Brainstorming About an Early 21st Century Technology Curriculum

by Kirby Urner
4D Studios
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My motivation in pulling these thoughts together is an upcoming summit meeting in London, put together by the Shuttleworth Foundation, aimed at providing a self-propagating, technology-savvy curriculum for South Africa.

Just as I sat down to write this, my wife phoned me to suggest I listen to the radio, which had a story about $100 laptops aimed at the developing world, rural areas especially. MIT's Negroponte was interviewed. The laptops implement peer-to-peer wireless and have a hand crank for charging a battery. The moral of the story: it's realistic to assume some access to high tech even in rural villages e.g. in Cambodia, where a pilot implementation of a laptop-based curriculum has already occurred.

Today's computer is a communications device and language learning tool. The screen provides a small window into a big world of information, both relevant and irrelevant. To keep a focus, successful curricula usually start with an environment already familiar to the student and build outward. If the student is in a village, ideas about village life should be built in to the lessons. If the student is in a city, more city concepts will be appropriate.

This isn't to say a village-based student can't or shouldn't study a city-based student's material or vice-versa. Rather, students should find, within their curriculum, some familiarity and awareness regarding the lives and circumstances of the students themselves. I call this the "mirroring function" and regard it as the responsibility of curriculum designers to build it in, having done some homework regarding the target audience or demographic.

A good curriculum reflects back an image of the student that's not too distorted, such that recognition and identification is possible. The experience is akin to finding a character in a story you're able to identify and grow with. If this kind of bonding is achieved, the student's level of "brand loyalty" to the curriculum will increase, resulting in a stronger performance and more satisfying results, both for the student and for the curriculum's designers, who do indeed wish for some kind of bond with their students, most of whom they will likely never get to meet in person.

Furthermore, what all students share is a planetary context. Various micro and macro concepts will be relevant to everyone, e.g. atoms, molecules, cells, microbes, a tree of life, humanity, infrastructure, agriculture, geology, ecosystems, solar systems, the galactic context (the Milky Way or some other indigenous label).

One goal of a curriculum is to help students develop an internal model that relates their medium-scale situation (e.g. the village, neighborhood, campus) to more macro and micro contexts.

A unifying concept across all scales, from micro to macro, is *energy*. In a first person context (i.e. in the immediate experience of the student), we burn energy within a metabolic process, converting joules or calories, through oxidation, into energy for work plus byproducts (human waste, carbon dioxide).

Given modern food labeling has joules (kilo-joules) or calories on an ingredients panel, we're in a position to tie personal eating habits to a larger energy economy.

If the local foods aren't packaged in this way, tabular data might be supplied from within the curriculum. How many joules in a pomegranate?

Of course one goal will be to get more specific about the components of this energy: proteins & amino acids vs. sugars vs. fats and so on.

The solar system is immediately relevant because most of our energy is coming from the local star. A planetary thermostat, relating to carbon dioxide levels in the atmosphere, keeps the temperature in a narrow range conducive to animal life (plate tectonics also relevant).

I would therefore propose that simulations involving various energy transformations be a central theme in this 21st century curriculum. Students will be trained to spontaneously analyze a system into its energy sources and requirements, next to an analysis of the kinds of work it performs (what does it do?).

The hydroelectric plant uses the gravitational energy of a dammed body of water to spin a turbine, generating usable kilowatt-hours (energy). A monkey eats a banana, a snake eats a monkey.

What does a function eat? What work does it then do?

In the computer world, we have the rather ubiquitous notion of a function that "eats" arguments and returns results. I sometimes refer to the oft-used parenthetical notation -- as in eater(arg, arg) -- as defining "a mouth."

An algorithm is something metabolic, in that it consumes real clock cycles, burns real calories, in working to a result. So a computer is likewise an ecosystem with energy inputs. We design it to model real world problems, so that we may play "what if" games, explore possibilities. This is a lot more feasible than actually trying everything for real.

The computer helps us eliminate unlikely-to-work strategies, helps give us a handle on the real problems facing us. These real problems generally have to do with providing life support of some kind, i.e. getting some real work done.

Also in the computer world, we've come up with the object oriented paradigm (OOP), a way of analyzing a problem in terms of objects that pass messages to one another, i.e. are in communication in some way. Furthermore, we learn to distinguish between a blueprint, template or class, and the actual "instances" of a class, i.e. the actual objects. This distinction helps drive the generalization or abstraction process: in working back to a model of the generic village or generic small store, what are the commonalities and what are the specifics?

The deep alchemy is to learn how to derive usable generics from specifics i.e. to come up with useful generalizations that are neither too idiosyncratic nor too far removed to be worthwhile.

Within OOP, a student learns a kind of empathy, i.e. how to project oneself into an object or system and ask "what are my internal states and what are my behaviors?" One may ask this as an inanimate object. I am an atom, cell, microbe. I am a planet, a star. What are my states, my properties, what are my methods or behaviors? How do I use energy? What do I feed on, what do I do?

In sum, I'm inclined to think a curriculum should mirror a student's first person circumstances in some reasonably proficient way, and immediately begin stimulating a problem-solving frame of mind, building towards an OO-informed way of doing the analysis, always keeping energy in the picture as a unifying concept.

Secondly, I'm thinking a major goal is to increasingly locate this personal frame of reference within a larger one that expands in the micro and macro directions, to encompass information about the very small and the very large – models of which nevertheless remain relevant to circumstances close at hand.

From this broad brush stroke beginning, I think the challenge is to define and refine the mathematical and analytic tools that will maximize the student's problem-solving abilities. One approach is to work backwards from the kinds of technical literature we expect a student to tackle with some confidence in adulthood.

The goal is not to reinvent the wheel and expect students to rediscover everything. We will build in the assumption that a big part of any job is assembling already discovered information, even if only to learn what still needs to be discovered.

Finally, I don't want to leave out the entertainment or "escapist" dimension. I am firmly of the view that our thought process is designed to work in a mythical mode, as well as in a more rational mode, and that solutions to difficult technical problems often come "from outside" as it were, thanks to a parallel pipeline we keep going.

To this end, I think computers are also theaters, stages on which to play out various stories, with puppets or animated characters. These puppets or characters then become available within more "real world" simulations we want to build and study, with an eye towards improving our own lives.

So our ability to fantasize, to dream up stories, has direct application in such adult activities as engineering. Disney's approach is a good example.

So I would like to see a curriculum which enables children to participate in the cultural storytelling of their environment, which means working *with* local memes, not invading with an eye to obliterating local traditions.

Native Americans love their coyote stories, and a computer-intensive curriculum should amplify their ability to transmit this lore to coming generations, not inhibit or dampen it. This isn't to say a Native American can't appreciate *Star Wars* or *Buffy the Vampire Slayer*. We should share our mythologies, but in a way that doesn't destructively lead to monoculture.

In other words, I want computers to come across as friendly to local storytelling, and for programming to be a way to delve into the art world, possibly in close alignment with inherited traditions. Computers should *extend* whatever culture they're in, *not* work to "wipe the slate clean" as if all that earlier culture didn't matter, didn't encode valuable life supportive information.

In pushing this approach, I'm also acknowledging the trend whereby computers and TV are becoming the same device. In the next iteration, computers become the device for making (authoring) audio and video tracks, not just passively listening to and watching them. Of course some of us are doing such authoring even now, as members of some privileged minority.

I envision training in multi-track editing becoming a standard part of young adulthood for many more students, as the technology picture continues to improve (skills one may then continue developing over a life-time).

For Further Reading:

Kirby Urner, *Trends in Early Mathematics Learning: Looking Beyond Y2K (first published 1999, latest version):*
http://www.4dsolutions.net/ocn/trends2000.html

Kirby Urner, *Pythonic Mathematics (June 2005):*
http://www.4dsolutions.net/presentations/urner_europython4.pdf

PDF slides used during the presentation in Gothenburg, Sweden, 2005:
http://www.4dsolutions.net/presentations/pythonicmath.pdf

Kirby Urner, *Another Alien Curriculum (2003)*
http://www.4dsolutions.net/ocn/alien.html