VCU's New Anti-Science Curriculum

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Virginia Commonwealth University (VCU) is currently in the final stages of revising its General Education (Gen Ed) requirements. While the specific course choices are yet to be announced, the draft outline requires, for instance, little-to-no math and science, and no U.S. history or government. The main problem, which I will discuss here, is that the proposed curriculum not only appears to be flabby—but is implicitly anti-science, at a time when we need to produce graduates—and citizens—who are critical thinkers, and can think *like* scientists—no matter what discipline they study.

I am an Associate Professor of Mathematics and Applied Mathematics at VCU. The proposed curriculum changes will have no direct effect on my department— but I am concerned that these new requirements will have on the students VCU graduates as well as our ability to attract students to this great university. Let me emphasize that I am not a philistine scientific cheerleader—but someone who also has an advanced degree in the humanities (philosophy), and who highly values his own liberal arts education. I believe that the arts and literature are valuable and should have a place in the curriculum, but that insofar as we intend for our students to achieve knowledge they must be taught proven and successful ways of attaining knowledge, and that our curriculum should be modeled on the example of the predictive sciences.

On the face of it, the new curriculum seems benign, each individual guideline, while vague, is anodyne—and every Gen Ed curriculum everywhere also involves some hodge-podge of courses. Math and science are often perceived as road-blocks to maximizing numbers of graduates and thus de-emphasized in curriculums. U.S. History and government have become unfashionable, or politicized, and easy to drop. And it might be claimed claimed that these subjects will inevitably come up in a variety of other courses. My own worry is that VCU's proposed new curriculum is even less substantive than this: the aggregation of "curriculum model" guidelines

suggests not only an aim of allowing any imaginable course into the curriculum, but a rejection of rigorous thought and the successful practices of the predictive sciences.

This curriculum might become a publicized and national embarrassment for VCU. And VCU might lose students to schools perceived to have more rigorous curricula, and make our VCU graduates less attractive to other graduate programs and employers. The proposed curriculum needs to be re-evaluated. VCU would be better off in focusing on preparing students that can collect relevant data, evaluate and reject theories (in every area of their lives), and propose new ones. No department can be opposed to this, every department should propose classes promoting this goal, and insofar as they do, can be included in a rigorous curriculum. VCU graduates need to be intellectually humble, open to all relevant ideas, ready to discuss any alternative, and we should have a curriculum that clearly states these goals.

Our modern world, everything that surrounds us, is built on a foundation of theories that are used to successfully make predictions. Bridges, buildings and other structures depend on mechanics (Newton's laws). Computers depend on our understanding of electricity (Maxwell's laws) and our understanding on materials at a quantum level (transistors). These were painstaking acquisitions of knowledge, accumulated over centuries of small successes, failed theories, new evidence, and the development of better theories. Every scientist knows how much we don't know, how humbling scientific investigation is, how much farther we need to go.

Our society has real problems. Some of them require political choices. There are no magic fixes to be expected from scientific discoveries. That said, all of our choices involve predictions. We hire new school superintendents because we predict they will do better (in some sense) than competing candidates. When they don't we revise our hypothesis (and fire that person). We chose a system of government because we predict that it will satisfy more of our goals than alternative systems. When it doesn't we revise the system (or the laws, or constitution). The more information we have, the more possibilities we can imaging, the more experience and data we have, the better predictions we can make. This is what it means to think like a scientist—it is not that you are right in virtue of being a scientist—you're not—it is that you are used to being wrong and you try your best.

One of the most important things in training someone to do mathematical research is to get the student to freely throw out possible ideas and discuss them. Most ideas are wrong. Discussing them, and why they are wrong, often helps you get to the ideas that are right. That said, students don't like to be wrong. They don't want to be caught out for their "dumb" ideas. They have to get over this to be successful. Being wrong most of the time is humbling—but essential to success. A great example is the search for the structure of DNA, one of the most important

recent scientific discoveries. Every high school student today knows the structure. But nobody did in 1950. Data was being generated, hypotheses more-or-less consistent with available evidence were being generated, new data of potential relevance were sought. Linus Pauling, a two-time Nobel Prize winner, published a single-helix model for DNA structure. It explained quite a bit of what was then known. It was dead-wrong. DNA has a double-helix structure. That's how it goes in the sciences. Pauling moved on, and did many other important things. Once the structure of DNA was known it led to many new predictions, new problems that came out of this understanding, and new tools. Today's CRISPR gene-editing technology, with the potential for a huge variety of applications can be traced back directly to this discovery—and these knowledge-discovery practices.

I am not arguing for any push to increase the sciences at VCU. Not every student wants to be a scientist and we don't necessarily need to produce more scientists. But the science requirement in the proposed curriculum can be fulfilled with a single "ethics of science" course—no actual science at all. Maybe not every VCU needs to learn a mass of facts about biology, chemistry or physics. But they should have some exposure to the relevant predictive theories that exist in these disciplines— that real predictive knowledge can be obtained—and that this is the accumulated efforts of scientists across the globe, working for hundreds and even thousands of years. These should be the models for every discipline insofar as it engages with the world. Many disciplines, in particular the social sciences, are sometimes thought not to be as amenable to predictive theories, that humans and human interactions are too "complex". This is simply defeatist: the challenges are indeed greater and may take centuries to resolve, but there is no proof yet that predictive theories here are impossible. We've just got to roll u our sleeves and get to work.

VCU's proposed Gen Ed requirements don't specifically include "critical thinking". Of course, no one could be opposed to this, and it might be claimed that but it is implicit in many of the guidelines, but it should be specifically emphasized. Skeptical ways of thinking need to be specifically encouraged. I once took a Social Justice course which seemed exciting at the time—we would talk about problems, and possible solutions, and address them—-but the course was, in fact, taught by a teacher with very specific views—and the students were just expected to repeat these views. Questions were not only not encouraged, they were actively discouraged. These practices exist in parts of the university where there is less of a tradition of being wrong—and less of the intellectual humility that is part of the practice of the sciences.

One important practice of critical thinkers, central to the study of philosophy but necessary in every discipline, is *conceptual clarification*. It is always useful to

get really clear about the concepts in our disciplines—and there can be great pay-offs. Modern mechanics (special relativity) *began* with Einstein's analysis of how to measure whether two events are simultaneous. Possible Gen Ed courses in every discipline might involve getting maximally clear about the central concepts of the field: what *does* it mean for events to be "simultaneous"?, what is "money"?, what is "gender"?, what is "dyslexia"?, etc.

The draft VCU Gen Ed proposal consists of a "Coherent Rationale", together with a "Curriculum Model"—a description of criteria for the actual courses that might be offered in the future and count for Gen Ed credits. The proposed "Coherent Rationale" is:

"VCUs General Education Program seeks to provide a diverse student body with a broad base of knowledge and the intellectual skills to participate actively in a changing world.

To those ends, the VCU General Education Program challenges students to seek creative answers to complex problems, see connections between disciplines and between ideas, and develop an informed perspective on the varieties of human experience."

This seems benign and possibly even good: of course we want our students to have a "broad base of knowledge", "intellectual skills" and to "see connections". The problem here is that this "rationale" does not provide a directive for producing the kinds of graduates anyone would actually aspire to be, much less want as a colleague, collaborator, or employee. The actual goal of the "rationale" is to produce graduates that "participate actively in a changing world". We don't want graduates that participate *actively*; we want them to participate *successfully*. Someone who, in trying to reduce autism, insists that vaccines are bad, and sets up an organization to promote this view, would be be *actively* trying to reduce autism. But she wouldn't be successful (the once-hypothesized connection between vaccines and autism has been thoroughly rebutted). A person considering new evidence, new hypotheses, open to hypothesis revision in the face of new data, is much more likely to participate *successfully* in reducing autism. That's what VCU's curriculum should aim at: *successful* graduates.

And why would VCU's educational "rationale" be to *challenge* students to find creative solutions—why don't we *teach* them to do this? Our rationale should be to *produce* students that develop creative answers to complex problems. It isn't much to challenge my students to solve unsolved math problems: its more important to teach them *how* to approach unsolved math problems. The "rationale" also places an importance on seeing "connections between disciplines". But what is the importance of this? Are there useful connections between mathematics and painting? Maybe,

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maybe not. What is really wanted here? Could a VCU graduate write a graduate application, resume, or cover letter that seriously and effectively claims that she can now see "connections between disciplines"? It would be better if a VCU graduate could write: *I can find creative solutions to problems.*

Let's now look at some points in the "model" meant to implement VCU's new Gen Ed curriculum, that is, the policies that are meant to justify new VCU Gen Ed courses. There is no imaginable course that couldn't be said to follow at least one of these vague guidelines. Four are highlighted here—but many of the others indicate a similar degree of flabbiness.

1. *"Explore varieties of human psychology or development."* Well, every student could usefully learn some psychology. There are more than one hundred years now of data, and some predictive theories. And much more in need of predictive theories. Human psychology is enormously complex, the science is nascent, and should keep scientists busy with interesting questions for centuries to come.

There's lots of knowledge about psychology that comes to bear in designing curriculum to most successfully teach kids to read, to make computer fonts maximally readable, to make computer programs "useable", etc. But why isn't the directive to "Learn human psychology and child development"? Whatever is true and useful must be generally true (in specifiable circumstances). There are no "varieties of human psychology"—any more than there are "varieties of physics" (there's not—there's just physics).

And why would you "explore" psychology—shouldn't VCU graduates *learn* psychology? Is something different than *learning* meant? Again, if you had actually learned psychology—and had useful things to tell others about human psychology (for instance, in explaining what is known about how children learned to read) you wouldn't tell anyone that you had *explored* psychology.

2. *"Consider the role of imagination in confronting and expressing the human condition."* Does "imagination" *confront* anything (even metaphorically)? What is really meant here? Can it be said usefully and clearly? Reading and discussing imaginative literature, for instance Kafka or Garcia Marquez, is arguably valuable. If that's what's meant, how about: "read and interpret imaginative literature"?

3. *"Recognize how knowledge is constructed differently in various communities".* Knowledge of course is knowledge. But there are fashions in academia that suggest that the most important kinds of knowledge are somehow not universal, that there is no "truth" to scientific or economic laws. One of these trends, alluded to in this curriculum guideline is "social constructivism" or the "social construction of knowledge". The main idea here seems to be that, because people come up with scientific laws (whether they are "discovered" or "invented" has been hotly debated for

decades), they must be somehow dependent on the backgrounds (cultural, political, etc) of the scientists who made the discoveries.

It is certainly true that the scientists make up the language they use (for example, whether a neutron is called a "neutron" or something else is a choice—which becomes a convention). Insofar as scientific language and practices are conventional there is something true here in "social constructivism"—but specific claims (that can be substantiated or falsified by evidence) in the social constructionist ideology are rare (and it has been said that the specific claims of social constructivists are either trivial or false). Social constructionism is the backdrop for the rejection of "truth", especially scientific truth, in certain parts of the Academy. As such this is the most pernicious and obviously anti-scientific guideline in the proposed VCU Gen Ed requirements. A better guideline here would be: *Recognize how knowledge is universal, and acquired only slowly over time, with great effort, by serious and thoughtful researchers across the planet.*

The anti-science of social constructivists has been directly connected to the rejection of vaccines, the rejection of global warming research, conspiracy theories regarding school shootings and 9/11, and political division. I once talked to someone who worked in NASA's public outreach office who answered citizen questions; she told me the majority of the questions were about whether the moon landing was real! We need to train VCU students to find the truth—not that truth is community-dependent—and how to effectively discuss these issues. The moon landing either happened or it didn't. There is nothing "constructed" about this.

4. *"Consider alternate viewpoints among disciplines, cultures and groups". Of course* VCU graduates should be trained to consider and evaluate all possible alternatives to any problem. But you don't want to consider all alternate viewpoints equally. There is no reason to waste time studying viewpoints that don't have any data to back them up. There's no reason why most cancer researchers should spend any time "considering" psychic surgery (a sham practice involving the fake removal of bad organs involving lots of blood but no incision). Many nursing schools have offered courses on "therapeutic touch"—a practice involving auras and no actual physical contact with the patient—and no supporting evidence that it works. There is no reason nursing students should "consider" therapeutic touch. Psychic surgery and therapeutic touch are sociological curiosities—not something to consider in any other context.

The danger here is that this guideline is interpreted to mean (and maybe actually meant to mean) that all possible viewpoints are "equally valid". In fact, there's a lot of nonsense out there. VCU students need to be trained to evaluate and reject nonsense. In our day of fake news and "alternative facts", our graduates need to

be trained to quickly separate the wheat from the chaff—and to be able to discuss *reasons* for their evaluations.

The new Gen Ed *courses* aren't specified yet—what is proposed so far are only guidelines for deciding which courses to include. But if these guidelines are accepted it will be too late to resist any of the proffered courses. Courses like "Social Constructivism", "Therapeutic Touch", etc, can all be made to fit into our curriculum. And at this point it will be too late. VCU will be a laughingstock—and worse—we will force a curriculum on our students that will make them less able to address the pressing problems in the world around them—and the pressing problems that effect *all* of us.

The proposed VCU Gen Ed curriculum seems less interested in student outcomes than in creating a curriculum where every department and major can offer classes. This is great for the departments: for many of them it will provide new students, demand, and reasons to hire faculty. But, by itself, has nothing at all to do with the students.

Now let me make some positive recommendations. A better "Coherent Rationale" for VCU's Gen Ed curriculum would be:

VCUs General Education Program seeks to provide a diverse student body with a broad base of knowledge and the intellectual skills to participate successfully in a changing world.

To those ends, the VCU General Education Program is designed to produce critical thinkers, who can find creative answers to complex problems, find data to support and reject theories, to humbly follow wherever evidence may lead, and to promote human well-being by their serious and diligent efforts.

I propose to make the "Curriculum Model" more succinct. It should not be so vague that any possible course might count. The guidelines should force disciplines to offer classes that will result in critical thinkers and scientific evaluators of evidence, that prepares VCU students to discover and evaluate all the choices that they will face in their research, endeavors, and lives as citizens, and to effectively discuss their strengths and weaknesses.

In addressing the anti-science implicit in the current recommendations, I have naturally focused on this issue. Of course, the usual selection of literature, creative arts and art appreciation are all enriching. I took a wide variety of these courses and considered them valuable, essential to the person I am now: I had two semesters each of literature, drawing, and piano. My "Listening to Music" course allowed me to hear the music that I loved in ways that have had a continued payoff.

VCU's curriculum should also require a statistics and computer science course. These are perhaps more fundamental and foundational than the traditional natural

sciences (biology, chemistry and physics). Statistics is fundamental to critical thinking, any discipline that involves numbers, and many important decisions that citizens and political leaders face. Very few things have single or clear causes: almost nothing is black and white, almost nothing in biology or human interactions involves single causes. Almost every experiment leads to a discussion of "statistical significance".

If a coin comes up heads in 70% of a large number of experiments, what does this mean for our future predictions of the outcomes of future coin tosses? It does not mean that it will come up heads on the next toss. But it is important information that you can use to place successful bets on. Our world is filled with information like this. Very little is known with absolute precision—but we often have some information and need to act on it in maximally successful ways. This is also the kind of reasoning that underlies controversial predictive software like where property and violent crimes might occur, who might be a terrorist, etc. Citizens can't adequately evaluate—or critique—these programs if they don't understand basic statistical inference—and its strengths and weaknesses.

The proposed VCU Gen Ed curriculum mentions computers exactly once—in the context of using them for simulations. But they are ubiquitous in our lives—and there is even a push now for elementary school students to learn some computer programming. We are surrounded by computers, our homes and cars are filled with computers. Most of us have very powerful computers in our pockets. Artificial intelligence is becoming more and more powerful. Computers can now easily defeat humans in games where human intelligence was once thought to be essential. Students don't necessarily need to learn how to program—although this is good training for critical thinkers (code is either right or wrong, works or doesn't). But they should have a basic understanding of how computers work, what programs are, who makes them, how networks are set-up, and where, what data, data storage, and data mining are. They should learn these things well-enough to discuss their effects, virtues and dangers are.

VCU has an opportunity to remake its curriculum to be a model for other universities, to have a curriculum that reflects its diverse student body *and* produce citizen-learners that are prepared to think in provably successful ways, to effectively think of ways to make change, and to use evidence to argue their points of view. We owe it to our amazing VCU students to give them such an education, to give them the tools to think up and make real change. To do this they will need to think like scientists.

VCU's Provost, the chief academic officer, is Dr Gail Hackett. She will soon make final decisions regarding this new curriculum. Her office is currently accepting comments about this Gen Ed proposal.