



Afterword: What is a Dynabook?

Commentary on "A Personal Computer For Children Of All Ages"

Alan Kay

This essay was recently published as an Afterword, along with "A Personal Computer for Children of All Ages", in a Japanese book which introduces the Scratch programming environment to elementary school children in a playful manner.

Get the book at: <http://amzn.to/1fUvmA1>

VPRI Paper for Historical Context

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Commentary on “A Personal Computer For Children Of All Ages”

by Alan Kay

41 years later, while rereading “A Personal Computer For Children Of All Ages”, I was struck by how much more context is needed today to understand where the ideas came from, why they turned out the way they did, and to be able to criticize the ideas then and now. I think the best way to approach this is first by a simple technical history, followed by more depth on the romantic social and technical idealism of my research community.

In the early 60s JCR Licklider, a psychologist at the Advanced Research Projects Agency put forth a great vision: *“It is the destiny of computers to become interactive intellectual amplifiers for all people pervasively networked worldwide”*. This ideal and the ARPA funding he provided led to the public domain inventions of many of today’s most important technologies, including computer graphics, artificial intelligence, interactive authoring of content and programs, graphical user interfaces, personal computing, the Internet, and more.

One of the earliest inspirations for the vision was the amazing Sketchpad system in 1962 by Ivan Sutherland. This was not just the invention of interactive computer graphics, but of real-time end-user “authoring of ideas” which were embodied in Sketchpad as working simulations. This was the first real example of Licklider’s romantic anticipation *“In a few years humans will be able to think as no humans have thought before”*¹.

A large scale experiment was the NLS “*augmentation of human intellect*” project headed by Douglas Engelbart. This is mostly remembered today as “the invention of the mouse”, but the research encompassed deep and significant explorations of “*personal computing*” itself: what it actually could mean to “*augment human intellect*”, and to “*boost the collective IQ of groups*”. For example, the ability to share all experiences remotely with others was a deep feature of the entire system.

A parallel large scale experiment in human interaction was the GRAIL system, the first to really explore stylus and gesture-based computing with the high-quality (even by today’s standards) invention of a stylus-and-tablet, and an interactive system for designing and building programs of complex systems.

Mathematician Seymour Papert (the co-principal-investigator of the MIT AI ARPA project), had a long standing interest in the psychology of children—especially children’s learning—from his association with Jean Piaget in Switzerland. These ideas led in the mid-60s to the invention of the LOGO programming language and a host of provocative experiments with “children coupled with programming to better learn mathematical thinking”.

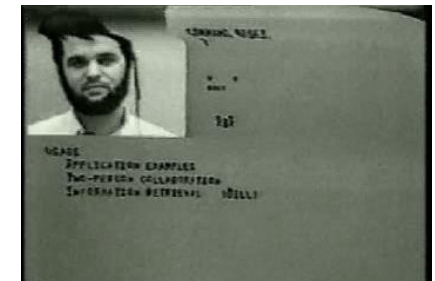
¹ Sketchpad was implemented on a gigantic air defense supercomputer the size of a large building. Fortunately the funders and researchers were optimistic!



1962-Ivan Sutherland making a dynamic bridge



ca1967-Doug Engelbart and “personal computing”



1968-Bill Paxton collaborating with Doug Engelbart



ca1968-Tom Ellis making a flowchart with GRAIL



ca Late 60s-Seymour Papert with children & turtle

Another large scale experiment, the ARPAnet, was the first packet switching and router architecture (1968-9), and it was robust enough to serve as the network for the ARPA community as it morphed into the Internet we have today.

An unusual research choice back then was the idea of a “*personal computer*” for “*personal computing*”. Although there were a few small “*computers for individuals*” back then, they were quite weak in capacity and computational power compared to the large “*main-frame*” machines that had to be shared in one way or another—often by “*batch processing*”. The LINC in 1962 was a break-through personal computer for bio-medical research technicians who needed real-time responses for data gathering and analysis.

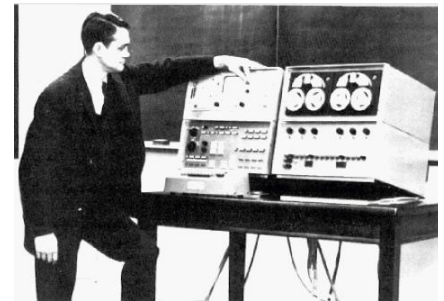
Sketchpad, NLS, GRAIL, and other experiments in highly interactive computing showed that really good user interface design and response dominated the experience, especially for the large range of users in the vision. “*User interface*” is not just about kinds of inputs, outputs and screen organizations, but about the notion of *service*—that is, the desired *content* of the interactions, and the larger goals of the interactions. In other words, we always need to ask “*What service model will enable our larger visions and goals?*”

In 1966, I was a fresh grad student in the ARPA community, and was excited by what had been done so far. So I jumped at the chance to work with Ed Cheadle on a desktop computer for engineers called “*The FLEX Machine*”: a highly interactive “*service partner for engineers and other professionals*” that could sit on a desktop and embody some of the great ideas from Sketchpad, LINC, GRAIL, NLS, etc. It had multiple windows, an object-oriented user and operating system, etc.

The next year I visited Seymour Papert, Wally Feurzig, and Cynthia Solomon to see the LOGO classroom experience in the Lexington schools. This was a revelation! And was much more important to me than the metaphors of “*tools*” and “*vehicles*” that were central to the ARPA way of characterizing its vision. This was more like the “*environment of powerful epistemology*” of Montessori, the “*environment of media*” of McLuhan, and even more striking: it evoked the invention of the printing press and all that it brought. This was not just “*augmenting human intellect*”, but the “*early shaping of human intellect*”. This was a “*cosmic service idea*”.

On the flight back to Utah I thought about how this service idea should be embodied, and quickly decided that children shouldn’t be tied to a desk. Earlier that year I’d seen Donald Bitzer’s flat-screen display prototype (a 1”x1” square of 16x16 pixels), which had brought forth thoughts of putting the FLEX Machine’s transistors on the back of a notebook-sized display to make a “*notebook computer*”.

“*A clear romantic vision has a marvelous ability to focus thought and will.*” I drew a cartoon showing a young girl and boy learning physics via an interactive game they programmed themselves and which manifests as



ca1962-Wes Clark and the LINC personal computer



ca1968-The “FLEX Machine” personal computer



1968-Don Bitzer's 16x16 1" square flat screen display



1968-The Dynabook cartoon

a shared resource on their little machines (a la NLS), and connected by a wireless network (ARPA was already experimenting with wireless as part of the ARPAnet project). I built a cardboard model of this in the next few days and experimented with size and weight (one could put lead pellets in the hollow model).

At this first brush, the service model was: *facilitate children “learning the world by constructing it” via an interactive graphical interface to an “object-oriented-simulation-oriented-LOGO-like-language.*

A few years later at Xerox PARC I wrote “A Personal Computer For Children Of All Ages”. This was written mostly to start exploring in more depth the *desirable services* that should be offered. I.e. *what* should a Dynabook enable? And *why* should it enable it?

The first context was “*everything that ARPA envisioned for adults but in a form that children could also learn and use*”. The analogy here was to normal language learning in which children are not given a special “children’s language” but pick up speaking, reading and writing their native language directly through subsets of both the content and the language. In practice for the Dynabook, this required inventing better languages and user interfaces for adults that could also be used for children (this is because most of the paraphernalia for adults in those days was substandard for all).³

One of the best statements of what ARPA thought should be made for adults—“The Computer As A Communications Device”—was written in 1968, the year of the Dynabook idea, by Licklider and Bob Taylor (a subsequent ARPA funder and later the founder of Xerox PARC). It is [available](#) online and can be found and read through the very technologies invented via the funding of these two visionaries.

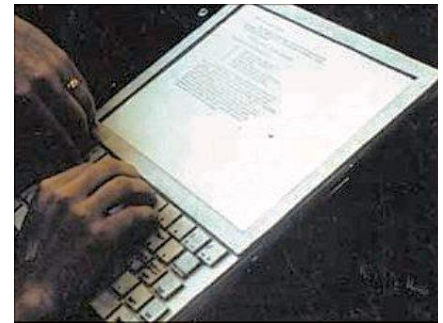
Deeper contexts for the questions came from the social idealism of many of the ARPA researchers. For example, Douglas Engelbart once said in an interview that, as a young man, he decided:

- he would focus his career on making the world a better place;
- any serious effort to make the world better requires some kind of organized effort
- harnessing the collective human intellect of all the people contributing to effective solutions was key
- if you could dramatically improve how we do that, you'd be boosting every effort on the planet to solve important problems—the sooner the better, and
- computers could be the vehicle for dramatically improving this capability

Similar sentiments were shared by many in this research community. A lot of the drive “make the world better” was intertwined with issues of the American Republic in those times of the Cold War, McCarthyism, assassinations of national figures, collusions and crimes in dealing

² — Cesare Pavese

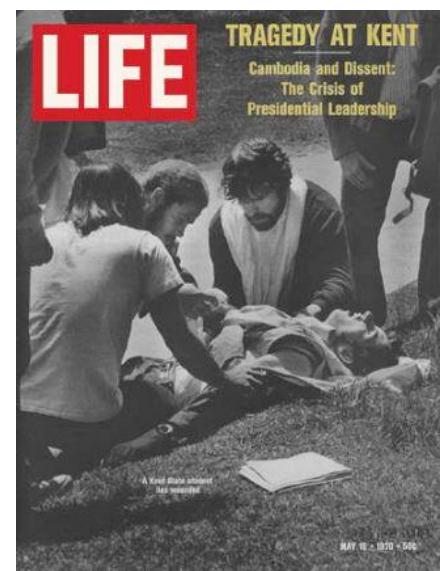
³ This is still unfortunately all too true today



1968-The Dynabook cardboard model



1968-Meeting about bridges (from Licklider & Taylor)



1970 – Four Kent State University students killed by National Guard

with race, the National Guard shooting and killing college students, an undeclared war in which many 10s of 1000s of Americans were killed, covert bombings of Cambodia, etc.

The Roman poet Juvenal's quip about the Roman Republic "But who will Guard the Guardians?" was a central question of the 60s.

Thomas Jefferson's reply to a similar question about democracy was often quoted (sidebar):

Back then, *it was in the context* that "education" meant much more than just competing for jobs, or with the Soviet Union; how well "real education" could be accomplished was the very foundation of how well a democratic federal republic could carry out its original ideals.

Jefferson's key idea was that a general population that has *learned to think* and has *acquired enough knowledge* will be able to dynamically steer the "ship of state" through the sometimes rough waters of the future and its controversies (and conversely, that the republic will fail if the general population is not sufficiently educated).

An important part of this vision was that the object of education was not to produce a single point of view, but to produce *citizens* who could carry out the processes of *reconciling* different points of view.

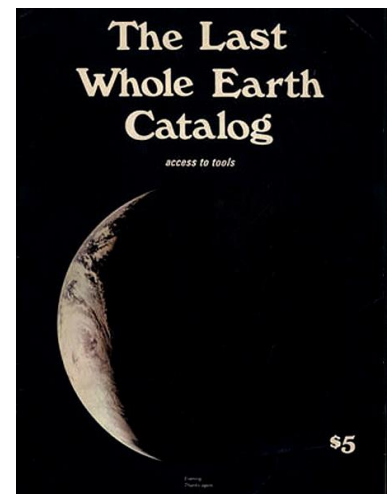
If most Americans today were asked "why education?", it's a safe bet that most would say "to help get a good job" or to "help make the US more competitive worldwide" (a favorite of our recent Presidents). Most would not mention the societal goal of growing children into adults who will be "*enlightened enough to exercise their control with a wholesome discretion*" or to understand that *they* are the "*true corrective of abuses of ... power*".

With all its faults, the political system invented by Jefferson and his colleagues has been so effective in making individual freedoms "possible and wide" and creating the wealth to support these ideals, that the idea of living within a *system ecology* that must be "maintained and gardened" has almost been lost, and the system itself rendered almost invisible.

From this viewpoint, one of the most glaring omissions in my 1972 paper is lack of mention of Stewart Brand's "Whole Earth Catalog" and what the organization behind it stood for. This is despite that I was asked in 1971 to choose the initial books for the Xerox PARC library, and my response was to take the PARC librarian over to the "Whole Earth Truck Store" in Menlo Park and purchase every one of the hundreds of books listed in the Whole Earth Catalog. I did this because the catalog proclaimed itself as "Access To Tools", and its selection included many of the best books written about a wide variety of systems and ecological thinking on large scales, use of tools, ways to think about the human condition, the place of technologies—high and low—in human life, governance, ways to think about business, and much more. It was the cream of both the culture and the counterculture: a center for

"I know no safe depository of the ultimate powers of the society but the people themselves; and if we think them not enlightened enough to exercise their control with a wholesome discretion, the remedy is not to take it from them, but to inform their discretion by education. This is the true corrective of abuses of constitutional power."

Thomas Jefferson to William C. Jarvis, 1820



learn any skill, it is not done as a simple addition, but produces a change to one's context for thinking as well as one's behavior. As Neil Postman said "*Rabbits + Australia is not a sum but a new ecology*".

This internal ecological change can be qualitative—as with the Australian ecology—and this led to McLuhan's idea that what's really important about tools and media is not what they can do, *but what human beings become by getting fluent in them*. This is what he meant when he said "*The medium is the message*". In other words, tools and media are part of what determines our sense of "normal"; big changes can radically shift an individual's and culture's sense of normal. Moreover, "normal" is not just mostly invisible, but for most people and cultures it is much the same idea as "reality". It's not thought of as a point of view, but as "the way things are".

A deep consequence of "The medium is the message" is role and identity change. For example, the printed book changed the answers to the questions "Who will learn?", "What will be learned?", "What is a point of view?", "Who will interpret and talk to God?", "Who will decide who rules?", "Who am I?". And many more.

The new answers were "anyone who wants to", "many more subjects than previously dreamed of", "not just the view of society, but of the *individual* who reads?", "the people, not the priests", "the people, not the monarchy or aristocracy", "someone who can learn to become".

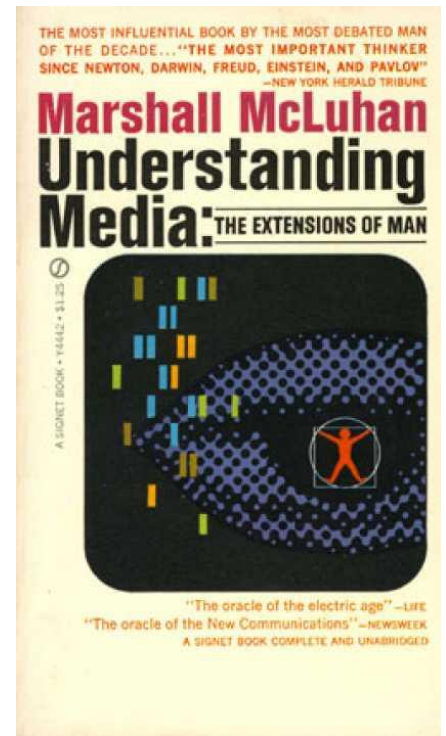
Another deeply important notion is that different media have different "carrying capacities" for ideas. As McLuhan said "You can argue about a lot of things with stained glass windows, but Democracy is not one of them"⁵. One of the media that does facilitate good argumentation about Democracy is writing-via-printing. And it is very good for the kinds of argumentation that form the center of scientific communication.

These ideas got us to ask the two analogous interrelated questions: (a) "what is the carrying capacity for ideas of the computer?", and (b) "what will be the role and identity changes brought by personal computing and pervasive networking?".

(a) The big whammy is that the computer is a *metamedium*—it can simulate any existing media and also be the basis of media that can't exist without the computer. I was particularly drawn to the idea of better childhood education with the new possibilities to represent powerful ideas that the computer brought would be a strong way to help children "*grow up thinking much better than most adults do today*".

(b) We thought that the largest role and identity changes brought by computing and pervasive networking should be *enfranchising individuals* to be able to do and think as previously only large organizations

⁵ Neil Postman pointed out later that television has been the greatest mass teacher of all time, yet it is a disaster because it is terrible at teaching what is important for a civilization to know, and it is good at teaching retrograde behavioral ideas.



1964-The quintessential McLuhan statement

and the hyperwealthy had been able to do. This was not a new thought—the printed book started the process, and many parts of the industrial revolution e.g. automobiles vs trains, were continuing to “open up much of what was possible to most of the population”. Many of these processes could be seen as “disintermediations” (more accurately “reintermediation”), and we expected that personal computing would find many ways to do this in all the processes that involved information and communication.

By shifting both “normal” and “the tools for learning and doing”, not just the answers but the *meanings* of the questions “Who am I?” and “What can I do?” and “Who can I learn to become” radically change.

Once the ideas of “media as environment” and “new media as reintermediators” are grasped, the important question is “Can we shape “the message” of our new metamedium to create a powerful positive force for “civilization”?”.

The inclusion of children begged to be informed by the ideas of Montessori, Dewey, Piaget, Vygotsky, Bruner, Moore, Papert and other great educational thinkers about how children can be helped to take on the richest understanding and thinking processes about the world around them. At the center of this line of thinking are three main ideas:

- The great power of human immersion in whole environments that Montessori suggested and Papert made memorable through his “It’s easier to learn French in France, so shouldn’t we make a *MathLand*?”
- Science is a very different and powerful new way of looking at us, the universe around us, and what it means “to find out” and “to know”. It is a set of methods/heuristics for getting around “what’s poorly formed in our genetic and cultural minds”; it’s a bigger idea than just better ways to understand Nature.
- The related influence of *literacies* as a kind of environment for human thinking, with use of the computer medium to provide new and more powerful extensions of what literacy and representation of ideas have already brought to us.

For example, Maria Montessori stressed that the main business of early childhood experience was to take on the strongest epistemologies of their time, and that the best way to do this was to embody the powerful stances about knowledge and thinking directly in the environments of the school and (if possible) the children’s homes. To us, the interactive computing to come would be like an environment, so a strong goal would be to invent good ones in which the epistemological stances of powerful ideas—such as scientific thinking—were embedded so the combination formed a new kind of literacy of human beings and the dynamic representations of a computer.

APCFCOAA assumes its readers would be familiar with the general ARPA approach to interactive computing⁶ as exemplified in “end-user” systems created a few years previously, such as Sketchpad, JOSS, NLS,

⁶ This assumption in 1972 was almost certainly quite naïve on the part of the author.

GRAIL, etc. (none of which are referenced in the paper). All of these allowed real-time access and provided instant response. Each had a carefully designed interface that combined ways to interact with some form of “end-user programming”. The interface, the ability to program (and the “simulation/modeling” stance of the programming itself), provided the basic service model of these systems, and these can be regarded as the first attempts to invent “new languages for new literacies” for interactive personal computing.

Part of this context for the Dynabook idea can be understood by looking at the [paper](#) “Personal Dynamic Media” done a few years later, with most of the text and examples drawn from a proposal made to NSF⁷ in 1975. By then, an “Interim Dynabook” had been made at PARC⁸ and many examples and experiments had been done, including by a wide range of children both within PARC and at a local school in Palo Alto. Most of the experiments were a combination of simulating media (some of which could only exist on a computer) combined with authoring systems for this media. Even though science learning was the big picture, the invention, learning and use of new tools to deal with “process and processes” was the early focus.



ca. 1973-“Interim Dynabook”-Xerox PARC “Alto”

A longer version of this essay would address the tantalizing question of “What should the Dynabook be about if we were to design it with what we’ve learned in the last 45 years?” So much more is now known about how human beings think and, most especially, make decisions, that the past naïve reliance on “automatic rationalism” from learning “sciences and systems” doesn’t hold up. Today, we would emphasize not just *learning to think well* in a complex world of many kinds of evidence, cultures and contexts, but being *trained to think well* under many kinds of stress, including those of time, scale, opinions, and almost invisible desires that are genetically generated and affect conscious decision making. It has often been noted that “Science is better than scientists” —meaning that the process of science overcomes many individual biases by setting high standards and involving many other scientists in the vetting processes.

Similarly, going back to the ideals and ideas of Jefferson and others, we would like “Our country (now our world) to be better than its citizens”, and especially as opposed to being “worse than its citizens”. And then to bring the individual citizens up to the level of that the aggregate can achieve. This is not a utopian dream—it can be done by better understanding of ourselves and our organizations, but in order to make it happen, it most especially requires citizens whose “discretion has been informed by education”.

⁷ It was for a major “transfer” experiment, and NSF turned it down.

⁸ ... which with its Smalltalk overlapping windows interface later became the basis for the Macintosh