Powerful Ideas Need Love Too!

Alan Kay
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Let me start the conversation by showing a video made by the National Science Foundation at a recent Harvard commencement, in which they asked some of the graduating seniors and their professors a few simple questions about what causes the seasons and the phases of the moon. All were confident about their answers, but roughly 95% gave explanations that were not even close to what science has discovered. Their main theories were that the seasons are caused by the Earth being closer to the sun in summer, and that the phases of the moon are caused by the Earth's shadow. Some of the graduates had taken quite a bit of science in high school and at Harvard. NSF used this to open a discussion about why science isn't learned well even after years of schooling. And not learned well even by most of the successful students, with high SATs, at the best universities, with complete access to computers, networks, and information.

My reaction was a little different. I kept waiting for the "other questions" that NSF should have asked, but they never did. I got my chance a few weeks later after giving a talk at UCLA. I asked some of the seniors, first year graduate students, and a few professors the same questions about the seasons and the phases of the moon and got very similar results: about 95% gave bogus explanations along the same lines as the Harvard students and professors. But now I got to ask the next questions.

To those that didn't understand the seasons, I asked if they knew what season it was in South America and Australia when it is summer in North America. They all knew it was winter. To those that didn't understand the phases of the moon, I asked if they had ever seen the moon and the sun in the sky at the same time. They all had. Slowly, and only in a few, I watched them struggle to realize that having opposite seasons in the different hemispheres could not possibly be compatible with their "closer to the sun for summer" theory, and that the sun and the moon in the sky together could not possibly be compatible with their "Earth blocks the suns rays" theory of the phases.

To me NSF quite missed the point. They thought they were turning up a "science problem," but there are thousands of science "facts" and no scientist knows them all; we should be grateful that the Harvard and UCLA students didn't "know the answers." What actually turned up is a kind of "math problem," a thinking and learning problem that is far more serious.

Why more serious? Because the UCLA students and professors (and their Harvard counterparts) knew something that contradicted the very theories they were trying to articulate and not one of them could get to that contradictory knowledge to say, "Hey, wait a minute..."! In some form, they "knew" about the opposite seasons and that they had seen the sun and the moon in the sky at the same time, but they did not "know" in any operational sense of being able to pull it out of their memories when thinking about related topics. Their "knowings" were isolated instead of set up to be colliding steadily with new ideas as they were formed and considered.

What was going on with them–and what similarly goes on with children every day in school? To understand this, we have to find out how we humans are "naturally" set up to think and learn.

We can get a clue from the Bible. King Solomon was held to be the wisest man who ever lived and it says why: he knew more than 3000 proverbs! And proverbs work as follows: if you come home from a trip and your family is glad to see you, then "Absence made their hearts grow fonder." But if you come home from a trip and they aren't particularly glad to see you then the reason

is...what? That's right, "Out of sight, out of mind." Each proverb exists to give meaning to a particular situation, and each is recalled on a case to case basis. If the proverb you use today (or the play or movie you see today) contradicts the one from last week, it is of no moment because proverbs and stories are evaluated mainly on how good they are right now, not how they compare to the other proverbs and stories in the pool.

This way of thinking and giving meaning to one's life and society in terms of stories and narratives is universal over all cultures, and is in our basic "wiring" as human beings. It is part of what we call "common sense." And it is the way most of the college students that NSF and I talked to had "learned science"–as isolated cases, stories that would be retrieved to deal with a similar situation, not as a system of inter related arguments about what we think we know and how well we think we know it. Story thinking won out. Claude Levi-Strauss and Seymour Papert have called this incremental isolated "natural" learning "bricolage"–which means making something by "tinkering around." This is one of the reasons that engineering predates science by thousands of years; some constructions can be accomplished gradually by trial and error without needing any grand explanations for why things work.

Yet if we look back over the last 400 years to ponder what ideas have caused the greatest changes in human society and have ushered in our modern era of democracy, science, technology and health care, it should be a bit of a shock to realize that none of these is in story form! Newton's treatise on the laws of motion, the force of gravity, and the behavior of the planets is set up as a sequence of arguments that imitate Euclid's books on geometry. All scientific papers since then are likewise given as special kinds of arguments, not stories. Tom Paine's Common Sense is a forty page argument about why monarchies are not a good form of government and why a democracy is likely to be better. (This was not actually "common sense," but "uncommon sense" since historically, the movement to democracy is incredibly rare.) The Federalist Papers are arguments that support different parts of the design of the Constitution. And the Constitution itself is a set of principles for building a very complex dynamic structure that should last for centuries whose "parts" (that is, us!) come and go and are only somewhat intercooperative. It is most definitely not a story!

Recent studies have shown that less than 5% of American adults (less than 7% in the UK) have learned to think fluently in these modern nonstory forms. A recent perusal of the top 150 selling books in the US (as of Sept 15th, thanks to www.usatoday.com) shows that 80% are in story form, 15% are self help books, 1.5% could be construed to have some scientific content, and none were in the form of serious argumentative essays (occasionally there appears an extended essay such as Bloom's The Closing of the American Mind, but none in the top 150 in Sept.). And these are percentages for the smallish number of Americans that buy books at all–remember that a bestseller is around 100,000 books, and a "run-away bestseller" is usually no more than 1,000,000 books in a nation of some 250 millions! Television, of course, is all about stories, and finds any other form almost impossible to deal with. Note, for example, how PBS deals with "serious subjects"–they are still given as stories, and at their very best, they function as ads for books that actually hold the real content.

Now my point here is not to urge that stories be given up. I love to hear and read them, and I love to see them enacted in the theater. If we couldn't think "story" in the theater, all we would see are actors in front of cardboard scenary supported by various noises from instruments in the pit. To enjoy theater, we have to give ourselves over to the narrative, experience actors as ourselves, the symbolic scenary as a place and mood, and the noises from the pit as stirring music. It works wonderfully well and we can participate deeply in what it means to be human via this process. But now consider going to a similar building, with similar people on a stage uttering similar glorious sentences, all supported by symbolic scenary and stirring music. Sound like theater? But here I am refering to a political rally.

What we are so willing to surrender in theater, we had better hold on to with both hands here! Since our whole meaning of life and relationships with others require us to invest symbols with meaning and to give up part of ourselves to ideas, we have to get pretty sophisticated to work both sides of the street: to be tender-minded when our souls can be lifted, and be tough-minded when someone is trying to take them away from us. I believe that the main goal of learning is to learn that discernment, to learn how to make symbols work for us.

But just being able to criticize the kind of story in which one is embedded is not nearly enough, given that so much of important modern content, both politically and scientifically, is rendered in forms other than stories. In order to be completely enfranchised in the 21st century, it will be very important for children to get fluent in the three central forms of thinking that are now in use: "stories," "logical arguments," and "systems dynamics." The question is "how?"

One of the arguments advanced for why it is so difficult to get most children to learn to think in these new ways is that "this kind of thinking is hard to learn." But it is quite hard to learn to ride a bike, harder still to shoot baskets, and one of the hardest things to learn how to do is to hit a baseball consistently. If one watches children trying to learn these skills, what one sees is that they fail most of the time, but keep on trying until they learn, usually over years. This is more like their attitude when learning to walk and talk than the defeatism so often found in schoolwork. In fact, what really seems to be the case is that children are willing to go to any lengths to learn very difficult things and endure almost an endless succession of "failures" in the process if they have a sense that the activity is an integral part of their culture.

Montesorri used this very successfully in her schools. Suzuki has had similar success in music learning via setting up a musical culture in which the child is embedded. Television and cultural continuity is very good at providing an environment that includes athletics and certain kinds of music and dance, and shows what it means to be highly skilled at them. An impressively large number of scientists either had a scientist parent or one who was extremely interested in science–sometimes just extremely interested in "learning as a high calling." Difficulty is not the real issue here. Belonging to a culture and building a personal identity are. We could call this "rite of passage" motivation.

If we hark back to the less than 5% estimates for the percentage of the American population that has learned to think in these new ways and recall that television is not a good medium to show these new ways of thinking, this means that most children will have no embedded cultural experience in these ideas before coming to school. I don't know what percentage of elementary school teachers have learned to think in these new ways, but I would guess from personal experience that it is very similar to that of the population as a

whole. This means that it will be very unlikely for most children to experience these new ways of thinking at home or at school or through television–especially as embedded into the general ways of doing and thinking which are so important to how children assign value to what they are going to try really hard to learn.

Now something that is very hard to do, and which is not seen by a child as an important "rite of passage," is simply not going to be focused on with the intensity, stick-to-it-ness and tolerance of failure that is required to get over the hurdles. One of the great problems with the way most schools are set up is that the children quickly sense that most of the stuff they are asked to do is not "real," especially as opposed to optional activities like sports and games, art and music. They know these are "real," and a school has to go to great lengths to make them artificial enough for the children to lose interest.

Let me give an analogy to how the "setting up an environment" strategy might be dealt with–it is drawn from a learning experience I had as a child.

Suppose it were music that the nation is concerned about. Our parents are worried that their children won't succeed in life unless they are musicians. Our musical test scores are the lowest in the world. After much hue and cry, Congress comes up with a technological solution: "by the year 2000 we will put a piano in every classroom! But there are no funds to hire musicians, so we will retrain the existing teachers for two weeks every summer. That should solve the problem!" But we know that nothing much will happen here, because as any musician will tell you, the music is not in the piano–if it were we would have to let it vote! What music there is, is inside each and every one of us.

Now some things will happen with a piano in every classroom. The children will love to play around with it, and a "chopstick culture" is likely to develop. This is "piano by bricolage. Some will be encouraged by parents to take lessons, and a few rare children will decide to take matters into their own hands and find ways to learn the real thing without any official support. Other kinds of technologies, such as recordings, support the notion of"music appreciation. " It seems to turn most away from listening, but a few exceptions may

be drawn closer. The problem is that "music appreciation" is like the "appreciation" of "science" or "math" or "computers," it isn't the same as actually learning music, science, math, or computing!

But 50 years ago, I had the experience of growing up in a community that desired "real music for all," and found a way to make it work. It was a little town in New England that only had 200 students in the high school, yet had a tradition of having a full band, orchestra and chorus. This required that almost every child become a fluent musician. The secret is that every child starts off as a musician in their heart and each has a voice to sing with. They taught us to sing all the intervals and sight-read single parts in first grade. In second grade we sang two parts. In third grade we sang four parts and started to chose instruments. Talent was not a factor, though of course it did show up. This was something everyone did, and everyone enjoyed. I did not find out that this was unusual until I moved away. An important sidelight is that there was a piano in every classroom and all the teachers could play a little, though I am sure that at least one of the teachers was not very musical. What seemed to make it work was that the community had an excellent musical specialist for the elementary grades who visited each classroom several times a week. I remember that one teacher didn't like my phrasing in a song and tried to change it, but the specialist did like it and encouraged me to see if I could phrase the rest of the song that way.

The central point to this story is not so much that most of the children became fluent musicians by the time they got to high school–they did and had done so for generations–but that as far as I can tell, almost all still love and make music as adults (including me).

We can find this "create an embedded environment and support classroom teachers with visiting experts" strategy in a number of schools today. The Open Charter School of Los Angeles has succeeded in setting up a "design culture" in their third grade classrooms that embeds the children in a year-long exciting and difficult adventure in the large-scale design of cities. The most successful elementary school science program I know of is in all of the Pasadena elementary schools and is organized along the same lines. It was developed by Jim Bowers and Jerry Pines, two Caltech scientists, and the key is not just an excellent set of curriculum ideas and approaches, but that the

classroom teachers have to gain some real fluency, and there is important scaffolding and quality control by expert circuit riders from the district.

To say it again, children start off loving to learn, and most can learn anything the culture throws at them. But they are best at learning ideas that seem to be an integral part of the surrounding culture. Having a parent or teacher that encourages them to study math and science is not even close to having one that lives math and science (or seems to). This is the strongest pedagogical strategy I have encountered over more than 25 years of working with children. Technologies–such as books, musical instruments, pen and paper, bats and balls–can help, but they are clearly not enough to get kids over the critical hurdles all by themselves. On the other hand, literacy, music, art, dance, and sports can all flourish with little or no supporting technologies at all–supporting adults are all that are needed.

A good rule of thumb for curriculum design is to aim at being idea based, not media based. Every good teacher has found this out. Media can sometimes support the learning of ideas, but often the best solutions are found by thinking about how the ideas could be taught with no supporting media at all. Using what children know, can do, and are often works best. After some good approaches have been found, then there might be some helpful media ideas as well.

Now let me turn to the dazzling new technologies of computers and networks for a moment. Perhaps the saddest occasion for me is to be taken to a computerized classroom and be shown children joyfully using computers. They are happy, the teachers and administrators are happy, and their parents are happy. Yet, in most such classrooms, on closer examination I can see that the children are doing nothing interesting or growth inducing at all! This is technology as a kind of junk food–people love it but there is no nutrition to speak of. At its worst, it is a kind of "cargo cult" in which it is thought that the mere presence of computers will somehow bring learning back to the classroom. Here, any use of computers at all is a symbol of upward mobility in the 21st century. With this new kind of "piano," what is missing in most classrooms and homes is any real sense of whether music is happening or just "chopsticks."

I have found that there are many analogies to books and the history of the printing press that help when trying to understand the computer. Like books, the computer's ability to represent arbitrary symbols means that its scope is the full range of human endeavors that can be expressed in languages. This range extends from the most trivial–such as astrology, comic books, romance novels, pornography–to the most profound–such as political, artistic and scientific discussion. The computer also brings something very new to the party, and that is the ability to read and write its own symbols, and to do so with blazing speed. The result is that the computer can also represent dynamic situations, again with the same range: from "Saturday Morning cartoons," to games and sports, to movies and theater, to simulations of complex social and scientific theories.

The analogy to a library of books and communication systems is found in the dynamic networking of millions of computers together in the Internet. Newly added are that one can use this new kind of library from anywhere on earth, it is continuously updated, and users can correspond and even work together on projects without having to be in the same physical location.

To us, working on these ideas thirty years ago, it felt as though the next great "500 year invention" after the printing press was being born. And for a few percent–very like the few that used the book to learn, understand, and debate powerful ideas and usher in new ways of thinking about the world–computers and networks are starting to be that important. The computer really is the next great thing after the book. But also as with the book, most are being left behind.

Here is where the analogy to books vs. television is most sobering. In America, printing has failed as a carrier of important ideas for most Americans. Few get fluent enough in reading to follow and participate in the powerful ideas of our world. Many are functionally illiterate, and most who do some reading, read for entertainment at home and for information on the job (viz the 95% of bestsellers as stories and self-help). Putting the Federalist Papers on the Internet will eventually provide free access to all, but to have this great collection of arguments be slightly more accessable in the 21st century than it is today in public libraries will make no change in how many decide to read its difficult but worthwhile prose. Once again we are face to face with something

that "is hard to learn," but has lost its perceived value to Americans–they ask why should they make the effort to get fluent in reading and understanding such deep content?

Television has become America's mass medium, and it is a very poor container for powerful ideas. Television is the greatest "teaching machine" ever created. Unfortunately, what it is best at teaching are not the most important things that need to be learned. And it is so bad at teaching these most important ideas that it convinces most viewers that they don't even exist!

Now computers can be television-like, book-like, and "like themselves." Today's commercial trends in educational and home markets are to make them as television-like as possible. And the weight of the billions of dollars behind these efforts is likely to be overwhelming. It is sobering to realize that in 1600, 150 years after the invention of the printing press, the top two bestsellers in the British Isles were the Bible and astrology books! Scientific and political ways of thinking were just starting to be invented. The real revolutions take a very long time to appear, because as McLuhan noted, the intial content and values in a new medium is always taken from old media.

Now one thing that is possible with computers and networks, that could get around some of the onslaught of "infobabble," is the possibility of making media on the Internet that is "self teaching." Imagine a child or adult just poking around the Internet for fun and finding something–perhaps about rockets or gene splicing–that looks intriguing. If it were like an article in an encyclopedia, it would have to rely on expository writing (at a level chosen when the author wrote it) to convey the ideas. This will wind up being a miss for most netsurfers, especially given the general low level of reading fluency today. The computer version of this will be able to find out how old and how sophisticated is the surfer and instantly tailor a progression of learning experiences that will have a much higher chance of introducing each user to the "good stuff" that underlies most human knowledge. A very young child would be given different experiences than older ones–and some of the experiences would try to teach the child to read and reason better as a byproduct of their interest. This is a "Montesorri" approach to how some media might be

organized on the Internet: one's own interests provide the motivation to journey through an environment that is full of learning opportunities disguised as toys.

This new kind of "dynamic media" is possible to make today, but very hard and expensive. Yet it is the kind of investment that a whole country should be able to understand and make. I still don't think it is a real substitute for growing up in a culture that loves learning and thinking. But in such a culture, such new media would allow everyone to go much deeper, in more directions, and experience more ways to think about the world than is possible with the best books today. Without such a culture, such media is likely to be absolutely necessary to stave off the fast approaching next Dark Ages.

Schools are very likely the last line of defence in the global trivialization of knowledge–yet it appears that they have not yet learned enough about the new technologies and media to make the important distinctions between formal but meaningless activities with computers and networks and the fluencies needed for real 21st century thinking. At their best, schools are research center for finding out interesting things, and like great research centers, these findings are best done with colleagues. There will always be a reason to have such learning centers, but the biggest problem is that most schools today are not even close to being the kinds of learning centers needed for the 21st century.

Will Rogers once said that its not what you don't know that really hurts you, but what you think you know! The best ploy here–for computing, science, math, literature, the arts, and music–is for schools to be quite clear that they don't know–they are the blind people trying to figure out the elephant–and then try to find strategies that will help gradually reveal the elephant. This is what the top professionals in their fields do. We find Rudolph Serkin in tears at age 75 accepting the Beethoven medal, saying "I don't deserve this" and meaning it. We find Nobel physicist Richard Feynmann telling undergraduates in his physics course at Caltech just how much he doesn't understand about physics, especially in his specialty! We can't learn to see until we realize we are blind.

The reason is that understanding–like civilization, happiness, music, science and a host of other great endeavors–is not a state of being, but a manner

of traveling. And the main goal of helping children learn is to find ways to show them that great road which has no final destination, and that manner of traveling in which the journey itself is the reward.