mathematics problem (based on the current state of knowledge), there are often multiple paths for arriving at that answer. In a broadly diverse classroom, all students thus benefit from hearing the different questions posed in the educational arena. Fostering habits of seeking multiple pathways to solutions would seem a prudent strategy for the development of innovation in the thinking of students in addition to enhancing each student's mastery of existing science.

When I discuss style with other theoretical physicists, the first reaction can be one of puzzlement, "What is the meaning of style in theoretical physics or mathematics?" Sometimes an initial reaction is, "Certainly no such thing exists in mathematics." Anyone, I believe, who reads the primary source literature in mathematics over a sufficiently long period of time can quickly conclude that there was a very different style to the writing and thinking about mathematics just over one hundred years ago.

Some might argue that we have come to a sort of end of history and have advanced to the point that style in mathematical thinking will undergo no additional evolution. In my opinion this is unlikely. One reason for this is the rapidly increasing capabilities of computers.

I argue that if the mathematical language upon which so much of the structure of science rests and has played a substantial role in shaping its culture can be subject to changes in style, then so too can education in any scientific field. Style seems likely linked to the sorts of irrational choices that are made. If this is the case, then style has indeed an important implication for learning.

One final suspicion my experiences in classrooms and laboratories has led me to believe is that, in fact, intellectual styles of the average U.S. student are likely changing under the influence of modern communications technology and computers. Once more, it seems difficult to argue that a lessening of the diversity of students will more adequately prepare them for a more successful educational experience changing in this regard.

#### (4.) Thoughts On Affirmative Action As A Tool For Achieving Diversity

In answering the question of my beliefs about affirmative action, I answer that it, or something very similar, has a definite role to play if this Nation is ever to get beyond the issue of traditional discrimination and to the more central issues of content of individuals' hearts and minds. For me personally, I say (as has been said by Gen. Colin Powell), I would not exist were it not for a policy of affirmative action.

It is my belief that affirmative action should never be used to reward the less qualified over the more so. Instead, if two individuals are both seen to be qualified, then affirmative action should play a role in a decision that has a wider societal importance. The relevance and appropriateness of the qualifications as well as the methods used to access these must be scrupulously examined as to whether they are free of traditional American biases. Application of such policies should be within a narrow range of uncertainty well recognizable in science as the limit on human infallibility and encoded in the concept of "the error bars" associated with observation and measurement.

In seeking increased fairness, principles must be applied in a consistent and morally defensible way. Efforts to achieve greater fairness must be lashed to principles deeply imbedded in the American experience, and found in its communities. One of the most difficult questions that this Nation has yet to successfully address is how use fair access of competing individuals for resources and to provide redress for the denial of right undertaken against an individual because they belong to specific groups. Affirmative action is (or was) an attempt to counteract a basic unfairness that we have all inherited and to offer the possibility of fostering increased diversity across a broad range of human endeavors in this Nation.

Albert Einstein made a number of remarkably forceful comments about discrimination and bias (particularly against persons of color). I wish to close with his comment about combatting these traditional practices,

"I do not believe there is a way in which this deeply entrenched evil can be quickly healed. But until this goal is reached there is no greater satisfaction for a just and well-meaning person than the knowledge that he has devoted his best energies to the service of the good cause."

However, as is the larger point of this essay, we are in the situation where the moral action is also one that is in the Nation's best interest in a globalized competition for brilliant ideas and innovation.

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## References

- [1] S. J. Gates, Jr. “Equity Versus Excellence: A False Dichotomy in Science and Society”, in the *The Scientist*, Vol 9, No. 14, (July 10, 1995); reprinted in *Physics and Society*, Vol. 25, No. 3, (July, 1996), (<http://www.aps.org/units/fps/sjul96.html#a4>) and ([http://www.the-scientist.library.upenn.edu/yr1995/july/equity\\_950710.html](http://www.the-scientist.library.upenn.edu/yr1995/july/equity_950710.html)).
- [2] S. J. Gates, Jr. “A Black Physicist’s Thoughts on Affirmative Action,” in the *roceedings of the 25-th Annual Conference of of the National Organization for the Professional Advancement of Black Chemists and Chemical Engineers* (NOBCChE), Apr. 17, 1998 at Dallas, TX (see excerpt at; <http://pubs.acs.org/hotartcl/cenear/980720/res.html>).
- [3] S. J. Gates, Jr. “On the Universality of Creativity in the Arts and Sciences,” in the proceedings of the Fifth Annual Conversation on the Liberal Arts, *Beyond Two Cultures: The Sciences as Liberal Arts*, Feb 18–19, 2005, Institute for the Liberal Arts, Westmont College, Santa Barbara, California.
- [4] S. J. Gates, Jr. “Science, Irrationality, and Innovation,” in *The Kean Review*, Vol. 1, Spring/ Summer 2008, 93-105.
- [5] A. Einstein, *Ideas and Opinions*, (translated by S. Bargmann). New York: Crown Publishers, 1954.