CULTURE, COMMUNITY, AND CREATIVITY

Mark Saul

Abstract:

The support of gifted students is a cultural value. Certain cultures, at certain times, have found ways to offer such support and therefore to produce scientific and mathematical achievements. The chief instrument of such cultures is community: groups of people working in concert, both on scientific achievement and on the continuity of that achievement into the next generation.

Examples are given (1) of cultures that have been scientifically productive and (2) of specific practices, developed by communities in these cultures that might be replicated or adapted in Middle Eastern countries seeking to support their gifted students.

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Intellectual achievement is a function of culture. Our minds do not work in a vacuum: They are constantly interacting with the environment. And our cultural environment—other human minds—is among the greatest influences on who we are and what we think of.

This observation may seem self-evident when applied to what is most often termed “culture”: literature, the arts, customs, and institutions. It is less obvious when applied to the natural sciences or to mathematics, subjects in which objectivity is prized and in which ties to a particular culture might at first seem to be obstacles to clear thought. While the details of experimentation or reasoning must be cleansed of subjective, culture-bound intellectual prejudices, the process of creating these experiments or arguments, as well as the motivation and support for such efforts, are clearly matters susceptible to cultural influences.

We can be a bit more precise. It is by now commonplace in the philosophy of science to note that the classic Baconian scientific paradigms provide procedures to follow in order to answer certain questions, to refine and use observed data, and to forge more general theories from those data. But the scientific method does not tell us what questions to ask, what data to report, what phenomena to observe. It is our intuition—our creativity—that guides us here. So, what conditions lend themselves to the development of this intuition, this creativity?

The flowering of almost any human phenomenon is linked to the economic development of a society: A society struggling for subsistence simply cannot afford a class of scholars or researchers, any more than it can afford professional artists or dancers. But economic growth, although necessary, does not seem to be a sufficient condition for the development of the sciences (or the arts). Creativity has been historically linked to cultural as well as economic phenomena.

For example, the cultures of Pharaonic Egypt and imperial Rome excelled in construction and engineering. Neither culture produced just one edifice nor solved just a single engineering problem. Because these cultures valued large-scale public works, there emerged in each groups of individuals who kept contributing insight and innovation.

And it is this group, this community of individuals, that is the instrument of culture, the structure that produced these artifacts. The edifices that remain of the Egyptian and Roman empires, as well as their intellectual legacy, are testimony to the support of a community of engineers and the culture that created and sustained it.

Other examples of such scientifically creative cultures and the communities they sustained include the culture of the caliphates of the Middle Ages, of the Italian Renaissance and of the classical Maya and Inca civilizations of the New World. All commanded the resources for scientific creativity, but also developed cultures favorable to the growth of scientific communities.

An important counter-example to this observation is provided by considering the Spanish empire. Spain found itself in possession of a considerable part of North and South America, regions that yielded an uninterrupted supply of gold and other raw materials. For a century, Spain was the wealthiest country in Europe. But the wealth flowed out of the country as quickly as it flowed in. There was no educated middle class to hold the wealth, to build for the future. And when the flow of gold dried up, Spain returned to being a small and poor country.

The object lesson for the world is clear: Creativity and intellectual achievement require a cultural base to flourish. For the countries of today's Middle East, there is a second, more specific message: Mineral resources will eventually run out. Human resources, properly nurtured, will never run out.

A MODERN EXAMPLE: RUSSIA

The great empires of antiquity offer guidance in the general principles relating culture to creativity. To get more useful and specific guidance, we must look more closely at recent cultural phenomena. In particular, we examine here an instance of the flowering of creativity in eastern Europe.

Like other very large countries, Russia is in many ways unlike its neighbors—if it can be said to have neighbors. Separated by a large land mass from Western Europe, Effectively landlocked for most of its existence as a state, and isolated at several times in history from outside influences, Russia is a part of Europe, yet culturally distinct from it. Its modern industrial economy was forced into existence, built on a quasi-feudal agrarian society and a barely nascent capitalism. For large parts of the twentieth century, its scientific community was isolated by international politics and constrained by domestic policies.

The Bolshevik revolution of 1917 wrenched a country governed by a medieval autocracy and supported by an agrarian economy into the twentieth century. The ensuing decade was an era of hope and dreams. The evolution of new styles of art, literature, music, dance, and architecture, which had started in the last years of the tsars, received new impetus and took unexpected directions, often supported by the nascent Soviet state.

Then the totalitarian noose started tightening around the country’s intellectual life. A mass emigration of talent depleted the artistic community. Young people with active minds saw only danger in a career in the arts. Even the sciences found themselves constrained. Biologists and social scientists were quickly given limits to their research. Even the physical scientists, whose work might have immediate application both to industry and to war, found that their research efforts were controlled or challenged.

Mathematics, on the other hand, offered intellectual freedom. Mathematicians needed no laboratories, so the regime had no levers of control of their work. And the regime needed their work, both ideologically and practically. Ideologically, because Communism (“Scientific Socialism”) saw science and technology as building the future of humanity. (Indeed, despite ideological and political restrictions, science in general did well under the Soviets.) Practically, because the physical and natural sciences, which found direct industrial and military application, depended on the results of mathematicians for their more immediately fruitful results. So, in the planned economy, mathematics played the role of a heavy or extractive industry, supplying the intellectual base for further development.

For all these reasons, mathematics attracted fine minds. And because these minds had some unspoken, even subconscious, antitotalitarian agenda, the mathematical community began to assume the character of a subculture within Russian, or Soviet, society.

One of the characteristics of any such subculture is a need to “reproduce”—to find new and younger members. More than in most mathematical communities, researchers took an active interest in education. Kolmogorov and Dinkin founded actual high schools specializing in the study of mathematics. Gelfand set up a “school by correspondence,” reaching students in remote areas. It was common for graduate students, young faculty members, and even well-established researchers to return to their high schools or elementary schools and run “math circles”: clubs in which younger students played with mathematics.

Much of this activity occurred in the 1960s, with Khrushchev’s “thaw” and de-Stalinization. Many cultural historians have noted that scientific and artistic creativity is not directly tied to political freedom. Indeed, some of the world’s greatest art and science was produced under strongly authoritarian political regimes (Elizabethan England, Russia under the Romanovs of the mid-1800s, the various principalities of the Italian Renaissance). Often, a slight release of political pressure is the occasion for an outpouring of creativity, and perhaps this is the reason for the peak in mathematical activity in Khruschev’s Russia.

A MODERN EXAMPLE: HUNGARY

The Russian scientific community developed in a harsh political environment in an enormous country with great human and economic resources The Hungarian community, in contrast, was subject to a variety of political surroundings (constitutional monarchy, liberal democracy, fascism, communism), in a small country struggling for its identity and economic security. Tibor Frank[1] notes the following characteristics of the Hungarian sociocultural environment:

1. Hungary was surrounded by alien and often more powerful countries. Some of the inventive qualities of Hungarian culture were a response to the need for national survival. Some of this inventiveness overflowed into the Hungarian intellectual world, supplanting a more traditional and conservative emphasis on conformity and rote learning.

2. High school teachers were often well equipped to recognize gifted young people, nurture their talents, and find them mentors when they outgrew the limits of high school education. The teaching profession developed this capacity largely because of the elitist nature of Hungarian (and, indeed, Central European) education: Because universities employed only the highest level of research talent, there were many individuals with strong scientific and mathematical backgrounds who found employment in the high schools.

3. The decline of feudalism and feudal privilege led to the inclusion of gifted individuals from non-Hungarian ethnic minorities in the economy and in the scientific workforce. Jewish scientists in particular found places in both these spheres of society that had been denied them earlier—sometimes at the price of assimilation, or “Magyarization.”

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[1] Tibor Frank, “The Social Construction of Hungarian Genius.”
http://www.princeton.edu/piirs/von_neumann_event/docs/Tibor_Frank_vonNeumann_paper_final.pdf
Accessed 29 November 2010

4. The growing economy of the Austro-Hungarian Monarchy required technological advances, so tolerated experimentation and liberalization of thought in these areas. Conservative control was more often exercised over the humanities and the arts in the same milieu.

5. The development of Budapest as a capital city gave the country a center of culture and industry. By the beginning of the twentieth century, that city was a center of learning whose culture spread to other areas of the country as well.

6. The urban culture of Budapest, in concert with other influences, led to the development of a cultural premium on the idea of competition for knowledge. The journal *KöMaL*, for high school students, developed into a force bonding gifted students of mathematics and physics which grew, over the decades, into a community of scholars. The journal and various other competitions led to the discovery of talent in these disciplines and, later, to a celebration of gifted students that provided a different kind of prestige than occupational status alone might confer. Too, the emergence of a cultural emphasis on modernism paved the way to an increasing internationalization, mainly in the best schools of *fin-de-siècle* Budapest that prized experimentation, inductive reasoning, pattern-breaking innovation, less formal relations between teacher and student, and personalized education.

7. The influence of the German school system and of German art, music, and science directly benefited Hungary and had a major impact on teaching, learning, and research. Many of the results were later exported once again by eminent exiles—from Hungary back to Germany and then from Germany to the United States.

8. The period from 1918 to 1920 marked the end of the Austro-Hungarian Monarchy and historical Hungary within it. This event was marked by a large exodus of minds, who were compelled by political circumstances to leave the country. Nonetheless, some of the great traditions of education—particularly, science and mathematics education—have survived until today.

OTHER MODERN EXAMPLES

The flowering of scientific and mathematical talent in Eastern Europe was not limited to the two countries discussed above. Romania, Bulgaria, and Poland all supported active and productive mathematical and scientific communities throughout the twentieth century.[2] Those countries regularly exported creative individuals during those years, yet their pool of talent was large enough to continue to foster gifted younger people in these areas. An example of a region in which talent is just emerging is Latin America. Peru is an example.[3] With a population of 25 million, Peru has included about 3 million school students—at various levels—in its national mathematical Olympiad. The Olympiad is supported by the Ministry of Education, and reaches virtually all the schools in the country. Mathematically gifted students, no matter where in the country they live, are likely to be discovered through one of the Olympiad events. In 2009, a 12-year-old student, discovered just this way, won a bronze medal at the International Mathematical Olympiad (IMO).

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[2] See Mark Saul. "Mathematics in a Small Place: Notes on the Mathematics of Romania and Bulgaria." in *Notices of the American Mathematical Society,* May 2003, pp.561-565.

[3] Saul, Mark. "More than a System: What We Can Learn from the International Mathematical Olympiad."*Notices of the American Mathematical Society* in press.

Latin America is rapidly developing a regional system of talent development. The countries are united by a single language, and have many elements of history and culture in common. Virtually all the countries in the region send teams to the IMO. Leaders from these countries work together, helping those from countries participating for the first time to learn how to work with talented students. In 1985, UNESCO helped to initiate the Ibero-American competition, which continues to this day. In 1997, The IMO in Argentina, brought together question graders from all over Latin America, who learned from each other about the mathematics and logistics of the Olympiad. Countries fielding teams often organize common training sessions.

A group of Latin American mathematicians have isolated an important problem to be solved in working with gifted students. Particularly when they come from smaller countries, these students don't see themselves as potential winners in the IMO. They've triumphed in their national contests, but when they meet students from larger countries, or from countries with older and deeper mathematical and scientific traditions, they are intimidated. They tend to lose confidence, and frequently don't do their best on in the competition. This question issue remains largely unaddressed.

WHAT IS TO BE DONE?

The vignettes given above provide more than intellectual contemplation of the phenomenon of scientific creativity. They suggest some courses of action. Here we can list some specific practices and institutions that have been developed by communities in various countries that have supported the development of scientific talent.

1. *Competitions.* : These have been attractive to young people and most successful in both discovering and nurturing talent. In mathematics, for example, competitions have a history stretching back to ancient times, and sometimes resulting in significant contributions to the field. Archimedes' Cattle Problem, whether or not it was meant as serious mathematics, was supposedly sent by Archimedes as a challenge to Eratosthenes and the mathematicians of Alexandria. The algebraists of the Italian Renaissance competed with each other in the solution of higher- degree algebraic equations, with results that have become classic. One of the earliest appearances of the result we now call Stokes' Theorem was on the Tripos competition at Cambridge, in Victorian times. And even today, the Clay Institute prizes can be seen as part of a sort of large-scale competition in the solution of mathematical problems.

Competitions for young people can expose natural talent. But they can also develop this that talent. Preparation for competitions can motivate students to learn about their subject, and good coaching can channel this motivation into a study of material which has implications further than that go beyond those of a competition question.

Competition also has a darker side. If the winning of the competition itself, becomes the goal, rather than a prize for achieving the goal of understanding, becomes the goal, then the powerful force of motivation gets misused. Students will concentrate narrowly on the subjects that the questions posed in the competition are likely to be about on the contest questions, and will drill on specific techniques for success in particular forms of competition.

Not only does this situation skew and constrict the kind of learning stimulated by the competition, but it also gives students a distorted view of working as a scientist. The work of doing science is very different from the “work” of solving a contest problem. The rewards of a scientific career are less immediate, but richer and deeper, than the rewards of success in a competition.

Finally, there are students who might make excellent researchers, but whose temperament is not suited to competitive situations.

For all these reasons, competitions must be shaped to hone their positive features and minimize their negative features. One way to shape them is to see competitions as part of a larger picture, including other elements of support discussed here. Competitions in other areas can also be found on online. Lists of mathematics competitions can be found at:
http://www.mathpropress.com/competitions.html
and
http://en.wikipedia.org/wiki/List_of_mathematics_competitions

2. *Study circles.* : These originated in Eastern Europe, and particularly in the Russian (Soviet) mathematical community. In that country the Soviet Union, it was common for graduate students, young faculty members, and even well-established researchers to return to their high schools or elementary schools and run “math circles”: —clubs where in which younger students played with mathematics.

Math circles can be run by any mathematically sophisticated individual, with any motivated students as participants. The central characteristics are that the students are not being graded and that the material covered has a recreational or 'fun' element to it. There are some math circles which are built around preparation for a particular contest or contests. There are others whose provide activities that mainly involve mainly mathematical games or puzzles. Still others are for teachers, or for older students who will eventually work with younger ones. Any situation in which people are exploring mathematics for its own sake, —for the sake of their own enjoyment of the subject, —may be termed a math circle.

There are also physics circles, biology circles, linguistics circles, and so on. An interesting concept is has been introduced by computer science aficionados, who have sometimes started a 'virtual' circle, in which communication is largely electronic. Many organizers of circles have found that the best sort of “e-circle” includes also an element of face-to-face human contact. For examples of mathematical circles in the United States (one particular country and one particular subject area), see http://www.mathcircles.org/

3. *Journals for pre-precollege students.* : Virtually every Eastern European country had a journal in mathematics and physics for high school students. The oldest (over 100 years old) is *KöMaL*, the Hungarian journal mentioned above. This journal is problem- oriented, and can be viewed as a long, slow, and intensive competition in solving the problems posed. Solutions are printed months after the problems are set, together with contact information and even pictures of those who solved them.

In a small country such as Hungary, this journal was a significant force in the forging of a mathematics and physics community. Researchers met colleagues early in life and kept up with them as their professional lives unfolded.

The Russian journal *Kvant*, started by Kolmagorov Kolmogorov in 1960, exerted a similar influence in that huge country. *Kvant* had a slightly different flavor, with rather long articles written by researchers on topics close to their own research. Problems provided within the article, based on the article’s material, provided an interactive element for readers. There were also problem sections, as well as sections including problems and activities for younger (elementary school) students.

Numerous other journals existed in Eastern Europe before 1989. Many of these have disappeared under the stress of free markets. For ten 10 years, the American U.S. journal *Quantum*, published by the National Science Teachers’ Association, was a counterpart to *Kvant*. It faced two problems. First, there was no tradition among American U.S. mathematicians and physicists of informal exposition for pre-precollege students, so the source of material was always largely translations from the Russian. Second, the journal was not never able to achieve financial independence; it stopped publishing after ten 10 years.

Journals are typically difficult to find on online. Not all journals have a presence on the World Wide Web. Some places to look for student journals include the following:

http://mathforum.org/library/resource_types/magazines/
http://www.dmoz.org/Science/Math/Education/Magazines/

4. *Summer programs.* : The circumstance of a long summer vacation for students has occasioned the growth of numerous summer programs for in mathematics and the sciences. These programs are typically run in on a university campus, but sometimes in a recreational summer camp facility. They are very intensive for students and faculty, as they gathering the most motivated of both to a central location for a short period of concentrated work. Often, student participation becomes a central experience in their students' lives, and alumni organizations have grown up around the programs, supporting them and also magnifying their effect on the community.

In some countries, weekend or winter vacation programs offer shorter examples of programs with the same intensity. Two remarkable programs, one in the US and another in Russia the Dubna Summer Program, near Moscow, Russia, and the Park City Mathematics Institute in Utah, in the United States, include the entire range of people in the mathematical community, from elementary school teachers to the most serious researchers of cutting-edge mathematics. These programs are the Dubna Summer Program, near Moscow, and the Park City Mathematics Institute in Utah (USA). The following websites list student programs in the United States:

http://www.artofproblemsolving.com/Wiki/index.php/Mathematics_summer_program
http://www.ams.org/programs/students/high-school/emp-mathcamps
http://www.studentsreview.com/summer_prog.shtml

5. *Internship programs.* : These are programs, held either during the summer or during the year, which afford entry for younger students into the working life of researchers in science or and mathematics. Internship experiences take various forms. On the simplest level, students 'shadow' (i.e., observe) scientists in their daily work. Some internship experiences are more hands-on, and allow students to help out in laboratories with day-to-day chores in laboratories.

On the highest level, internships involve an experience similar to that of a graduate student with a mentor. The student has a specific project on which she or he works on independently, with guidance (often minimal) guidance from the mentor–researcher or an associate. A very effective practice is to have the student write a short research paper, or give a presentation, about the results achieved.

This last practice feeds into those competitions in which participants write and defend research papers, such as the Intel Science Talent Search (in the United States), the Shing-Tung Yau High School Mathematics Awards (in China), or and the International Science and Engineering Fair (international). For internship programs in the United States, consult http://www.ceinternships.com/

6. *Websites.* : This resource is just starting to expand worldwide. Websites offer resources, online tutorials, indexes to other websites, and bibliographies. The following websites for the development of student talent is are just a sample of this rapidly- developing resource.
http://www.sldirectory.com/teachf/scied.html
http://www.artofproblemsolving.com/
http://nrich.maths.org/public/

IN CONCLUSION

The countries of the Middle East have a long history of scientific achievement, one that might be drawn on in building a modern talent development system. But countries of the region might well look towards the models of Latin America and Eastern Europe.

However, cultural borrowing is not like borrowing a book from the library. It is rarely possible to take a successful practice from one context and transplant it directly into another context. Usually, the practice changes. Sometimes particular elements are filtered out, leaving others that endure and serve the host culture well. Sometimes the whole concept gets transmuted, so that it looks completely different in the new environment, yet serves the same purpose as its model in another environment. And sometimes a cultural borrowing simply fails.

The central concept that endures, whatever else does not, is that of community. A fine mind will always look for opportunities to grow and learn. Where these opportunities are to be found depends on culture. An environment which that offers exposure to science and learning will attract good students to these fields. Some of them will become great students, and, eventually, productive scientists. But without this basic support, students with good minds will wander off into other fields for which their culture offers support and rewards.

In turn, basic exposure to science and learning is itself a cultural value. Unless people value science, they will not see the need to offer it to their brightest students. It is important that a culture see itself as a producer of scientific minds, in order to ‘“own”’ the field of science as one of those in which their students can excel.

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