What Went Wrong with the Computer Revolution: Thoughts about Education?

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Gene:

Frank Starmer, an engineer, a biostatistician, and computer scientist, and I, a physician interested in biology, pathologic physiology of disease states, and the growth and development of young people, have exchanged ideas for the last forty years. Each of us believed that computers would eventually free us from geographical constraints. In time, the wisdom of the ages would be available wherever there were telephone lines or satellite accesses. Universities could have been replaced by small central campuses, thus greatly reducing faculty.

In a world of rapid change, the old paradigm of many years of schooling before engaging in useful work would disappear. Theory and practice would merge. By the age of 18 every young person would have skill sufficient to hold a job paying a living wage. Students would no longer be passive vessels to be filled by lecturing professor. The young people would be learners and the older hands facilitators of learning.

The purpose of this discourse is to examine what went wrong. Why did our dreams not become a reality?

A professor working in the clinical areas of a medical school has the opportunity to approach the young students, whom I call learners, in a non-traditional way: A patient comes in believing we can create a better fit between his body and his environment. Our first job is to find out what is troubling him. The patient tells his story, and the group of learners determine what he needs from us. Though I am the senior learner, I start from the same point as my younger colleagues. They have the advantage of having met the patient 8 to 24 hours earlier than I. I have the advantage of years of experience in solving patients' problems. Given the lead time, the learners will have the information about the problem present in standard text books. My job is to examine with my team the accuracy of the text book material to see if the statements there in are supported by firm evidence. Our next step is to go to the library and other colleagues in various disciplines to search the new information produced between the time the text book was written and the present. The learners and I meet again at an appointed time to discuss the new bits of knowledge and as a group, weave them into our solution of our patients' problem. At this time we explore what is not known about the problems and ask questions that can only be answered by further research. The problem is now approached by finding what is relevant but unexplored. Again each member of the team is assigned an area of inquiry, and during a final meeting, the possible areas of productive research are revised. The process is judged to be successful if we effectively care for the patients and if the members of the group continue to learn when I am not present.

In summary, I learn when I work, and they learn when they work. There is little overlap in learned appropriate criticism. Learned poise facilitates the process and makes the young folks think I'm wonderful; however, I know that they are the ones who are wonderful.

You will note that I use written material present in the library. The library is my tool to problem solving. I knew that our dream of computer assisted learning would not be realized until a new generation of senior faculty born and bred with computers were in charge of my learners. Frank Starmer will now be our mentor and show how problem solving can be facilitated by people of his generation.

Frank:

I literally grew up with computers. In 1959, as a high school graduate, I was fortunate to land a summer job with Blue Bell in Greensboro, at that time one of the major players in the manufacture of the world's work clothes. They had an IBM 650 with a 2000 word drum memory, 80 bytes of tape buffer that could be used for memory and a Ramac Disk. During the week, I was required to resolve errors that were detected by the Plant Production Planning software - and quickly learned more about the internal structure of Blue Bell than most other folks. I quickly realized that the computer was a tool for learning. What better way to understand a business than to resolve errors spit out by the computer. I could have studied organizational charts for the entire summer and never come close to understanding the organization. On the otherhand, the computer errors identified important business activities that needed a little care. If this were not so, no one would be resolving the errors.

The weekends at Blue Bell were a different story. With only a few other operators in the computer room, I was free to use this machine after all the week's work was done. I played 3D tic-tac-toe. I beat the machine a few times, but usually I lost. I learned to program. I learned that sequential allocation of program instructions on the drum was inefficient. I learned that if I understood how long it took the 650 to execute an instruction and located the *next* instruction at the place where the drum had rotated during that time, then there would be no rotational delay waiting for the next instruction. I could increase the speed of a program 10x by such optimization. I could even outperform SOAP (Symbolic Optimization Assembly Program), the IBM product. This was my first introduction to problem-based learning.

I entered Duke as an undergraduate and by my 3rd year, had managed to become a helper in the Math department computer lab. I had the good fortune to take a neurophysiology course from John Moore and Paul Horowitz. (The excitement of this class was amplified by all the Duke faculty and grad students/post docs that Dan Tosteson brought to Physiology - Ted Johnson, Clay Armstrong, Toshio Narahoshi, and many others). When we hit the Hodgkin Huxley model, I immediately wrote a program to explore its behavior. It was my way of learning. I became infamous within the engineering school, accused by one faculty member of being unable to think without a computer. Little did he know that the computer had become a thinking amplifier and learning assistant. I was sort of guilty as charged. I was addicted to the imagery that I could create with numerical experiments on the Duke computer. I consistently failed to compete effectively with my classmates when memorization was involved. I uniformly outperformed my classmates when thinking was involved - because I had the computer as my secret weapon.

At the same time, I was working part time in the hospital in the cath lab. Gene and Henry MacIntosh (and later, Joe Greenfield) provided a critical lesson somewhere along the way - that it was ok to be curious. You see, I grew up in a very conservative family where it was felt that it was better to be quiet and be thought a fool than to open your mouth and remove all doubt. During medical grand rounds and the Friday afternoon Cath Conference, I watched Maddy Spach, Joe, Henry, Ed Orgain, Paul Cap and others, simply state that they did not understand something. I quietly watched these bright folks admit their ignorance. What a refreshing escape from keeping one's mouth shut. (Its unfortunate that this same recognition of the asset of ignorance and its resolution, i.e. being aware of what you dont know, only rarely appeared in my classes on the Duke campus.)

Gene, Henry and Joe continued to open doors for me. We developed programs in Cardiology at Duke that used the computer to extending our thinking and replace our memory. The Cardiology Databank that I built and Galen Wagner and Bob Rosati fed, was our first example of computer-based memory. Gene and asked us how we knew whether anything we did clincally made a difference. The reality was that we did not. So Galen and Bob started a telephone followup of discharged CCU patients. Soon we knew that if our CCU patient was uncomplicated, they were all alive 6 months later. Gene wanted to know why we kept them in the hospital for 3 weeks. There was no answer - so Fred McNeer built a clinical trial of early discharge. It was our first contributuion to evidence based medicine.

When Duke formed the computer scence department, I joined up and started teaching undergraduate and graduate students. I used my problem based approach - using projects as a measure of student performance instead of examinations. I am proud to say, I never constructed or gave a written exam to any student. With a 15 minute conversation, I knew more than any exam would tell me.

When Unix became available, I applied to Bell Labs for a license and received it in 1974. I used Unix to excite our students in computer science. Tom Truscott and Jim Ellis, two of our energetic students, decided to share class and seminar information with Steve Belovin at UNC. We used our Dec PDP 11/70 with UNIX to transfer the information. Other schools joined up and USENET was started. The rest is history.

The early experience with USENET and email during the late 70s and early 80s, convinced me that my computer memory could be amplified by accessing resources available within the USENET news groups. I was excited by the learning that was available through the news groups and quickly realized that I had experienced the transition from a library or print-centric university to a network-centric (and now Internet-centric) unversity.

I was continuing to learn from students just as I learned from medical house staff - and found that the problem-driven learning paradigm of the world of medicine could be easily transferred to computer science. Xiaobai Sun and I tried this idea with her Numerical Methods course. We identified a single problem (an excitable cell) and built the learning around solving the equations of this cell (30 years earlier, this was the work of John Moore’s class). Class size moved from 4 students to 30 students to 40 (the max) within several semesters. The math department was frustrated because they were losing students to Xiaobai’s problem-driven class.

Xiaobai and I taught a clase in Biological Communication in the mid 90s, just when Mosaic, the University of Illinois web browser, appeared. We knew nothing of this new technology so we assigned each student to make a web page of the week’s main ideas. If, after a month, we derived no value from the exercise, we would stop the activity. The first student made a nice page. The 2nd student added links to other sites. The 3rd student added animation. I was hooked - we now were in the era of internet-centric learning and could bring the best material around the world to our small learning space. We could focus on thinking and building new ideas instead of memorizing and remembering.

Google, now has taken us to the next level and made the internet-memory available to the non-specialist. The replacement of my biological memory with the Internet memory has not been easy. Unlearing old habits seems harder than learning new habits. It has taken me several years to exchange my habit of asking a question to a colleague or friend for asking the question to Google. My young learners at MUSC, the IT Lab, taught me this new skill. Now I am finding that asking the question via the image option of Google is often more useful then a text search.

Said another way, Google and the Internet resources that it indexes are now part of my *memory*. Having studied use-dependent sodium channel blockade in the laboratory with Gus Grant for 20 years, I fully understand the role of repetition in both learning and forgetting. However when I ask my colleagues about the forgetting curve they are certain that I have lost it. I smile becaue I know that they have lost it. What did they lose? They lost all the information memorized and learned during their university days that was never recalled - thereby refreshing the remembering of that material. With Google and the Internet as my Internet-memory, I have stopped trying to remember things rarely used, but rather, simply key in an appropriate group of words and ask Google to search for me.

So if Gene and I get it - why has our educational establishment been so slow in adapting to an Internet-centric problem-driven learning paradigm? This paradigm is characterized by problem based learning within a framework of scaffolding (core concepts) and the Internet memory. Global connectivity and commodity computing provides us with a new tool permitting us to re-target remembering energy to thinking. There are several excuses for the slow progress toward this new paradigm but no real reasons.

The resistance, we believe, is a composition of cultural obstacles:

- First, what is education? My conviction is that it is not simply presenting ideas and insights to junior learners. Rather, it is actually conveying to junior learners the ideas and insights I have developed over the years of my lab and classroom adventures. Education is also helping a student or junior learner to recognize what they do not know and then to chase their curiosity until they understand something. Many of my colleagues are busy altering the presentation of their material so that its accessible via the Internet. They do not like change, they do not like eduction. They seem only to like professing. Only a few of my colleagues are asking the question: what does global connectivity bring to the table that enables me to better convey my insights, understandings, and ideas to my junior learners? Said another way, what does this technology enable me to do that I can not do without it?
- Our brains are engaged in learning, remembering, doing or thinking. The Internet provides the opportunity to amplify my biological memory with an Internet memory. By using my Internet-memory to recall infrequently used facts, I can, for the first time, redirect my available mental energy away from recalling things I cannot remember and direct it to more productive things: thinking, doing, or learning. To depend on Internet memory requires unlearning old habits. Unlearning is often more difficult than learning - and many folks become discouraged because they do not acutely feel the freedom associated with a dependence on an Internet memory.
- All to many people lack the courage to expose their ignorance with the goal of reducing it. Somewhere in our educational system we were taught that its better to be silent and thought a fool than to open one’s mouth and remove all doubt.
- There are two classes of learners: memorizers and understanders. Today’s educational evaluations are dominated by tests that reflect one’s ability to remember, not one’s ability to think and synthesize. As long as we reward memory, it will be difficult to encourage learners to shift from their personal memories to the Internet memory.
- Most core concepts are not taught from a basis of main ideas or scaffolding - but rather from all the atomic information units required to build a structure. People like us, perform poorly without scaffolding that forms a frame of reference upon which we can hang these atomic units.

We are optimistic about the future of education - but pessimistic about the pace of the transition from content-mastery to problem-based learning. President Kennedy demonstrated that when dealing with inorganic building materials, we could walk on the moon by the end of the 1960s - a short 9 year project.

President Johnson demonstrated the complexity of problem solving when dealing with biological building materials (people). Consequently, after 40 years, the social goals of the "Great Society" remain largely unmet today. We’ve been struggling with these cultural obstacles. Perhaps global connectivity will remove these barriers and accelerate the rate of social progress. We hope so.

Back to my thoughts