The three cultures: the role of the arts in the education of mathematicians

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In 1959 C.P. Snow delivered his influential lecture ”The Two Cultures”, exposing the cultural divide between the humanities and the sciences in western society. We revisit this in the context of the modern internet and multimedia age, and see what implications it may have for the education of mathematicians.

This conference is largely predicated on the belief that it is a good thing that those studying science at undergraduate level should also be exposed to a broader curriculum, which should include study of the humanities. I want to examine this axiom, with particular reference to mathematicians.

Let me begin with a few words at a personal level. I had the fortunate opportunity, though a combination of circumstances and the interventions of one or two particularly far-sighted individuals, to have something which was far from the norm in the British educational system — that is, a wide-ranging education right through to the very end of high school, studying not only maths and science but also literature, classical languages and music, all to an advanced level. I do not know what impact it had on my scientific development — apart from improving my efficiency of learning, since as an undergraduate I had far too many other interests to be able to afford to spend unnecessary time on my academic work. I certainly appreciate the benefit it had on my personal development.

Sadly, the broader curriculum is largely unheard of in the UK. There, the choice between the arts and the sciences is something one makes at the age of 16. It used to be the case that in order to gain admission to Oxford or Cambridge, one needed to demonstrate some level of broader knowledge. Candidates for the entrance examinations in Science would have to take a “general paper”, with essay questions on a range of cultural topics. But once the student was admitted, that was the end of it, at least within the formal curriculum. And in any case, this condition was abandoned over 20 years ago, and it is normal for some school pupils at the age of 16 to abandon completely the study of all subjects other than Mathematics, Physics and Chemistry; and for others to study nothing other than English, History and Politics.

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Some universities have a curriculum which permits students to take elective courses from other faculties in their beginning year, but there is no universal tradition.

This is a predicament with a long history, to which many people have drawn attention, and suggested remedies. I do not feel particularly competent to add to these suggestions. But in any case this begs the question: why do we believe this is worthwhile? Students who are going to become practising scientists need to compete in an increasingly cutthroat environment and to master subjects which are becoming increasingly complex. It amazes me to see the level of technical knowledge that a beginning PhD student in my field — pure mathematics — needs before starting research, compared with what was needed in the 70s. How can we justify wasting such a student's valuable time as an undergraduate with subsidiary classes which will be of no benefit to their future profession? And in the internet age, self-education is a much more realistic proposition than in the past — if students want to broaden their knowledge in a non-specialist direction, is that not within their own grasp?

Of course there are several possible answers to that. One natural answer is that we believe a rounded education is a good thing. For mathematicians at least, one can argue that the creative act of mathematicians is finding patterns in abstract structures, and that exposure to the arts can facilitate this.

Others might argue to the contrary, that a "one size fits all" approach is not the right thing. Broader education, they would say, is appropriate for those who are not destined to pursue their field to a professional level; but those who are going to be leaders in their field should be allowed to specialise early on. I want to argue that there is a strong case to be made, particularly in mathematics, that this latter approach is wrong, although perhaps not for the most obvious reasons.

But first, I want to go back 60 years, to the English writer C. P. Snow. Snow started off as a physical scientist who after several years of a successful academic career worked for a while in government, before becoming a full-time author. At that time, the passport to a successful government career, as a diplomat or senior civil servant, was a degree in the humanities — most often, what was called "Greats", a 4-year Oxford degree in Greek, Latin and classical civilisation. It must have been intensely frustrating to Snow that during his time in government, dealing with policy in science and technology, he had to cope with colleagues whose scientific knowledge was totally non-existent. At the same time, in the post-war scientific revolution, Snow believed strongly that the future of civilisation rested on scientific and technological progress. He crystallised his thinking in an article, later revised and expanded into a lecture in 1959, called "The Two Cultures" which I expect is familiar to many of you. Its primary premise is that there was, in Western society generally but particularly in the UK, a striking and harmful divide between what he called the two cultures: that of "traditional intellectuals" and that of scientists. Scientists knew little of the arts; and the traditional intellectuals took pride in their level of scientific ignorance. His damning criticism is often quoted, but too good not to repeat:

> A good many times I have been present at gatherings of people who, by the standards of the traditional culture, are thought highly educated, and who have...been expressing their incredulity at the illiteracy of scientists. Once or twice I...have asked...how many of them could describe the Second Law of Thermodynamics. The response was cold... [and] negative. Yet I was asking...the scientific equivalent of "Have you read a work of Shakespeare's?" I...believe that if I had asked..."What do you mean by mass, or acceleration?" ,...the scientific equivalent of..."Can you read?", not more than one in ten ...would have felt that I was speaking the same language.

One could question his language, but it was hard to argue against the existence of this divide at the time. Fewer people nowadays remember what Snow then went on to say, which was political, and far more controversial. He argued that perhaps the greatest byproduct of scientific culture was moral enrichment. There were those in the traditional culture who used a supposed deep insight into man's fate to justify the kind of social deprivation and inequality that, a scientist would argue, was within men's will to correct. Such people, he said, were obscuring the social truth just to be able to retain their own comforts. It is clear that he had the architects of the British Empire in his sights. He also singled out a number of literary figures for particular contempt — in the second version he put more emphasis on the injustices in the third world, and the role that scientists would need to play in addressing them.

I doubt anyone would try to argue that the cultural divide between the arts and the sciences can be interpreted so harshly nowadays, although I will return to this point later. But leaving this aside, where stands Snow's "Two Cultures" today? Not all has changed, but a lot has. First, Snow was talking about a post-war intellectual elite, in what was still a strongly class-stratified British society. We surely need to revise the test by which we judge literacy, taking into account the far more flexible contemporary standards of what constitutes "serious" artistic work. Even by these standards, I expect that many maths and science majors, whose literary experience might not extend beyond Harry Potter, would fail the test.

As much as he anticipated the continual explosion of technological development, Snow could hardly have imagined the pervasiveness of technology in every aspect of

21st century life. He would surely be pleasantly surprised to discover the role of technology in so much contemporary artistic creation.

He would be less happy to see that, although our society almost universally embraces modern technology, it has little understanding of, and respect for, the science which underpins it. As a pure mathematician I am often asked, not always very kindly, what is the purpose of my field of research, which is Number Theory. People are taken aback when I answer, ”well, you probably already used number theory at least three times today already”, and explain that if they answered their mobile phone, drew money from an ATM or used the internet they were using the results of many years of research in number theory. Along with the lack of understanding of the relationship between mathematics and the pure sciences, and in turn their relation with technology, many people, including some of our policy-makers, regard pure research as a luxury we can no longer afford, and in turn we face increasing pressure from our funding bodies, both in their allocation of funds, with its emphasis on things like ”e-science”, and in creating complex hurdles we have to jump to substantiate the ”impact” of our proposed research.

And what of the notion that the two cultures are speaking different languages? Not much has changed there, except for a tendency for scientific terms to be adopted by the English language, usually in a less than precise way. We are so used to hearing the phrase “exponential growth” from people who certainly don’t mean that (often they say this after only looking at two data points!), and quite probably have no idea what the concept means. We tire of having to explain the meaning of the words “theory” and “proof”. But there are more insidious abuses of mathematical and scientific language prevalent today, I refer of course to pseudo-science, or pseudo-mathematics, where nonsensical jargon is used to attempt to justify non-scientific conclusions, “new age science”, or other superstitions.

Coming much closer to home, one of Snow’s proposed remedies was a reform of the British education system, both at school and at University, to widen the curriculum substantially. Here too he would be disappointed, although unsurprised. As I already mentioned, early specialisation remains the norm. It could be worse. A few years ago, a leader of one of the UK’s major teaching unions proposed that compulsory mathematics instruction be dropped at the age of 14. Among the “pointless” subjects he thought no one needed to know was the theory of quadratic equations. Thankfully this particular proposal was not implemented, and it caused enough upset to generate a debate on the subject in the UK Parliament, which contained at least a couple of law-makers who were aware of the relevance of quadratic equations to Newton’s laws of motion, for a start. But the whole episode draws attention again to the lack of appreciation of the role of pure science in the scientific and technological developments in the last hundred years — although in this case, one should say the last 400.

So — these kind of attitudes are no good for science, and no good for society either. But what does this all have to do with my main subject, which is the education of mathematicians? Perhaps one reason why Snow was not so successful in his day, and why this cultural division still exists, is that scientists have something of an image problem. If they do, then mathematicians have a particularly bad one. Where do young people learn what mathematicians are like? In my country, certainly not from their teachers — very few maths graduates go into school teaching — they can secure far better jobs elsewhere. So from the media — TV and cinema, mostly. And the typical movie mathematician is not exactly your normal person. He is almost invariably socially dysfunctional and psychologically troubled. In biography, the stereotype is the portrayal of the late John Nash in Beautiful Mind. In fiction, take Matt Damon's brilliant but disturbed janitor in Good Will Hunting, or Anthony Hopkins's delusional professor in Proof — a particularly bad illustration, as not only does he suffer from mental illness, but his daughter, who is studying his work after his death, starts to succumb to it as well. So not only are great mathematicians mad, but too much maths will probably turn you mad if you weren't to start with. It's hard to imagine a worse advertisement for our profession.

We are fortunate to have a number of scientists, one or two of them mathematicians, who can and do appear in the media to engage the public and try to dispel popular misconceptions about members of our profession and their work. In the UK we have the young TV physicist and former pop musician Brian Cox, who has something of a rock-star image (and following). In maths there is my colleague in Cambridge, David Spiegelhalter, who is Professor of the Public Understanding of Risk, and has done much work to dispel public misconceptions about probability and risk, and debunk many of the superstitions which are too prevalent today,

There is only so much we can do in educating non-scientists in the sciences. The cultural change we need to bring about is the same that Snow identified — it is still the case that ignorance of the sciences is considered to be acceptable — and ignorance of mathematics even a badge of honour, ”proud not to be a nerd”. My hope is that eliminating this negative image will remove much of the imagined justification for this attitude. In training those who are going to be professional mathematicians, we need to do our best to produce leaders who not only can do research, but also can present basic concepts, with a human face, to non-scientists.

And what about the others, those who will go into other professions? Certainly the well-rounded individual aspect is important here, and they will gain valuable insights into the rest of their fellow humans as a result. But there will be a further benefit —

they will then be more widely accepted as role models in logical and critical thought, skills which we teach to all our students, but nowhere more so than in mathematics, perhaps the only discipline in which there can be absolute knowledge, but only through a logical proof which is correct in every step. For someone who is not going to be a professional, this is surely a key outcome of a mathematical education, and being able to pass these intellectual skills on to others is one of the greatest benefits of the study of mathematics — or another rigorous science.

This brings me to the third culture of my title. It is not the culture of science, nor of the arts — rather, it is the elephant in the room, the wilful ignorance of both science and the humanities which we see too often in the media, among our political and social leaders — it is the anti-culture of denial — be it denial of climate change, denial of AIDS, denial of basic human rights, denial of foundations of society which go back many centuries. Some of its proponents have the hallmarks of those intellectuals which C. P. Snow castigated so harshly. Among its followers may be found many people who have been through some of our most distinguished academic institutions, and so for them this is a culture of intellectual dishonesty. But many honest people are unwittingly brainwashed into joining this culture. Narrowing the divide between the two cultures, and disseminating as widely as possible the skills of critical and rational thinking, can play a large part in resisting this tendency, which has no place in our modern society. I hope that the broader education of mathematicians can play a modest but important role in this process.