

centers 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 it's 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 acknowledge 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 to 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.

Alan Kay is a Fellow at Apple Computer Corp.

centers 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 it's 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 acknowledge 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 to 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.

Alan Kay is a Fellow at Apple Computer Corp.

Revealing the Elephant: The Use and Misuse of Computers in Education

By Alan Kay

Sequence: Volume 31, Number 4

Release Date: July/August 1996

Throughout history, people have learned how to make sense of the world around them through stories. Long before King Solomon, whose command of 3,000 proverbs earned him the reputation as the wisest man who ever lived, stories played a central role in education. 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.”

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 may come as 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 40-

Revealing the Elephant: The Use and Misuse of Computers in Education

By Alan Kay

Sequence: Volume 31, Number 4

Release Date: July/August 1996

Throughout history, people have learned how to make sense of the world around them through stories. Long before King Solomon, whose command of 3,000 proverbs earned him the reputation as the wisest man who ever lived, stories played a central role in education. 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.”

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 may come as 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 40-

page argument about why monarchies are not a good form of government and why a democracy is likely to be better. 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 fewer than 5% of American adults have learned to think fluently in these modern non-story forms. A recent perusal of the top 150 selling books in the U.S. 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. 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 million books in a nation of some 250 millions!

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 scenery 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 scenery 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.

page argument about why monarchies are not a good form of government and why a democracy is likely to be better. 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 fewer than 5% of American adults have learned to think fluently in these modern non-story forms. A recent perusal of the top 150 selling books in the U.S. 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. 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 million books in a nation of some 250 millions!

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 scenery 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 scenery 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.

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 “Montessori” 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 are likely to be absolutely necessary to stave off the fast-approaching next Dark Ages.

Schools are very likely the last line of defense 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

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 “Montessori” 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 are likely to be absolutely necessary to stave off the fast-approaching next Dark Ages.

Schools are very likely the last line of defense 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

Rethinking the “Television Model”

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 initial content and values in a new medium are always taken from old media.

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 Net surfers, especially given the general

Rethinking the “Television Model”

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 initial content and values in a new medium are always taken from old media.

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 Net surfers, especially given the general

But now consider going to a similar building, with similar people on a stage uttering similar glorious sentences, all supported by symbolic scenery and stirring music. Sound like theater? But here I am referring 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 requires 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.

Beyond Storytelling

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 become fluent in all three of the central forms of thinking that are now in use. As we have seen, only one of these forms of thinking is done through “stories,” such as King Solomon's proverbs and other tales in which an explanation is embedded in a narrative; yet—as we have also seen—the other forms of thinking are not in story form at all. These other two forms of thinking are “logical argument,” in which an explanation is set forth as a tightly connected sequence of assertions about the world (such as those

But now consider going to a similar building, with similar people on a stage uttering similar glorious sentences, all supported by symbolic scenery and stirring music. Sound like theater? But here I am referring 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 requires 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.

Beyond Storytelling

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 become fluent in all three of the central forms of thinking that are now in use. As we have seen, only one of these forms of thinking is done through “stories,” such as King Solomon's proverbs and other tales in which an explanation is embedded in a narrative; yet—as we have also seen—the other forms of thinking are not in story form at all. These other two forms of thinking are “logical argument,” in which an explanation is set forth as a tightly connected sequence of assertions about the world (such as those

proffered by Tom Paine)—it is a kind of powerful clockwork for working out implications; and “systems dynamics,” a kind of ecological way of thinking about complexity, in which the parts actively interact. And so the question is: How exactly can we get children to explore ways of thinking beyond the one they’re “wired for” (story-telling) and venture out into intellectual territory that needs to be discovered anew by every thinking person: logic and systems “eco-logic”?

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 length 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.

Maria Montessori used this determination 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. 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% of the American population that has learned to think in these new ways

proffered by Tom Paine)—it is a kind of powerful clockwork for working out implications; and “systems dynamics,” a kind of ecological way of thinking about complexity, in which the parts actively interact. And so the question is: How exactly can we get children to explore ways of thinking beyond the one they’re “wired for” (story-telling) and venture out into intellectual territory that needs to be discovered anew by every thinking person: logic and systems “eco-logic”?

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 length 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.

Maria Montessori used this determination 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. 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% of the American population that has learned to think in these new ways

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 30 years ago, it felt as though the next great “500-year invention” after the printing press was born. And for a few—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 as was also true 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 accessible 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?

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 30 years ago, it felt as though the next great “500-year invention” after the printing press was born. And for a few—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 as was also true 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 accessible 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?

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. One can use this new kind of library from

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. One can use this new kind of library from

and recall that television is not a good medium to illustrate 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.

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! 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 “chopsticks culture” is likely to develop. Some will be encouraged by parents

and recall that television is not a good medium to illustrate 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.

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! 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 “chopsticks culture” is likely to develop. 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.” 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 had only 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. 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 choose 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. 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).

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.” 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 had only 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. 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 choose 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. 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.

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.

From Music to Technology

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

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.

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.

From Music to Technology

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