

UC Davis Honors Program
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The power of diversity and the need for experts

It was such a privilege for me to get to teach Math 21B, which is a single variable integral calculus course, in the honors program this year. I was so impressed by every one of the students in my class, that it was hard to resist the temptation to throw out the course syllabus and push the students to their mathematical limits!

I honestly felt the class was capable of anything and that our time might be better spent jumping into more advanced topics and picking up the multi-variable calculus, linear algebra, differential equations and numerical methods along the way. It was inspiring for me because I got to see such tremendous capability, and notably within an astonishingly diverse group for just 16 students. The students range of personal interests is perhaps best exemplified by the array of final project ideas, which, beyond having to be closely related to math, was effectively a free choice. There were projects in artificial intelligence, statistics, cryptography, astrophysics, quantum mechanics, crypto-currencies, economics, biology, and even one of my personal favorites: computer-generated poetry.

This diversity reminds me of a story I know. Let's travel back in time together with our imaginations. Imagine it is the year 1000, contemporaneous with the likes of people like Norse explorer Lief Erickson. There is a city, and there is a regent of this Medieval city – a queen for example. The queen is wise, and therefore knows it useful to discuss ideas with others before making important decisions. Thus, she seeks out to appoint a counselor from among her most learned subjects.

The queen puts out the call and three guilds answer. The engineering guild, the philosophy guild and the mathematics guild. A representative from each group went to the queen and she said: whoever best solves my problem, I will appoint as my royal adviser – a position of great honor and power.

She gave to each representative, the mathematician, philosopher and the engineer, a rope and told each to enclose the largest region with the rope. The next day all three returned to present their solutions. The philosopher placed the rope in a near perfect circle in front of the queen while explaining a circle is the shape that maximizes the enclosed area for a given circumference. LOGICALLY this must be the solution the philosopher declared triumphantly! The queen agreed this was the correct solution, but she asked the engineer what they had done. The engineer, looked at the philosopher with a MANUFACTURED smile, and led the queen around the city walls. As they walked the engineer showed the queen throughout the night the engineers had pulled the rope apart strand by strand, tied them together and run the thin strand around the entire city in a huge loop! The queen and philosopher were both stunned by the capability of the engineer. To be fair though, the queen almost pityingly then asked the mathematician if they might offer another solution. The mathematician reached into their pocket, pulled a knotted rope, dropped it onto the floor and stepping into the center of the rough loop saying simply "I declare myself to be on the outside of the enclosed area." And, all members of the court gasped at the creativity of the solution. So you are the queen. Who do you choose as your adviser, and more importantly, why?

Although the mathematician's solution is technically the best (*after all, the mathematician did enclose the entire Earth absolutely demolishing the answers proposed by the philosopher and engineer with specific regard to the queen's question*), all these solutions are each interesting and essentially correct answers to the question, and more importantly each is different from the others. You see, it is the diversity of ideas that allows for the richest understanding of problems. Not to make the story too one sided, regarding philosophy, mathematics and engineering, suffice it to say that different questions would elicit perhaps similarly creative responses from other experts in areas of the humanities, social, natural and life sciences, for example.

(This idea is similar to the sentiment expressed by: If the only tool you have is a hammer, then every problem is a nail to strike.)

If everyone's creative approach is generated by the same core philosophy, aesthetic sensibility and standards of value, then this will limit the spectrum of solutions considered. The wise queen would realize that and therefore appoint all three advisers to diversify her council in order to maximize creativity and generate the most complete analysis possible to every problem. So too as a species must we place a high value on our diversity – ALL KINDS - in order to become more complete and stable as a unified whole, and more capable in all areas from technology to justice to the culinary arts, even in ecosystem stability, such as by way of biodiversity.

Sometimes you hear people say things like “why doesn’t everybody just speak English?” Which seems harmless enough a conjecture, but it’s just wrong. Just think of a world where all chefs cooked the same food – the same way – everywhere – always. Yuck! Why is it so hard to extend that analogy to problems involving philosophy, engineering, biology, the arts, or even matters of language, ethnicity, sexuality, and religion. You see, it is not enough that we merely tolerate diversity, it is understood that we embrace it, we design for it, and nurture it because we need it to become our best.

In the words of Linus Pauling “To have great ideas, have many ideas!” You’ll recall that American Chemist Linus Pauling is one of just 4 people that have won 2 Nobel Prizes, along with Physicists Marie Curie, John Bardeen and Biochemist Frederick Sanger. Back to Pauling’s idea about having many ideas... while it’s true for your individual work, it’s also true in a much stronger sense for our society as whole. If everyone is a mathematician, or biologist, or farmer (*and we’ve come pretty close to trying that last one*), the polarizing affect of such one dimensionality will stifle our creativity, and ability to flourish as a society in both a group and individual sense.

That said, promoting diversity does not ideally permit each individual to be a jack-of-all-trades and master of none. We need deeply educated people. We must have specialists and experts. Why is it that someone is called Professor, Doctor, Chef, Councilor, Foreman, Officer, Plumber, Electrician, Pilot, Sergeant, Captain, Judge, etc. these are not titles like Baron, Lord, King, Queen, Pharaoh, etc, instead these are earned titles that reflect expertise acquired by way of specialized education. Earned titles are about knowledge and depth of acquired skills. What even is an education?

Just think for a moment about that... what is your education...? (*A moments pause.*)

Your education, any education for that matter, is essentially the sum total of all the problems you understand the solution to, and for experts this group of problems becomes a connected knowledge that is more than the individual sum of its parts (*thereby violating one of Greek Mathematician Euclid of*

Alexandria's axioms that the whole is equal to the sum of its parts). Because your mind is not a deterministic, axiomatically driven system, it is organic, nonlinear, and a miracle of organized complexity.

When you are an expert you see how the whole world is connected to what you know. Like “the whole world in a glass of water.” When you understand EVERYTHING there is to know about just a simple glass of water, you would understand much of what there is to know about the whole universe. In this way, to an expert, what looks like just a glass of water, an equation, an experiment, a fruit fly, to anyone else, to you becomes this idea of everything.

We are all driven by evolving passions, guided by different motivations, and so the results of our educations, even within very narrow fields, invariably produce different results, and that is a good thing. Follow that passion and see where it leads you, and don't assume to know how it will change you, and how you then will change others. Become an expert, and some people will try to follow your path, they too will go a slightly different way because they are different from you, and together, as a diverse group of learners, we go on all the paths, explore the whole world of ideas and share our findings with each other – in art, music, stories, lectures, books, videos, blogs, the internet, witty memes – and as a world we grow. You will see when you become an expert in anything – IN ANYTHING – the problems for you to solve start naturally appearing and in your own way, you will be prepared to add something of present value and lasting interest, just like the philosopher, engineer and mathematician all did within the story. Your education is never complete your whole life, and no one, not even you, can predict what you are truly capable of contributing!

So as you go forth and continue your education, whether it be in industry, the arts, or sciences, or somewhere else, remember the maxims we have discussed here.

- First, remember that the mathematicians (and logicians) are usually the ones with ideas that are the most technically correct. So we must tolerate them and seek their council.
- Second, collectively we must place a high value on diversity in order that our sense of things does not become polarized and attenuated.
- Third, aim to develop expertise, but follow your own passion and pursue the problems that you genuinely find authentic and interesting. Every problem you understand will become part of what you are able to contribute, and you cannot predict how all these problems will work together to produce your ideas.
- Fourth, acknowledge your efforts and amazing capabilities at a meta-cognitive level. In the future, as much as now, realize that you will always be your harshest critic. Where others stand in wonderment at your abilities and masterpieces, you will pick out the littlest flaws and focus in on them. Such is the nature of expertise.
 - Realize that everyone is different and differently-abled, and sometimes we see what others are capable of and discount what we ourselves can do! Perhaps this is true for many of you now, perhaps even for some of the faculty in the room / and definitely for many throughout the school (and everywhere really). You think that you aren't as good as the people sitting next to you think you are, that your friends and colleagues are more talented, and you just barely made it and don't belong. No! NO!
 - You earned it. It wasn't luck, or others giving something to you because they felt sorry for you. No! You did the work. You belong here. You earned your degree. You deserve the praise, the promotion, the success, the job. You doubting yourself is a kind of imposter syndrome, it's normal, but believe in yourself and your abilities. Degrees and laurels, jobs

and titles are merit based and people won't give those things to you. You earn them, and when you earn them, you need to rise above the self doubt that everyone feels. I believe in you... the faculty here all believe in you, but still that's not enough, you have to believe in yourself!

Finally, if I could give you one small piece of personal advice, it is just this. Smile. Smile more, and smile often. Sometimes even a faked smile when you don't feel like, when given to another is returned to you and becomes your own genuine smile, and then there are two smiles in the world where just previously there were none. This is a theorem in the calculus of smiles. Good luck, go forth with tolerance, become experts with confidence and don't forget to smile.

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